European Commission

CASCADE Database and Web Services

CASCADE PROJECT - Catastrophic Shifts in Drylands; How Can We Prevent Ecosystem Degradation

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2016

CASCADE
Catastrophic shifts in drylands

Joint Research Centre

EUR 28415 EN

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JRC Science Hub
https://ec.europa.eu/jrc

JRC105245

EUR 28415 EN

PDF	ISBN 978-92-79-64996-7	ISSN 1831-9424	doi:10.2760/295510
Print	ISBN 978-92-79-64997-4	ISSN 1018-5593	doi:10.2760/822434

Luxembourg: Publications Office of the European Union, 2016

How to cite this report: Panagos P., Yigini Y., Boni M; *CASCADE Database and Web Services*; EUR 28415 EN; doi:10.2760/295510

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Abstract

This document presents a 'Cookbook' description for installing the software tools necessary to develop and configure the CASCADE Project database and Web Services. The portal developed may provide the basis for project, the data collected, processed and provided by the project partners. The contents below describe the process of preparing the data and the portal to host the project outputs and associated components.

The work presented here is a direct output and deliverable of the EU Framework 7 project 'CASCADE - Catastrophic Shifts in Drylands', Grant Agreement Number 283068. CASCADE Project investigates and analyses a range of dryland ecosystems in southern Europe to obtain a better understanding of sudden shifts in drylands that may lead to major losses in biodiversity and concomitant ecosystem services. Based on these analysis, CASCADE develops ways to predict the proximity of the CASCADE's dryland ecosystems to thresholds in such a way that these predictions can be used by policymakers and land users for more sustainable management of drylands worldwide.

The work described here was conducted by the Land Resources Unit of the Joint Research Centre of the European Commission. The Land Resources Unit provides information for European and International policies aiming to balance competing land-use demands whilst securing access to natural resources and maintaining ecosystem services. Land and soil should be considered as finite resources – we must optimise food, fibre and fuel production whilst maintaining and enhancing the land's role as a carbon sink and a hydrologic reservoir that underpins biological diversity; our research documents trends in the condition of land, the efficiency of its use and management choices, along with how these respond to changing environmental, societal and economic conditions.

1 Introduction

1.1 Project Overview

One of the most challenging themes in ecology over the last decades is the quest for the understanding of discontinuous changes in ecosystems. Several terms have been used to indicate such changes, such as 'sudden regime shifts', 'thresholds', tipping points', 'catastrophic shifts' and 'critical transitions'. Discontinuous changes have since then been observed and analysed for a wide variety of ecological systems, including lakes, drylands, peat-lands, rangelands, marine systems, and mussel-beds.

Some of these discontinuous shifts in ecosystems imply undesired and irreversible changes. For example, shallow lakes can suddenly change into eutrophic systems with a large loss in biological diversity, and drylands can catastrophically lose both biological and economic production.

For this reason, early warning signals can be very helpful to take well-timed adequate and cost-effective measures to prevent undesired sudden shifts. The need of early warning signals has been indicated for e.g. dryland ecosystems and lakes, but it has also been argued that sudden regime shifts will occur without warning. The present proposal will focus on sudden regime shifts in dryland ecosystems. The reasons for this choice are twofold;

First: Drylands cover about 40% of the terrestrial land surface of the globe, and are home to over two billion people. In Europe, drylands represent over 32% of its land mass and are home to 25% of its population. In both Europe and worldwide, drylands are crucial determinants of the economy, culture and climate.

Second: For catastrophic shifts in dryland ecosystems, early warning signals are now being developed, opening perspectives for timely and appropriate measures. Sustainable management of drylands asks for such measures, but should also aim to keep short term costs of measures (e.g. temporary migration of herds) as low as possible without compromising benefits in the long-term. This perhaps more crucial in drylands than in other regions, as livelihoods are often more marginal, and any cost of unnecessary measures is more likely to tip the livelihood balance.

By focusing on these vulnerable ecosystems, especially by improving our understanding of the drivers, and mechanisms behind shifts and by developing timely signalling tools, we aim to bring the science of sudden shifts in ecosystem a major step forwards and to find ways in which these shifts can be avoided and in which livelihoods can be supported. CASCADE will investigate a range of dryland ecosystems in southern Europe to study a range of physical and socio-economical drivers. This is done by performing research in 6 study sites in the Mediterranean region, ranging from Portugal to Cyprus (Figure 1).

Figure 1. CASCADE Study Sites

The CASCADE approach will develop a common-ground participatory approach that will serve as the basis of the sustainable management of the ecosystems, the biodiversity within these ecosystems, and the services provided by the ecosystems. Such detailed, integrated modelling and participatory evaluation of dryland degradation and its causes and solutions have not been undertaken for European dryland regions yet. Therefore, results of CASCADE will be of direct benefit for natural resource managers in dryland areas, and will provide targeted information, guidance and recommendation for related policy makers as well.

2 Data Collection and Data Preparation

2.1 Data Collection

The role of the JRC in the project is to manage and store all the field site data. The Joint Research Centre prepared easy-to-fill templates to collect the project data from the partners for the 6 study sites which are located in southern Europe in a transect from West to East (Figure 1).

1-Albatera - Portugal

2-Ayora Mariola - Spain

3-Caramulo - Spain

4-Castelsaraceno - Italy

5-Messara - Greece (Crete)

6-Pissouri - Cyprus

The 6 sites together cover the whole European part of the Mediterranean, as they range from Portugal to Cyprus. Most sites have distinctly semi-arid climate; the only exception being Portugal. However, despite the higher rainfall amount in Portugal, this site is also seasonally dry and is therefore fully representative for Mediterranean conditions.

The data collection templates were prepared using MS Excel to avoid compatibility issues. The data collection workflow is presented in the Figure 2, the data types and the providers are presented in the Table 1.

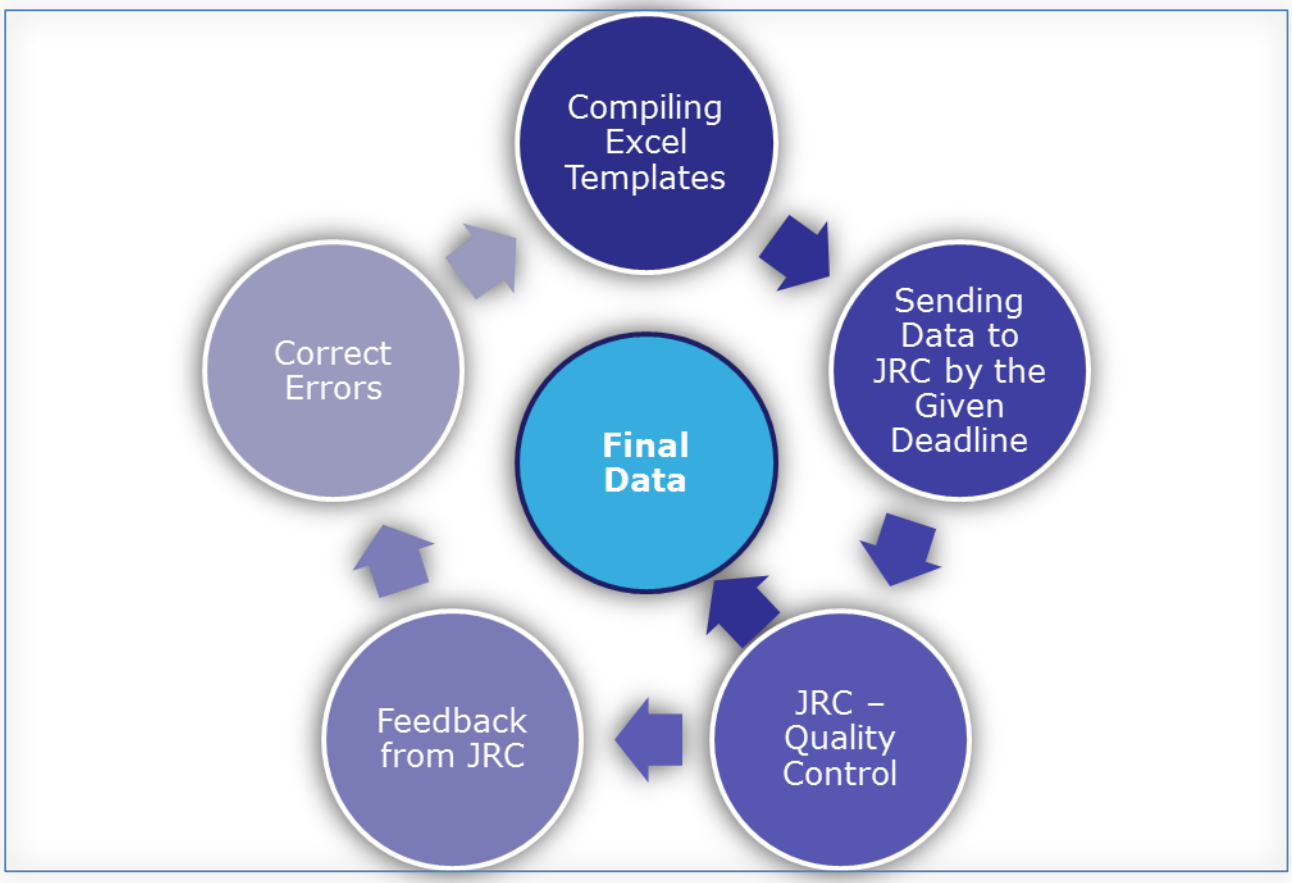


Figure 2. Data collection workflow

After the finalisation of the field data, CASCADE database was transferred to the European Soil Data Centre (ESDAC) site hosted by the JRC in order to complement soil data at European scale, thus gradually creating a general picture of soils in Europe.

Table 1. CASCADE Project Data

Study Site	Feature	Metadata	Data provider
1. Varzea (PT)	Climate	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)
	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Excel sheets, Table 1	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Vegetation Data	Excel sheets, Table 2	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland
2. Albatera (ES)	Climate	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)
	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Table 1	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Vegetation Data	Table 2	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland
3. Ayora Mariola (ES)	**Climate**	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)
	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Table 1	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Vegetation Data	Table 2	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland
4. Castelsaraceno (IT)	Climate	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)
	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Table 1	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Vegetation Data	Table 2	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland
5. Messara	Climate	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)

	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Table 1	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Vegetation Data	Table 2	All Project Partners (WP2, WP3, WP4, WP5, WP6)
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland
6. Pissouri (CY)	Climate	Climate Variables (Precipitation and Temperature)	WP2 (Technical university of Crete)
	Figures	Figures in .jpg format	WP2 (Technical university of Crete)
	Shapes	.kml or .shp files	WP2 (Technical university of Crete)
	Soil Data	Table 1	All Project Partners
	Vegetation Data	Table 2	All Project Partners
	Resilience Data	Excel Sheets, .pdf report	WP7 - University of Bern, Centre for Development and Environment (UNIBE-CDE), Switzerland

2.1.1 Soil and Vegetation Data

Each study site partner received two site-specific excel templates, one for vegetation measurements and one for soil measurements, to be filled in after each sampling.

The VEGETATION template is intended to include available data for the 2 destructive measurements (usually, first and last sampling) and the 4 (seasonal) measurements. The timing of the measurement is indicated in the name of the variable. For example, HEIGHT_t2, refers to plant height measured in the second field campaign. Variable names in the database are abbreviated; full names are in the METADATA sheets (Table 2 and Table 3).

The data providers considered the following before filling in the data:

1. GROWTH variables (e.g. plant height growth) will be available from the second field campaign since they are calculated from the difference between two consecutive measurements.

2. Many growth phenomena in nature exhibit a logarithmic or exponential increase. For this reason, you have to calculate your GROWTH variables as ln (t2) – ln (t2).

3. Cases in which a variable is obtained from several stems, branches or leaves, GROWTH cannot be automatically calculated in the database, since the result is the average of the growth measurements of the different stems or branches that are being monitored.

There are separate worksheets in each excel template, for the case of VEGETATION these are the following:

1. COMMENTS, where the partner can write any information about the status of the sampling, including sampling dates, whether variables are missing and why, etc.;

2. PLANT_DATA, where the partner insert the data; and

3. PLANT_METADATA, where the partners are asked to please specify the UNITS that the measurements are taken in. This is essential for further data checking and storage and, eventually, for analysis.

Table 2. Metadata for soil data tables

VARIABLE	*UNITS*	*DESCRIPTION*	*LABELS*
ST_#		Study site number, as in DOW	
SITE_NAME		Study site name	
DEG		Degradation level	D = degraded, PD = partly degraded 1 (1 fire), PD2 = partly degraded 2 (2 fires), C = control
PLOT_#		Plot number in the global database	
PLOT_ID		Plot ID given by each site partner (if applicable)	
MPLOT_TYPE		Microplot type	P = plant patch, I = (bare-soil) interpatch
MPLOT_#			
MPLOT_ID			
PLANT_SP		Plant species	
PLANT_FT		Plant functional type	
N_TOT		Total nitrogen	Method: Elemental analysis
N_ORG		Organic nitrogen	Method:
NO3		NO3	Method: Salicilic acid + NaOH 2M
NH4		NH4	Method: phenol - hypochloryte reaction
P_AVAIL		Pavailable (0.01 CaCl2 extraction)	
DOC		DOC (0.01 CaCl2 extraction)	Method: Dicromate + Sulfuric Acid
NA		Na (0.01 CaCl2 extraction)	
HWC		Hot Water extractable Carbon	Method:
PMN		Potentially Mineralisable Nitrogen	Method: phenol - hypochloryte reaction
SWC		Soil water content	Method:
DEPTH_GWATER		Depth of groundwater table	

		(if applicable)	
SAND	%	Soil content of sand particles	Method
SILT	%	Soil content of silt particles	Method
CLAY	%	Soil content of clay particles	Method
PH		pH (KCl)	
CEC		Cation-exchange capacity	
C_ORG	%	Organic carbon content	Method
CACO3		CaCO3 (if pH>7)	
DENS		Soil bulk density	
STONE_SUR_COV		Stone fraction on the soil surface	

Table 3. Metadata for plant data tables

VARIABLE	UNITS	DESCRIPTION	LABELS
ST_#		Study site number, as in DOW	
SITE_NAME		Study site name	
DEG		Degradation level	D = degraded, PD = partly degraded, C = control
PLOT_#		Plot number in the global database	
PLOT_ID		Plot ID given by each site partner (if applicable)	
MPLOT_TYPE		Microplot type	P = plant patch
MPLOT_#			
MPLOT_ID			
PLANT_SP		Scientific name of target plant	
PLANT_FT		Plant functional type (shrub, steppe grass, etc.)	
MAX_HEIGHT	cm	Maximum plant height	
MAX_HEIGHT_GRO		Maximum Plant height GROWTH	
AVG_HEIGHT	cm	Plant height (taking into account the representative height of the whole patch, not maximum height)	
HEIGHT_GRO		Plant height GROWTH	Difference in plant height between two consecutive measurements
PLANT_BAS	mm2	Plant basal Area	Shrub: average of two perpendicular diameters for one stem or, if target plant has multiple stems, average diameter for the whole set of stems (see protocol in case of doubt). Tussock grass:average of two

			perpendicular diameters.
PLANT_BAS_GRO		Plant basal diameter GROWTH	Difference in plant basal diameter between two consecutive measurements
CANOPY	m2	Canopy area	Estimation of the larget cross-section of the canopy
CANOPY_GRO	m2	Canopy area GROWTH	Difference in plant canopy growth between two consecutive measurements
BRANCH_BAS	cm	Branch basal diameter (only for shrubs)	Average of the measurements taken on 3 representative branches for each shrub
BRANCH_BAS_GRO		Branch basal diameter GROWTH (only for shrubs)	Difference in branch basal diameter growth between two consecutive measurements
BRANCH_LEN	cm	Branch length (only for shrubs)	Average of the measurements taken on 3 representative branches for each shrub
MAX. BRANCH LENGTH_T2	cm	Maximum Branch length (taking into account the length of the inflorescence)	
INFLORESCENCE LENGTH_T2	cm	Length of the inflorescence	
BRANCH_LEN_GRO		Branch length GROWTH (only for shrubs)	Difference in branch length growth between two consecutive measurements
LEAF_LEN	cm	Leaf length (only for grasses)	Average of selected-leaves measurements from one plant
LEAF_LEN_GRO	cm	Leaf length GROWTH (only for grasses)	Difference in leaf length growth between two consecutive measurements
RWC	%	Relative water content (only for first and last samplings)	
SLW	g/m2	Specific leaf weigth (only for first and last samplings)	
SLA	m2/g	Specific leaf Area	
HUBER	unitless	Huber index (only for shrubs, and for first and last samplings)	
BIOMASS	g	Total branch or tiller biomass (only for first and last samplings)	
D13C		d13C (from dry plant material of first and last samplings)	
FLOWERS		Number of flowers per branch (once per year), in charact. Branch	
FRUITS	g	Weight of fruits per branch (once per year)	
SPIKES	g	Dry weight of spikes (once per year)	Average per plant

SEEDLING_T	Number of new seedlings (or sprouting shoots) of target spp.	Anthyllis cytisoides
SEEDLING_X1	Number of new seedlings (or sprouting shoots) of X1 spp. (indicate spp. in next column)	X1= Artemisia herba-alba
SEEDLING_X2	Number of new seedlings (or sprouting shoots) of X2 spp. (indicate spp. in next column)	X2=?

2.1.2 Climate Data

The climate data were also collected and transferred to the JRC, as climate plays an important role in the dryland ecosystems. The climate data were prepared by the WP2 team from Technical University of Crete (TUC), Greece. Climate data were provided by the Study Site coordinators. WP2 analysed the data for all 6 Study Sites using exactly the same procedures. Monthly precipitation and monthly mean temperature were plotted to determine if there was any trend in these over the time. For visualising the climate data both temperature and rainfall, data series covering the period 1960-2012 were used. Additional climatic data (Potential Evapotranspiration – PET, Aridity index, standardized precipitation index – SPI) will be uploaded in the CASCADE database upon copyright agreements from the Project partners.

2.1.3 Resilience Assessment Tool For land management systems in Mediterranean drylands

The WP7 prepared a questionnaire allows documenting and assessing the resilience of a land management system (defined as an area managed under the same combination of management practices), and the potential of land management practices in preventing or reversing catastrophic shifts in the ecosystem.

A special study about the issues of sustainability, resilience, timing and scale was conducted to get more insights into potential mechanisms including the role of management measures regarding ecosystem tipping points, thresholds and shifts for guiding land managers at various scales. A special focus was put on the resilience of the management measures towards change. This includes questions about how resilient a specific management practice actually is and what kind of change would be required to make it more resilient or to adapt it to ecosystem changes.

As a final result, an accurate but simple method for this resilience assessment, attached to the WOCAT tools used by the WP7 researchers, developed and tested within the

CASCADE study sites. This 'resilience tool' can also be used beyond the projects lifetime and in other areas.

The WP7 contribution consists of two main elements,

1. An excel database which holds the actual data on the first sheet; the second sheet lists the code of each variable used for the assessment together with the related question of the questionnaire.
2. A document which presents the answers to the questionnaire (.pdf)

The WP7 data and the output documents were processed and transferred into the ESDAC's web environment.

3 Data Processing

The project data were processed and harmonised to be imported into the ESDAC environment (Figure 3)

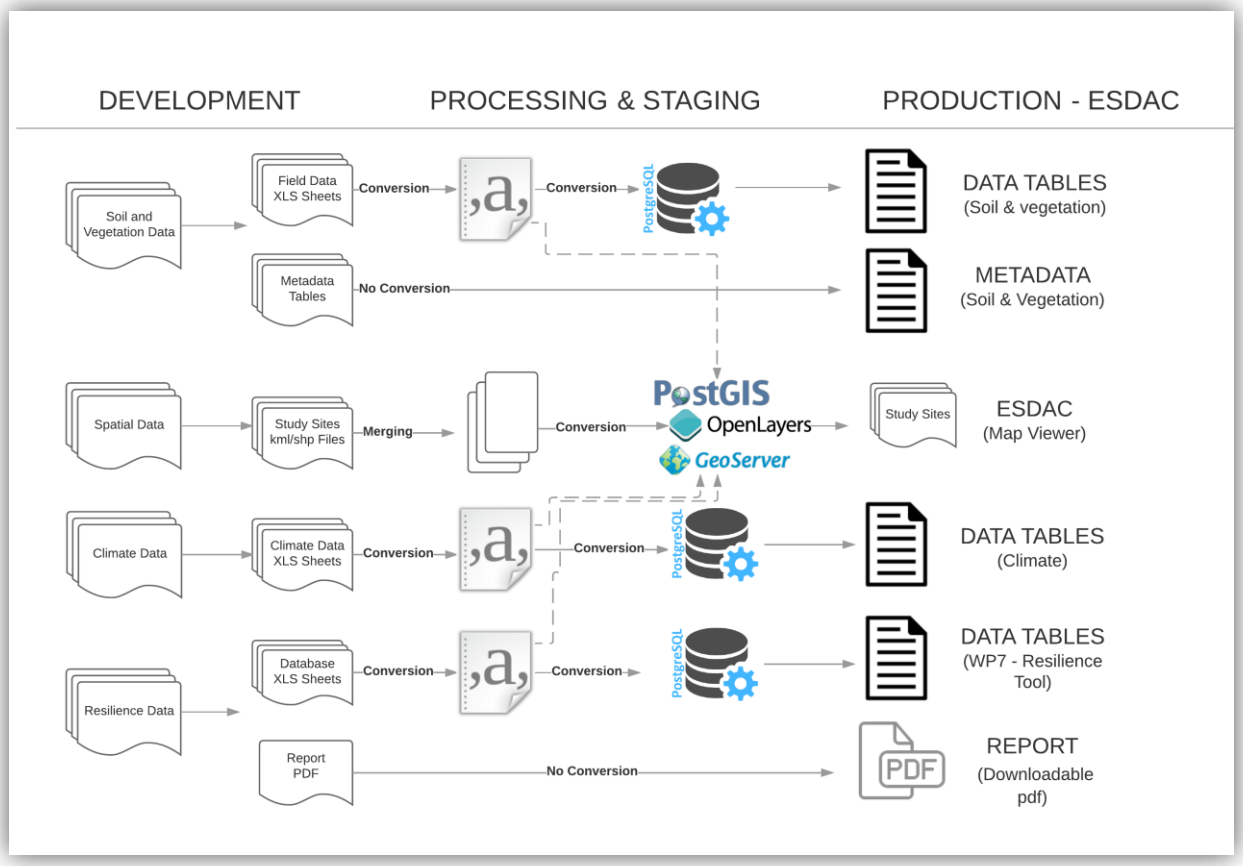


Figure 3. Data processing flowchart of the CASCADE Data.

3.1 Vector Files

The spatial data for each of the study sites were provided in vectors by the WP2 in .kml or .shp formats. These spatial data files were merged, linked to the soil, vegetation, climate and resilience data tables and imported into the ESDAC's Web GIS interface (GeoServer, OpenLayers, PostGIS) and published in the dedicated section of the ESDAC Web Portal.

3.2 Soil and Vegetation Data Tables

The field data for soil and vegetation measurements were collected as non-spatial data tables in MS Excel file format. The excel sheets were converted into .csv files, linked to the spatial data, (Study Site Polygons) then imported into the PostgreSQL database as required.

3.3 Climate Data

The climate parameters were provided by the WP2 as in non-spatial data tables in MS Excel file format. The excel sheets were converted into .csv files, linked to the spatial data, (Study Site Locations) then imported into the PostgreSQL database as required.

3.4 WP7 – Resilience Tool and Questionnaire Data

The WP7 developed the "Resilience Assessment Tool For land management systems in Mediterranean drylands" and the tool's outputs were provided in two main data types

- A database in MS Excel format which holds the actual data on the first sheet; the second sheet lists the code of each variable used for the assessment together with the related question of the questionnaire.

- A document which presents the answers to the questionnaire (.pdf)

The MS Excel data table was split into two separate tables as Responses and Variables and these two tables were edited and converted to be joined to the geo-spatial files (Study Site Locations)

The pdf report was uploaded into the ESDAC Server and linked for direct download.

4 CASCADE Data Web Services

4.1 Backend

Both websites, ESDAC main web-portal and the ESDAC Web Map Viewer, have been developed using POSTGRESQL and POSTGIS databases. Backend interface facilitates all the administrator tasks including data adding/editing, user and content management.

4.1.1 Web Server

ESDAC web portal and ESDAC Web Map Viewer are hosted on CentOS 7 Linux virtual machines running Apache HTTP Server and Apache Tomcat services.

Both websites were developed in three different environments/Virtual Machines:

- DEV: Development
- STG: Staging
- PROD: production

4.1.1.1 Server and Operating System (CentOS 7)

CentOS Linux is a community-supported distribution derived from sources freely provided to the public by Red Hat for Red Hat Enterprise Linux (RHEL). As such, CentOS Linux aims to be functionally compatible with RHEL. The CentOS Project mainly changes packages to remove upstream vendor branding and artwork. CentOS Linux is no-cost and free to redistribute. Each CentOS version is maintained for up to 10 years (by means of security updates -- the duration of the support interval by Red Hat has varied over time with respect to Sources released). A new CentOS version is released approximately every 2 years and each CentOS version is periodically updated (roughly every 6 months) to support newer hardware. This results in a secure, low-maintenance, reliable, predictable and reproducible Linux environment.

CentOS Documentation: https://wiki.centos.org/

4.1.1.2 HTTP Server (Apache/2.4.6 – CentOS 7)

The ESDAC Web Portal running on an Apache HTTP Server. The Apache HTTP Server Project is an effort to develop and maintain an open-source HTTP server for modern operating systems including UNIX and Windows. The goal of this project is to provide a secure, efficient and extensible server that provides HTTP services in sync with the current HTTP standards. The Apache HTTP Server ("httpd") was launched in 1995 and it has been the most popular web server on the Internet since April 1996.

4.1.1.3 Java Server (Tomcat 7)

GeoServer requires a Java 8 environment (JRE) to be installed on the system. The ESDAC GeoServer needs java servlet 3.0 which is implemented by Tomcat 7.0. The Apache Tomcat® software is an open source implementation of the Java Servlet, Java Server Pages, Java Expression Language and Java WebSocket technologies. The Java Servlet, Java Server Pages, Java Expression Language and Java WebSocket specifications are developed under the Java Community Process.

Documentation link: https://tomcat.apache.org/tomcat-7.0-doc/index.html

4.1.1.4 Content Management Script (Drupal CMS)

ESDAC Portal is running on Drupal CMS which is a free and open source content-management framework written in PHP and distributed under the GNU General Public License.

4.1.1.5 Map Server (GeoServer)

The CASCADE's geo-spatial data (Sites, Site Locations, and Polygons) are served and managed by GeoServer (Figure 4, 5 and 6). GeoServer is a Java-based opensource software server that allows users to view and edit geospatial data. Using open standards set forth by the Open Geospatial Consortium (OGC), GeoServer allows for flexibility in map creation and data sharing. GeoServer allows display spatial information to the world. Implementing the Web Map Service (WMS) standard, GeoServer can create maps in a variety of output formats. OpenLayers, a free mapping library, is integrated into GeoServer, making map generation quick and easy. GeoServer is built on Geotools, an open source Java GIS toolkit. GeoServer also conforms to the Web Feature Service (WFS) standard, which permits the actual sharing and editing of the data that is used to generate the maps. Others can incorporate data into their websites and applications.

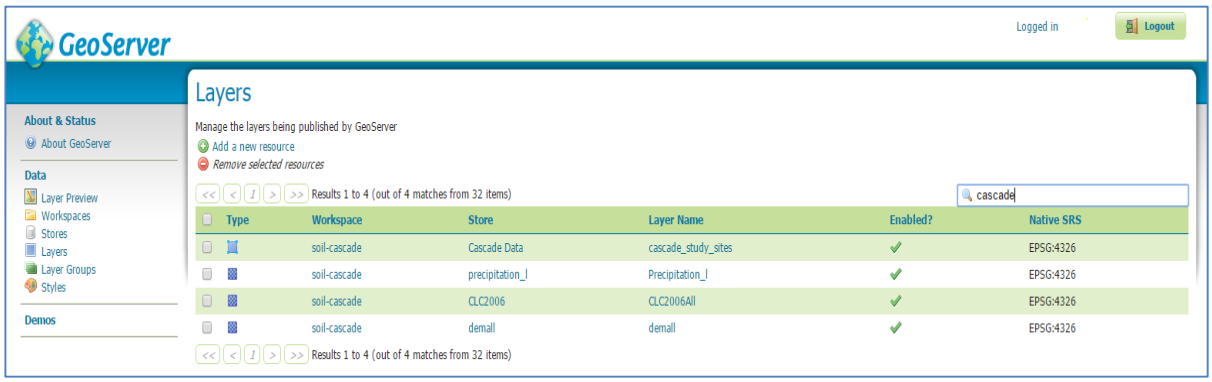


Figure 4. Layer management section of Geoserver's Admin Interface

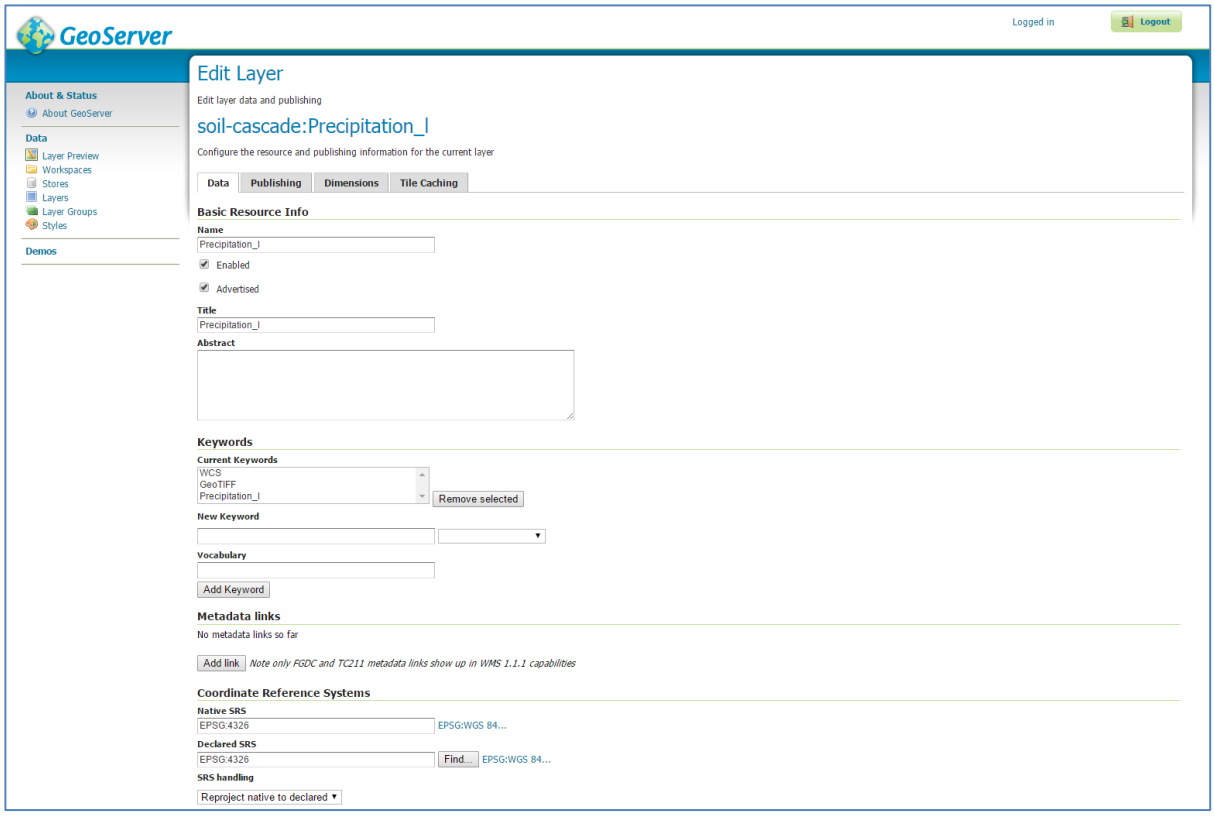


Figure 5. Layer editing screen of Geoserver's Admin Interface

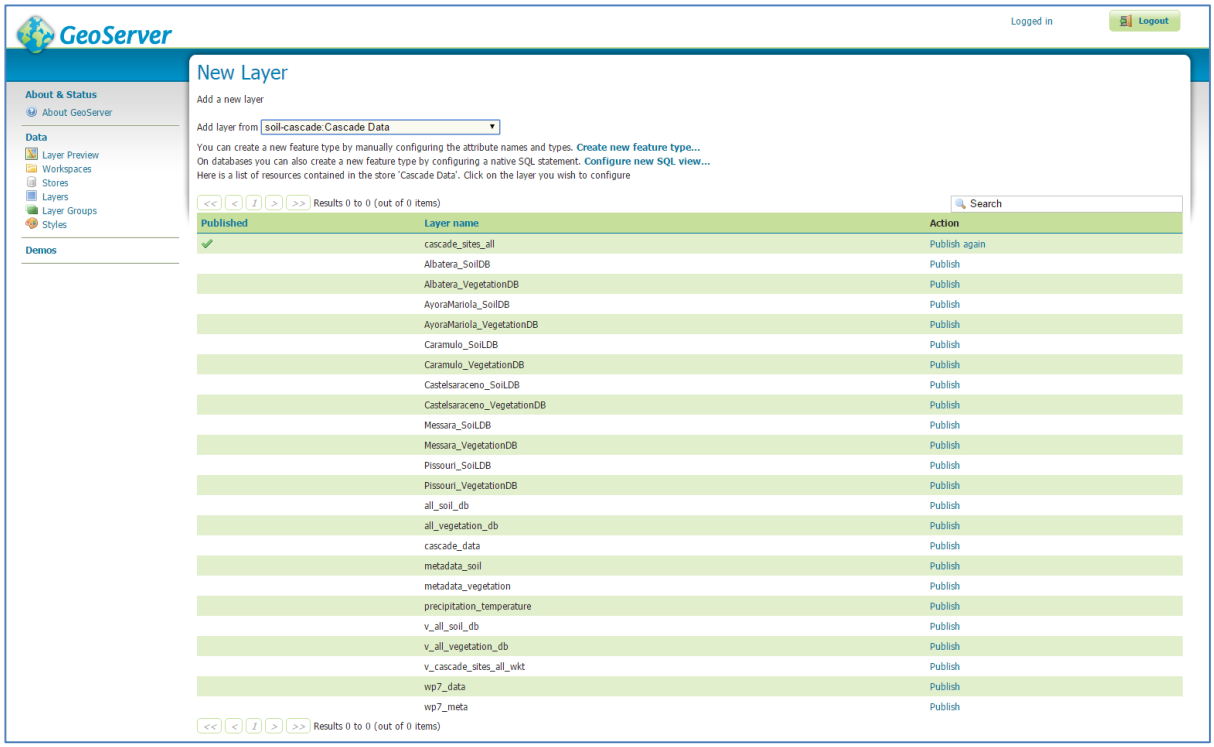


Figure 6. Adding a new layer on Geoserver's Admin Interface

4.1.1.6 Spatial and Not Spatial Relational Databases

CASCADE's spatial and non-spatial data were processed and imported into the ESDAC's Web GIS interface (GeoServer, OpenLayers, PostGIS) and published in the dedicated section of the ESDAC Web Portal. The Project's spatial and non-spatial data are stored in POSTGRESQL and POSTGIS databases (Figure 7, Figure 8).

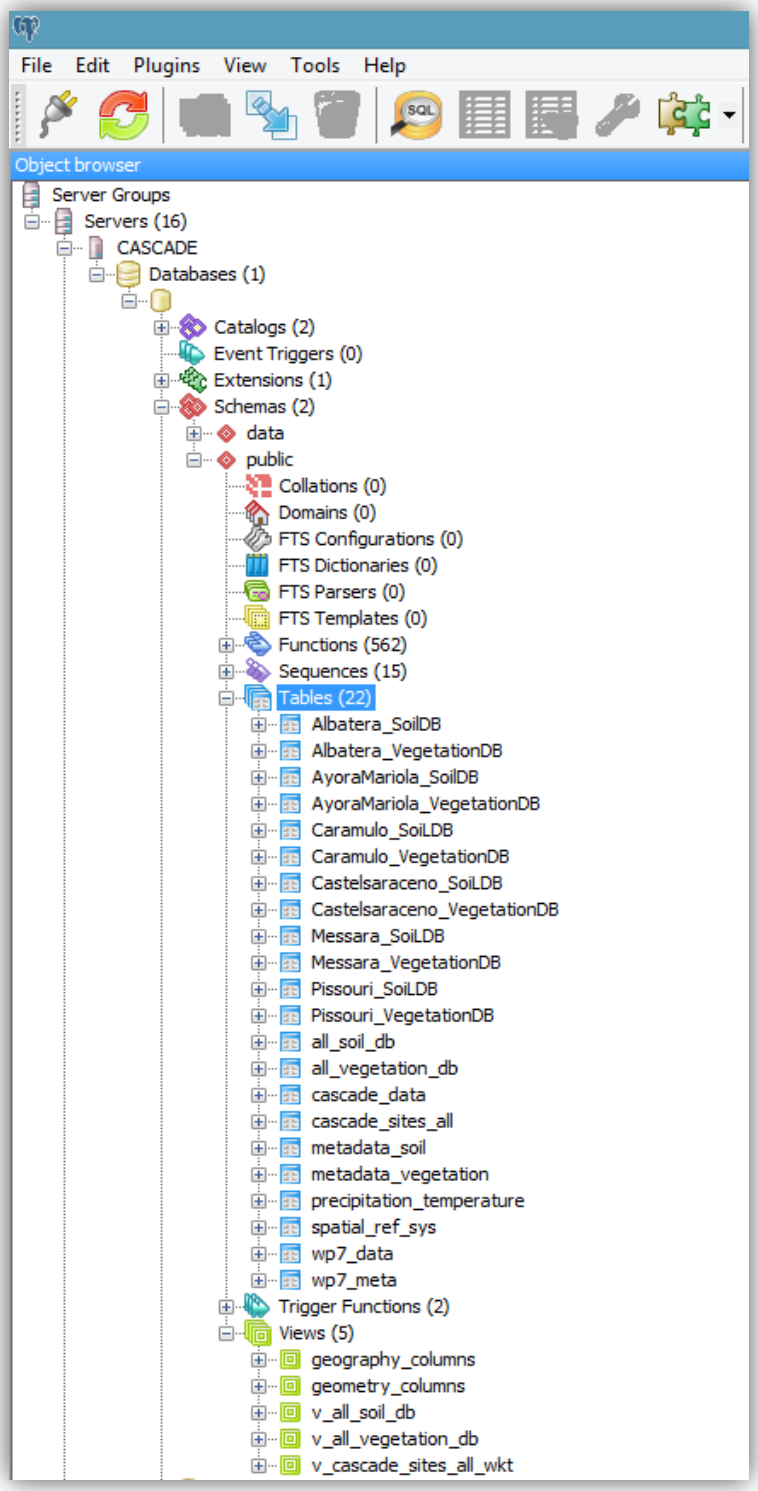
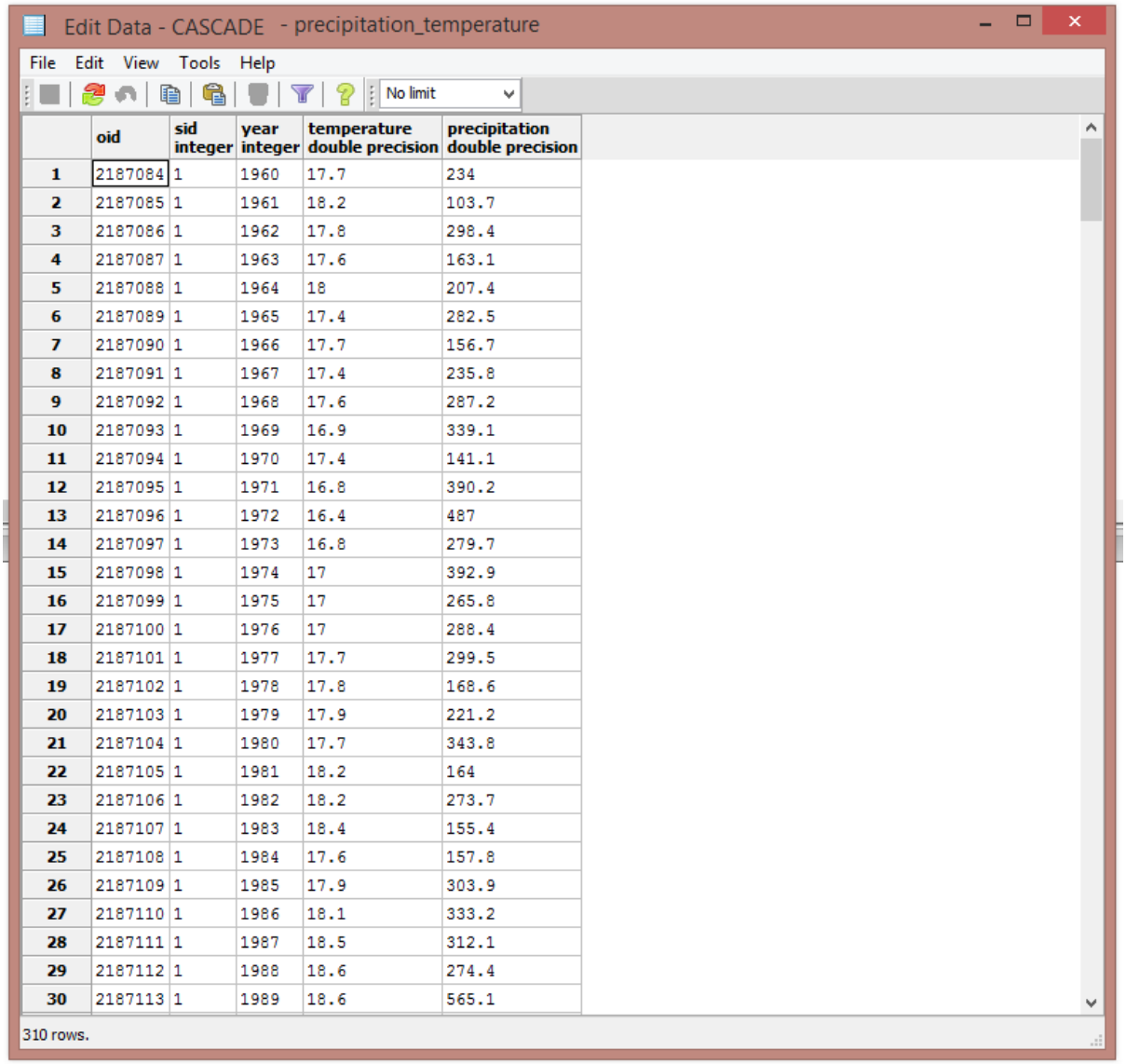


Figure 7. Database structure of the CASCADE Web Services



	oid	sid integer	year integer	temperature double precision	precipitation double precision
1	2187084	1	1960	17.7	234
2	2187085	1	1961	18.2	103.7
3	2187086	1	1962	17.8	298.4
4	2187087	1	1963	17.6	163.1
5	2187088	1	1964	18	207.4
6	2187089	1	1965	17.4	282.5
7	2187090	1	1966	17.7	156.7
8	2187091	1	1967	17.4	235.8
9	2187092	1	1968	17.6	287.2
10	2187093	1	1969	16.9	339.1
11	2187094	1	1970	17.4	141.1
12	2187095	1	1971	16.8	390.2
13	2187096	1	1972	16.4	487
14	2187097	1	1973	16.8	279.7
15	2187098	1	1974	17	392.9
16	2187099	1	1975	17	265.8
17	2187100	1	1976	17	288.4
18	2187101	1	1977	17.7	299.5
19	2187102	1	1978	17.8	168.6
20	2187103	1	1979	17.9	221.2
21	2187104	1	1980	17.7	343.8
22	2187105	1	1981	18.2	164
23	2187106	1	1982	18.2	273.7
24	2187107	1	1983	18.4	155.4
25	2187108	1	1984	17.6	157.8
26	2187109	1	1985	17.9	303.9
27	2187110	1	1986	18.1	333.2
28	2187111	1	1987	18.5	312.1
29	2187112	1	1988	18.6	274.4
30	2187113	1	1989	18.6	565.1

310 rows.

Figure 8. Table View (CASCADE Climate Data)

PostgreSQL

PostgreSQL is an object-relational database management system (ORDBMS) based on POSTGRES, Version 4.21, developed at the University of California at Berkeley Computer Science Department. POSTGRES pioneered many concepts that only became available in some commercial database systems much later.

PostgreSQL is an open-source descendant of this original Berkeley code. It supports a large part of the SQL standard and offers many modern features:

- complex queries
- foreign keys
- triggers
- updatable views

• transactional integrity

• multiversion concurrency control

Also, PostgreSQL can be extended by the user in many ways, for example by adding new

• data types

• functions

• operators

• aggregate functions

• index methods

• procedural languages

And because of the liberal license, PostgreSQL can be used, modified, and distributed by anyone free of charge for any purpose, be it private, commercial, or academic.

Technical documentation could be found at https://wiki.postgresql.org/wiki/Main_Page

PostgreSQL administration and development tool: pgAdmin

"pgAdmin" is the most popular and feature rich Open Source administration and development platform for PostgreSQL, the most advanced Open Source database in the world. The application may be used on Linux, FreeBSD, Solaris, Mac OSX and Windows platforms to manage PostgreSQL 7.3 and above running on any platform, as well as commercial and derived versions of PostgreSQL such as Postgres Plus Advanced Server and Greenplum database.

pgAdmin is developed by a community of PostgreSQL experts around the world and is available in more than a dozen languages. It is Free Software released under the PostgreSQL License.

PostGIS

PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. In addition to basic location awareness, PostGIS offers many features rarely found in other competing spatial databases such as Oracle Locator/Spatial and SQL Server. Refer to PostGIS Feature List for more details. PostGIS is released under the GNU General Public License (GPLv2). Refer to License FAQ for more information. PostGIS is developed by a group of contributors led by a Project Steering Committee.

Documentation: http://postgis.net/documentation/

4.2 Frontend

The CASCADE data services is the part of the ESDAC Portal (European Soil Data Centre) (Figure 9) and has a dedicated section which is accessible from the portal's navigation menu. The end user interface to the CASCADE Data Services hosts the project data in 3 data formats

- Geo-spatial files which presents the study site locations and the borders.
- Non-spatial data tables show tabulated climate, soil, vegetation and WP7 data.
- Static files which are the downloadable static contents including .pdf reports and .csv files for non-spatial tables.

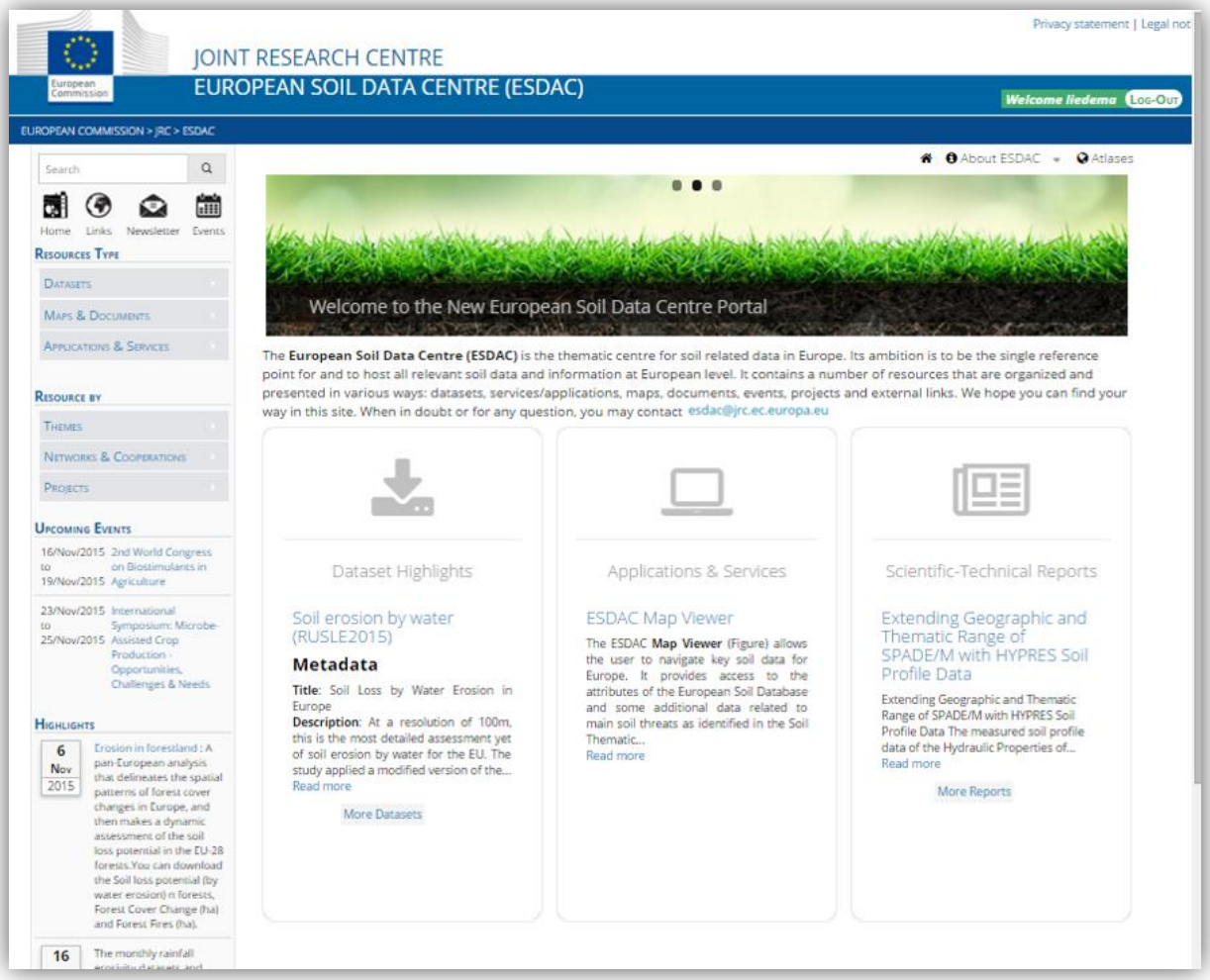


Figure 9. European Soil Data Centre Main Page

4.2.1 Website Access

The Project's pages and the data are password protected and meant to be accessed only by the project partners and system administrators. The users should register on the European Commission Authentication Service website (EU Login) and authorised by the

ESDAC's system administrator to gain the access. EU Login is the European Commission's user authentication service. It allows authorised users to access a wide range of Commission web services, using a single email address and password. Authorised user can login into the project webpage using their EU Login accounts (Figure 10).

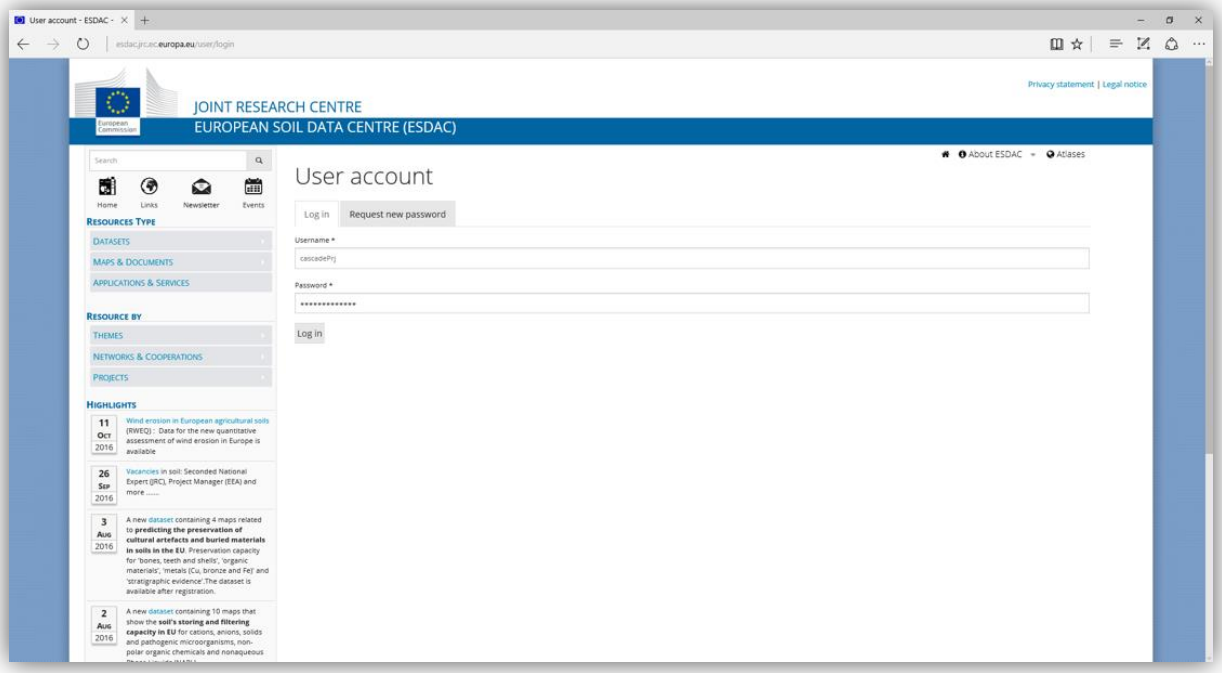


Figure 10. CASCADE Web Login Page

4.2.2 Spatial Data

As mentioned in Data Collection and Data Processing section, study site locations and the polygons are served by GeoServer. The following figures show the user interface

4.2.2.1 Study Sites

The following figures show the CASCADE's user interface and the study site locations.

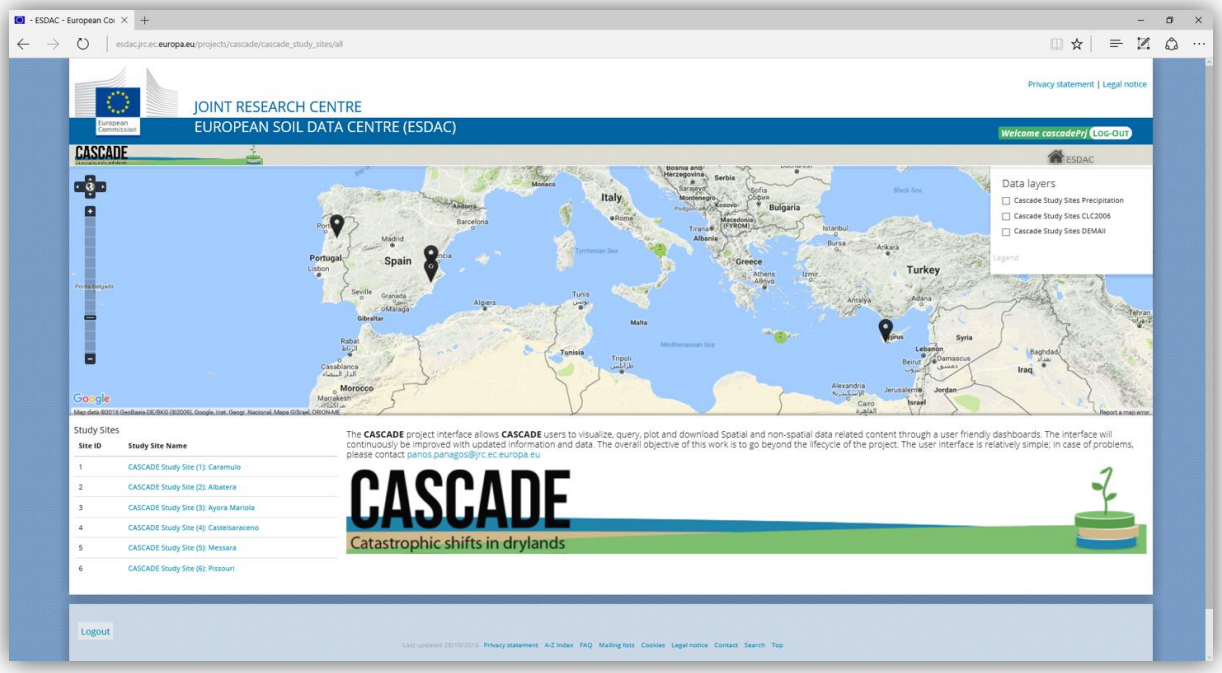


Figure 11. CASCADE Study Sites

The hosted data for the each study site may be accessible from the left menu. Individual study site pages can be seen by clicking on a study site name on the left menu. On the individual site pages, the map automatically zooms to the study site related to the data shown on the page.

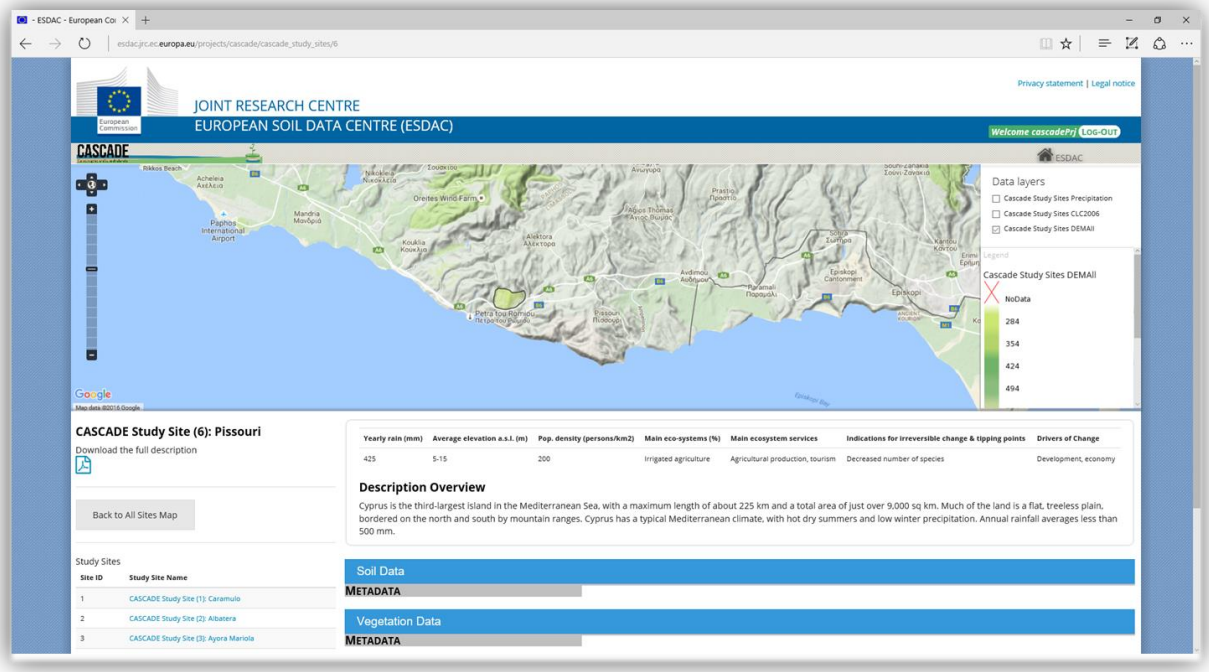


Figure 12. Single study site view

Figure 13. Short Information pop-up for the study sites

The short description of the related study site is shown in a modal-box by clicking the site icon on the map. The pop-up box contains also a link to the full description of the study site as a .pdf file (Figure 13).

4.2.2.2 General Site Characteristics

Land cover and elevation layers were prepared to present two main characteristics of the study sites. The land cover classes and the raster files derived from CORINE 2006 and CORINE 2000. The CORINE Land Cover (CLC) inventory was initiated in 1985. Updates have been produced in 2000, 2006, and 2012. It consists of an inventory of land cover in 44 classes. The elevation data were extracted from EU DEM. The EU-DEM is a 3D raster dataset with elevations captured at 1 arc-second (about 30 metres).

Both of the datasets are provided by the European Environment Agency. The land cover and elevation layers are exported in .geotiff format, styled with OpenLayers and served by GeoServer. (Figure 14).

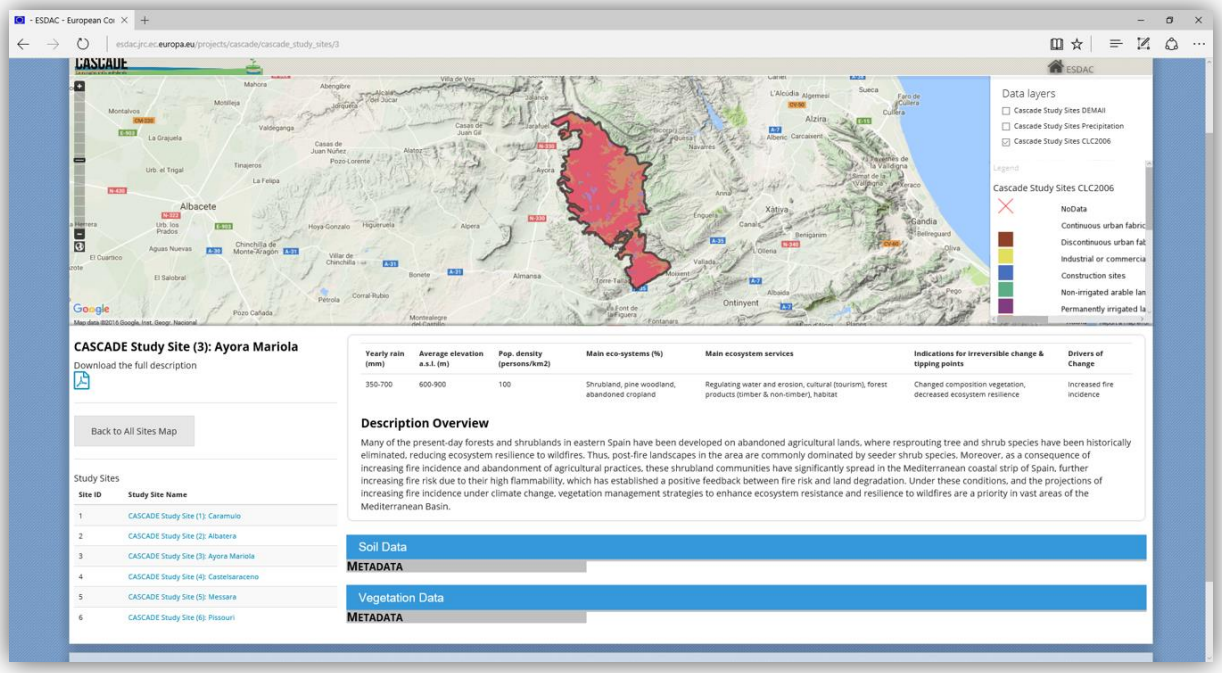


Figure 14. Land cover view of one of the study sites

4.2.3 Non-Spatial Data

Non-spatial data are the data tables and the static downloadable files hosted in the ESDAC Portal.

4.2.3.1 Soil and Vegetation Data tables

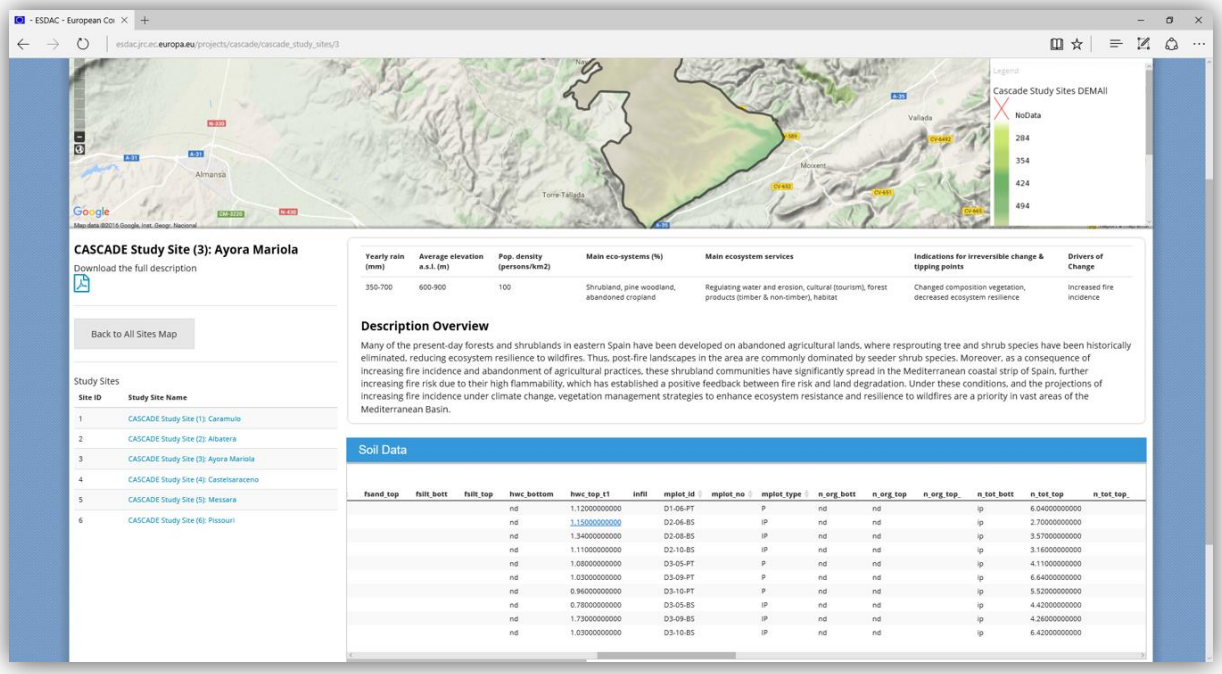


Figure 15. Table view of the Soil Data

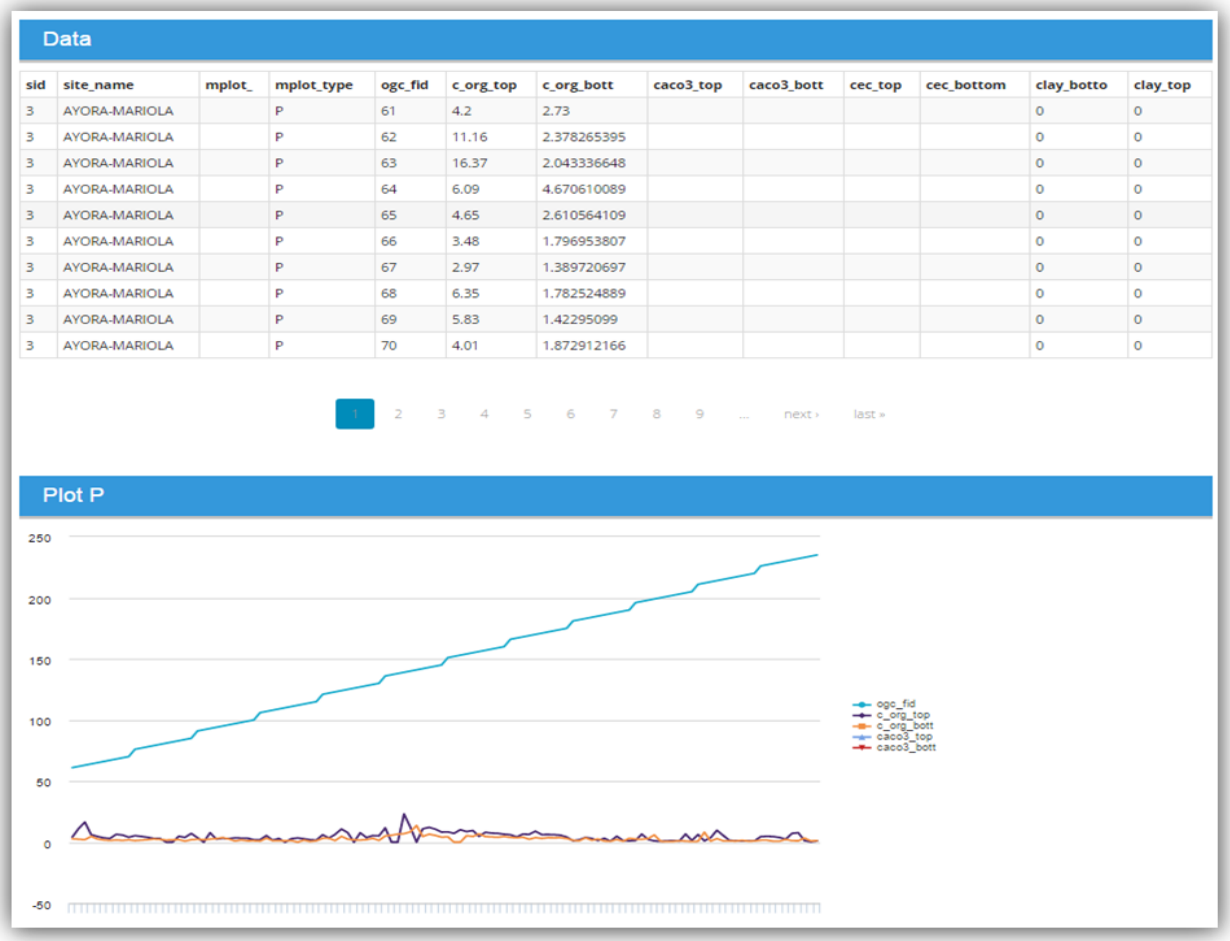


Figure 16. Table and plot view of the soil data

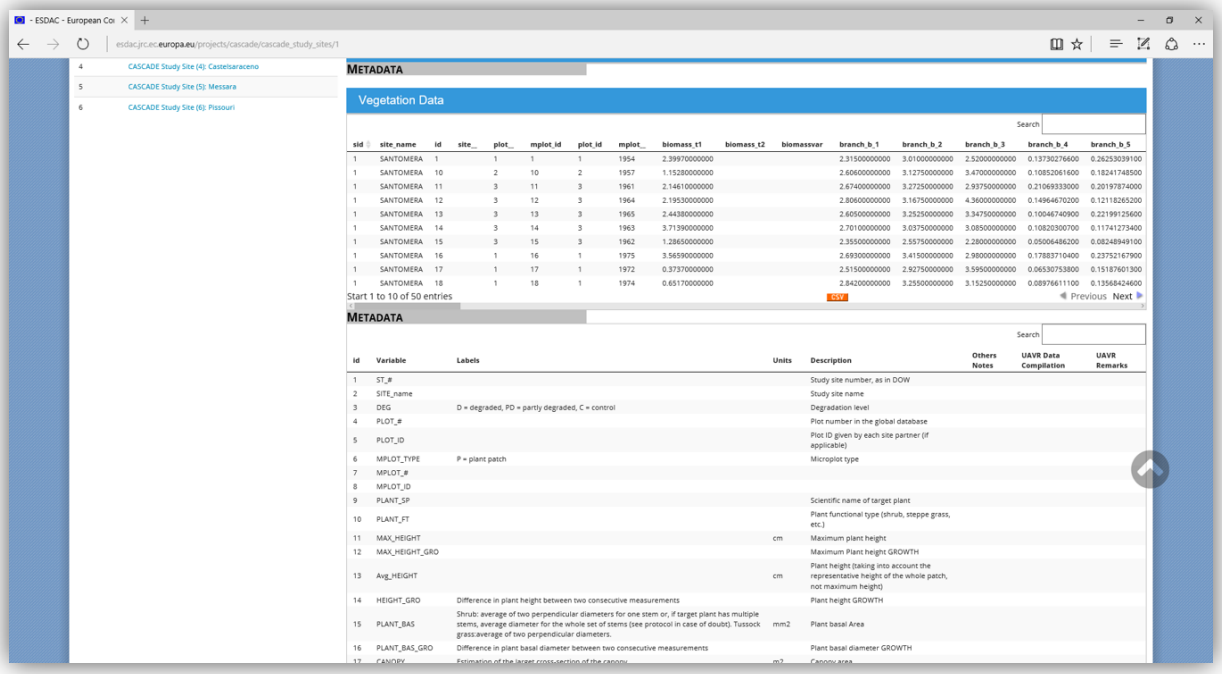


Figure 17. Table view of the vegetation data and the metadata

4.2.3.2 Climate Data

The climatic parameters (annual total precipitation and annual mean temperature) are presented as expandable tables together with the soil and vegetation data. The precipitation and the temperature records are also plotted for the period between the years 1960 – 2011 (for most of the sites) for visual examination.

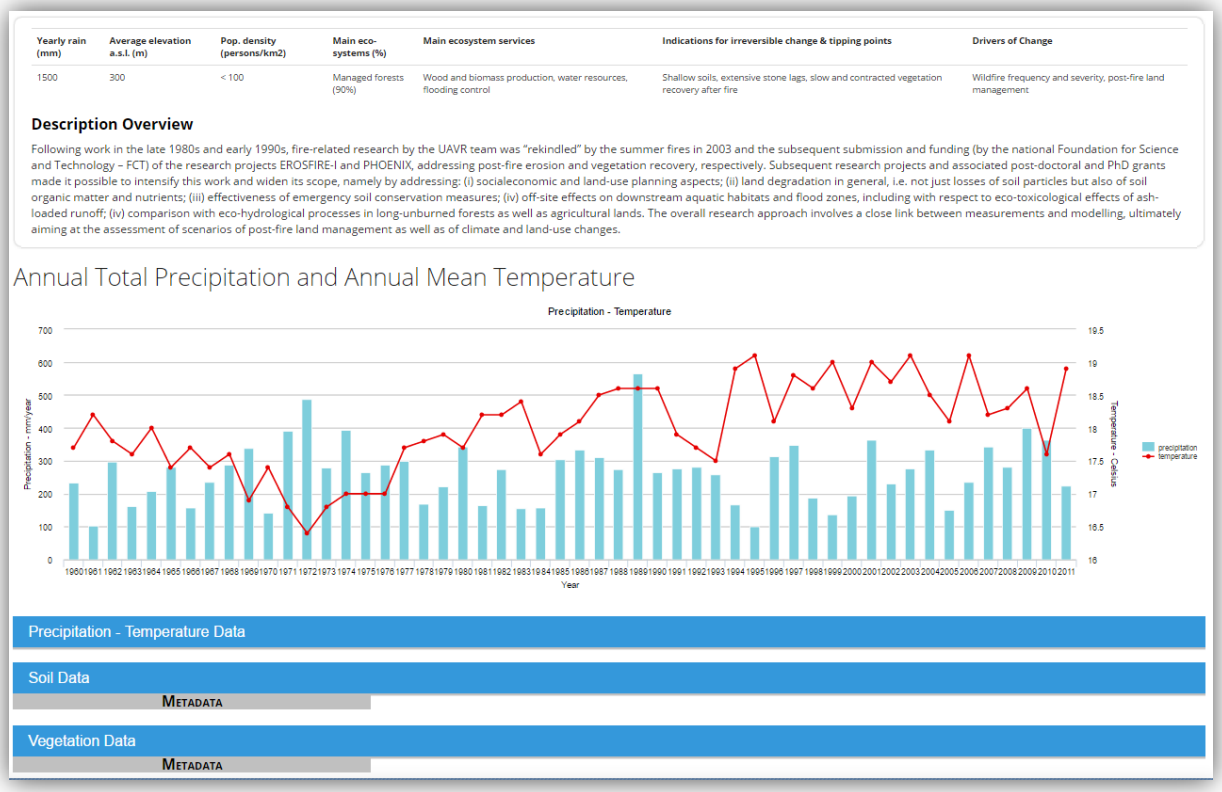


Figure 18. Climate data and the plots for annual total precipitation and annual mean temperature.

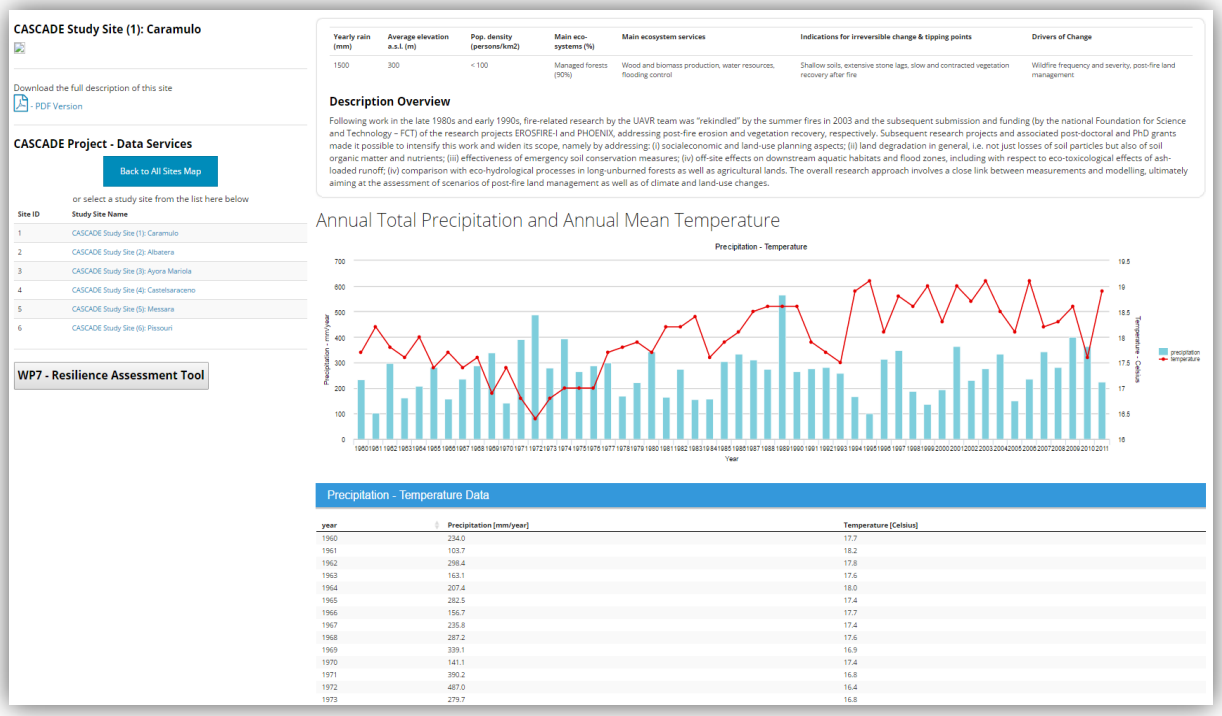


Figure 19. Table and plot view of the climate data

4.2.3.3 WP7 - Resilience Tool Data

This questionnaire is meant to evaluate the state and the resilience of a land management system defined as an area under a unique combination of management practices implemented for a specific objective. The study was conducted in all the project study sites. The WP7's Resilience tool data also hosted as sortable and searchable tables as shown in the Figures 20 and 21. The system allows users to sort the certain columns and to filter the results by keyword search.

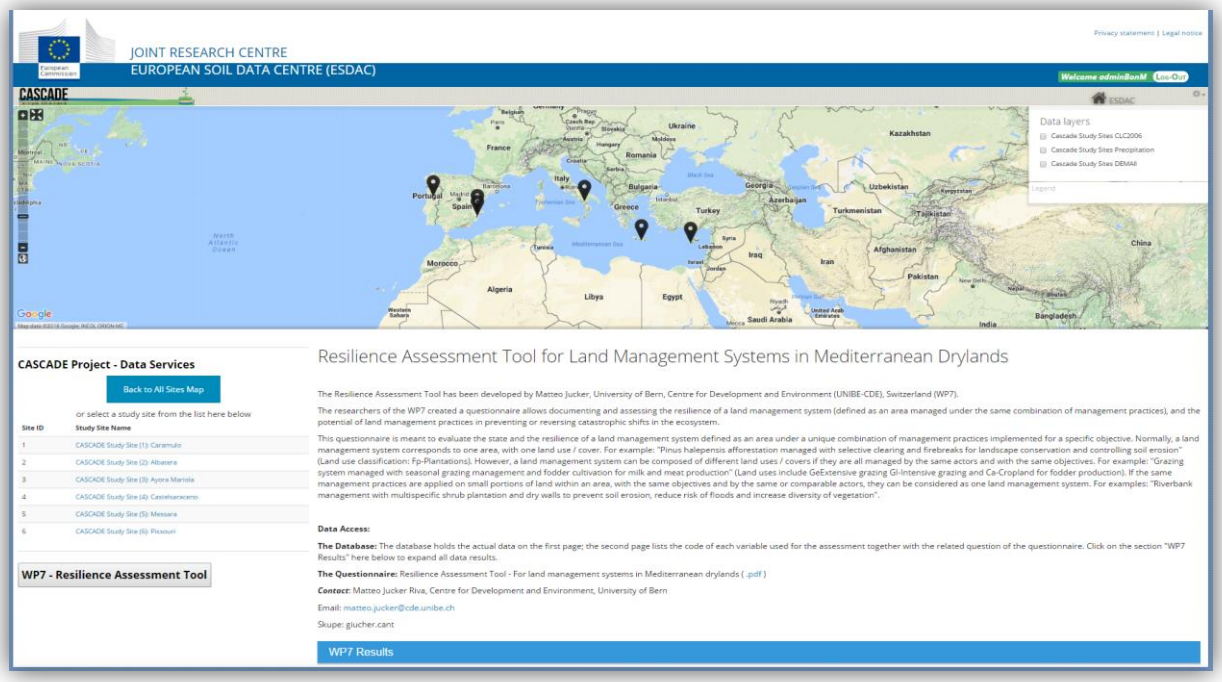
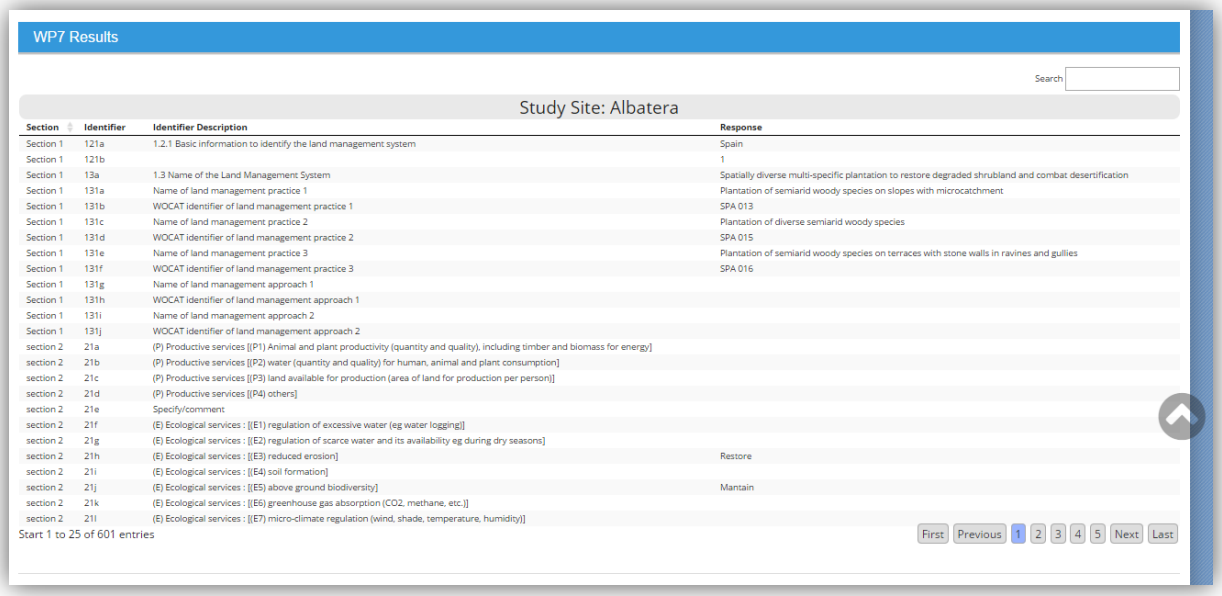


Figure 20. Introduction page of the WP7, Resilience Assessment Tool



Section	Identifier	Identifier Description	Response
Section 1	121a	1.2.1 Basic information to identify the land management system	Spain
Section 1	121b		1
Section 1	13a	1.3 Name of the Land Management System	Spatially diverse multi-specific plantation to restore degraded shrubland and combat desertification
Section 1	131a	Name of land management practice 1	Plantation of semiarid woody species on slopes with microcatchment
Section 1	131b	WOCAT identifier of land management practice 1	SPA 013
Section 1	131c	Name of land management practice 2	Plantation of diverse semiarid woody species
Section 1	131d	WOCAT identifier of land management practice 2	SPA 015
Section 1	131e	Name of land management practice 3	Plantation of semiarid woody species on terraces with stone walls in ravines and gullies
Section 1	131f	WOCAT identifier of land management practice 3	SPA 016
Section 1	131g	Name of land management approach 1	
Section 1	131h	WOCAT identifier of land management approach 1	
Section 1	131i	Name of land management approach 2	
Section 1	131j	WOCAT identifier of land management approach 2	
section 2	21a	(P) Productive services [(P1) Animal and plant productivity (quantity and quality), including timber and biomass for energy]	
section 2	21b	(P) Productive services [(P2) water (quantity and quality) for human, animal and plant consumption]	
section 2	21c	(P) Productive services [(P3) land available for production (area of land for production per person)]	
section 2	21d	(P) Productive services [(P4) others]	
section 2	21e	Specify/comment	
section 2	21f	(E) Ecological services : [(E1) regulation of excessive water (eg water logging)]	
section 2	21g	(E) Ecological services : [(E2) regulation of scarce water and its availability eg during dry seasons]	
section 2	21h	(E) Ecological services : [(E3) reduced erosion]	Restore
section 2	21i	(E) Ecological services : [(E4) soil formation]	
section 2	21j	(E) Ecological services : [(E5) above ground biodiversity]	Mantain
section 2	21k	(E) Ecological services : [(E6) greenhouse gas absorption (CO2, methane, etc.)]	
section 2	21l	(E) Ecological services : [(E7) micro-climate regulation (wind, shade, temperature, humidity)]	

Figure 21. Table view of the WP7, Resilience Assessment Tool (Variables)

4.2.3.4 Downloadable Files

The project's soil, vegetation and climate data can be downloaded as comma delimited files by clicking on the relevant buttons (Figure 22). And the .pdf documents for the site descriptions and the report can be downloaded by provided html links (Figure 23).

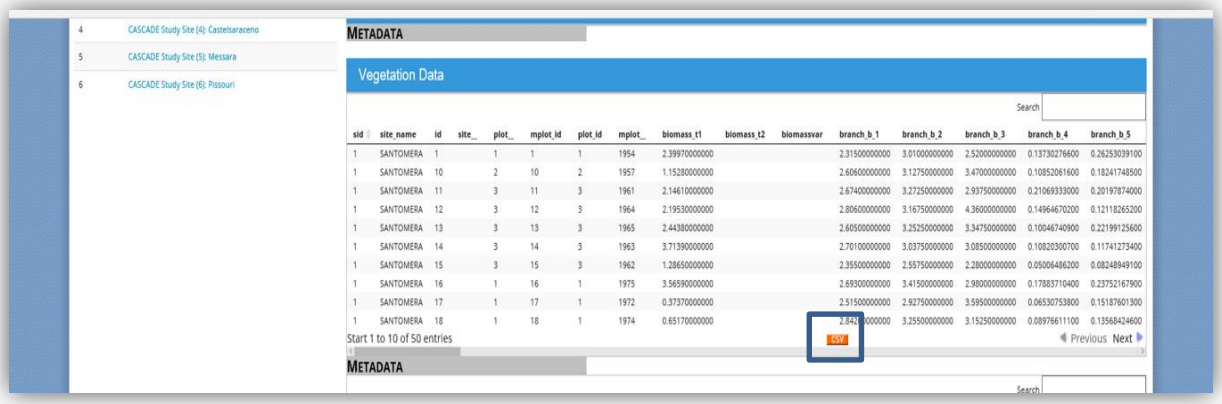


Figure 22. Exporting the tabular data as comma delimited files (.csv)

The field data can be downloaded as comma delimited (.csv) files by clicking on a CSV button placed at the bottom of the each of the Soil/Vegetation tables.

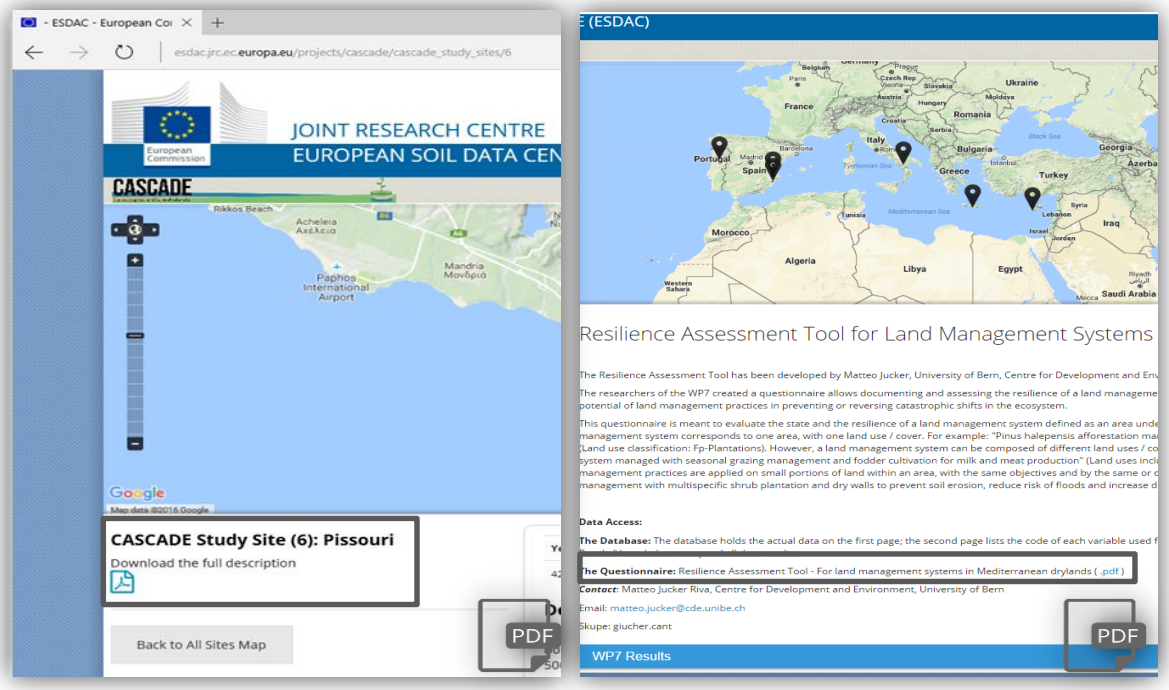


Figure 23. Downloading the static files (.pdf)

5 Conclusions – Outlook

This document presents a 'Cookbook' description for developing and configuring the CASCADE Project Web Services. The portal developed may provide the basis for project, the data collected, processed and provided by the project partners.

This framework consists of a collection of opensource software and tools. These software are free and publicly available on the internet and can be used to create any similar environment to host spatial and non-spatial data. The steps as outlined in this document will aid the process of designing, installing and commissioning a similar data portal. Using open source software and scripts has a great strength of advantage and costs zero at the point of installation. However, users will have to observe how these software are updated and revised, and adapt their systems periodically.

The CASCADE Data Services section of the ESDAC Portal may be accessed via internet directly to access the data sources provided. At this stage, the project data access is limited to the project partners with their EU Login accounts and will be public after acceptance of a data sharing policy among the CASCADE Project Partners.

CASCADE partners will release the project data through the current authentication mechanism applied in ESDAC. CASCADE is one of the FP7 projects which an open data policy is foreseen after the end of the project. ESDAC has a long-term mandate and ensures the data maintenance, distribution and documentation. Through the professional data infrastructure (helpdesk, data distribution, versioning, metadata, security), ESDAC ensures the proper data management of CASCADE and in the future is foreseen to host data from other soil related FP7 and HORIZON2020 projects.

List of abbreviations and definitions

EU – European Union

JRC – Joint Research Centre

ESDAC- European Soil Datacentre

TUC- Technical university of Crete

RHEL- Red Hat for Red Hat Enterprise Linux

HTTP - The Hypertext Transfer Protocol

GNU GPL - The GNU General Public License

OGC - Open Geospatial Consortium

WMS – Web Map Service

WFS – Web Feature Service

ORDBMS - Object-relational Database Management System

CMS - Content Management System

WOCAT - World Overview of Conservation Approaches and Technologies

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doi:10.2760/295510

ISBN 978-92-79-64996-7