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VALIDATED LOCAL RISK ACTIONABLE DATA FOR ADAPTATION



D4.2

Final non-climate data manipulation and visualization tools description

TERRANIS

WP4 - Development of data manipulation tools

The project has received funding from the Horizon Europe Framework Programme under grant agreement No 101112837

Mission call and number

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Start Date of the Project: 1st June 2023
Duration: 36 months

DELIVERABLE REPORT

Deliverable ID	**D4.2**
Deliverable name	**Final non-climate data manipulation and visualization tools description**

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Task	T4.1	Implement ingestion, manipulation and integration tools for multi-source non-climate data

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Contributing beneficiaries	Hereon, HCU, TerraSP, TAKT, ASITIS, CMCC

[1] Dissemination level: **PU** = Public, **PP** = Restricted to other programme participants (including the Commission Services), **RE** = Restricted to a group specified by the consortium (including the Commission Services), **CO** = Confidential, only for members of the consortium (including the Commission Services).

[2] Nature of the deliverable: **R** = Report, **P** = Prototype, **D** = Demonstrator, **O** = Other.

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1. Introduction

1.1 About VALORADA

The EU aims to transform 150 European regions into sustainable and climate resilient regions by 2030. VALORADA contributes to addressing this challenge by co-developing tested FAIR customisable data-manipulation tools to access available climate datasets and to enable the sharing, community validation and use of local socioeconomic, demographic and Earth-Observation data. With a rigorous transdisciplinary approach, the respective risks of climate change are analysed with the local actors in five demonstrators in Europe. Data required for the analysis are compiled from the various already existing repositories (e.g., Copernicus Climate Change Climate Data Store) and locally sourced non-climate data catalogues processed by local communities and regions. The project will co-develop and make available prototype climate data and non-climate data manipulation tools to support and improve existing data portals and platforms and to enable user-oriented multi-data integration.

VALORADA aims to achieve Technology Readiness Levels (TRL) 7 and above. VALORADA's tools will enable the acquisition of different useful climate and non-climate data and make them "interoperable" in terms of metadata, as well as tools able to harmonise the geographical and time references chosen for the data. The "Analyst toolbox" will be composed of software tools able to combine different kinds of data all relevant for assessing climate risks and to calculate resulting indicators. VALORADA will contribute to scaling up to 150 regions through the implementation of dedicated scalability and replicability activities with at least 10 European regions and through strong collaboration with other Horizon projects. Additional activities include capacity-building schemes for end users as well as providers of climate services. VALORADA will explore and assess the options to facilitate the connection of the VALORADA data tools to the Copernicus Atmosphere Data Store.

VALORADA's vision statement: VALORADA wants to empower European regions and cities to steer the upcoming societal transformation towards sustainable and climate-resilient development through their own actions.
VALORADA's mission statement: VALORADA will enable the integration of diverse datasets that enable merging local knowledge with climate and non-climate datasets by means of co-developed data-manipulation tools and climate data.

1.2 Objectives of WP4

• Define and develop multi-source data manipulation tools and make them available and customised to the service providers in charge of the regional demonstrators.
• Define together with WP1, WP2 and with the service providers of WP3, the climate service data which needs specific geographic downscaling, and perform the needed downscaling for the benefit of each service provider of WP3.
• Develop tools for generating a set of indicators combining climate, EO-based and non-climate data for assessing the vulnerability and risks mitigation benefits of the regions
• Assess the maturity level for operationalization with full compliance of the FAIR principles
• Assess the potential integration of the relevant tools into the Climate and Atmosphere Data Store (CADS) and/or other C3S related activities and Climate-ADAPT.

All the tools developed in this WP4 will comply with findability, accessibility, interoperability and reusability as described within the FAIR data principles.

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1.3 Objectives of Task 4.1

Definition of task 4.1: Implement ingestion, manipulation, and integration tools for multi-source non-climate data;

The purpose of this task is to make available a set of services and software tools for manipulating locally sourced socio-economic, demographic and EO data (previously identified with the demonstrators 'local stakeholders) relevant to locally contextualising climate data. This task includes:

• "Populating" the various local datasets into GeoNetwork catalogues, as well as the EO data and Copernicus services available and being of interest for building indicators to inform about climate risks, as identified in the impact climate chains built in WP1. This task involves all the local service providers participating in the demonstrators.

• Making available a set of tools able to handle (in a global approach or in separate steps) the following functions:

- "data ingestion" to get access to the data registered in the metadata catalogues. These tools will allow to ingest the data and images necessary for the relevant areas of interest into a "GeoServer" dedicated to the local area, with a common geographic and time reference, in order to allow easy further manipulation of these different data (optimising data access and data extraction on the time and spatial axis, resampling data).
- "data normalisation" to express the different data (local datasets, EO images and land use maps) into common geographical units (hexagonal grids or local administrative units) allowing further merging and alignment of these data with different spatio-temporal resolutions.
- "data analysis and manipulation" in order to generate indicators values, corresponding to the risks identified by the local stakeholders and described in the climate impact chains, and to the indicators definition issued from WP2.

These tools will be made available by TerraNIS (as WP coordinator) or by the different service providers participating to WP4, either as software suite able to be integrated into the local services providers platforms, or as a "Software as a Service" (SaaS) mode running in the TerraNIS cloud environment and made accessible via APIs.

1.4 Positioning and status of the tools

The previous Deliverable D4.1 presented the set of tools that had been identified during the first phase of the project. This initial phase, conducted through a series of workshops and discussions with local stakeholders from the different demonstration regions, allowed the consortium to identify a range of existing tools developed by project partners (hereafter referred to as proprietary tools). These tools were expected to manipulate the data available in the demonstration regions in order to enable the visualization of key analytical indicators required to contextualize the various climate risks identified locally.

The present Deliverable D4.2 describes the effective implementation of these tools. It specifies which tools were ultimately deployed or further developed, how they were adapted to local environments, and details the indicators and input data required for each tool in each demonstrator. This new version is therefore not on selection principles, but on actual deployment, operational use, and consolidation.

The tools retained and implemented are capable of ingesting multi-source and heterogeneous data, depending on the characteristics and availability of data in each demonstrator. They allow the generation of indicators directly linked to risk and vulnerability components, and, where relevant, the

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normalization of results into units of analysis. This includes the integration of climate data, Earth Observation products, and locally sourced socio-economic or thematic datasets.

All tools are closely connected to the metadata catalogue described in Section 6 of this deliverable. The catalogue gathers metadata records for all indicators and datasets visible in the tools, as well as for the datasets used in indicator calculations. As previously stated, the tools (and associated calculation processes) are designed to ingest heterogeneous and multi-source data. In practice, a single thematic dataset may differ in format, structure, resolution, or source from one demonstrator to another. The metadata catalogue provides detailed and demonstrator-specific information about the exact datasets used in each case. For this reason, throughout this deliverable, whenever a dataset exists in different forms across demonstrators, readers are encouraged to consult the catalogue to obtain precise information on the data effectively used in each regional context.

All tools are grouped and made accessible through a dedicated ArcGIS Online platform in the form of Web Applications and Dashboards. ArcGIS Online is a cloud-based geographic information system platform that enables the hosting, management, visualization, and sharing of geospatial data and interactive applications via web interfaces. The VALORADA ArcGIS Online environment managed by TerraNIS hosts the tools for all demonstrators, with the exception of Greece. The Greek demonstrator is hosted on a separate ArcGIS Online environment managed by TerraSpatium, while remaining technically connected to and accessible from the TerraNIS VALORADA platform.

The tools described in the following sections fall into two categories. First, proprietary tools already existing and operational prior to or at the beginning of the project, owned by project partners. These include tools developed by TerraNIS, Aristotle University of Thessaloniki, and TerraSpatium. These tools are not openly reusable by external users beyond the project framework. Second, tools developed within the VALORADA project by TerraNIS, namely the Flooding, Forest, Protected Area, and Agriculture tools. The tools have reached a quasi-operational level. Their deployment in a new context would only require limited work to understand and integrate the relevant local data. Their potential reuse and transparency are supported by the associated metadata catalogue, which documents input data, methodologies, and indicator definitions.

The current configuration of the tools is the result of the second demonstration phase, which began in mid-2025 following the local data collection phase and the integration of these datasets into the respective tools. This was followed by an evaluation phase, including Assignment 1 at the end of 2025, during which feedback from local stakeholders in each demonstrator was gathered and analyzed. The tools were subsequently refined and improved based on this feedback.

The availability of the tools across the different demonstrators was defined during the Implementation workshops held at the end of 2024. During these workshops, local stakeholders selected the indicators (and then corresponding tools) of interest for their territory, based on their specific climate risk context and local priorities. As a result, the tools were deployed only in the demonstrators that expressed a concrete need for the thematic scope addressed by each tool.

Furthermore, the tools were significantly adapted for each demonstrator. Their final configuration depends on two main factors: the specific indicators selected by local stakeholders and the availability and characteristics of local data. In many cases, differences in data formats, spatial resolution, structure, or completeness strongly influenced the way indicators were calculated and visualized. Consequently, although the tools share a common methodological framework, their implementation and outputs are tailored to each demonstrator, reflecting local priorities and data realities.

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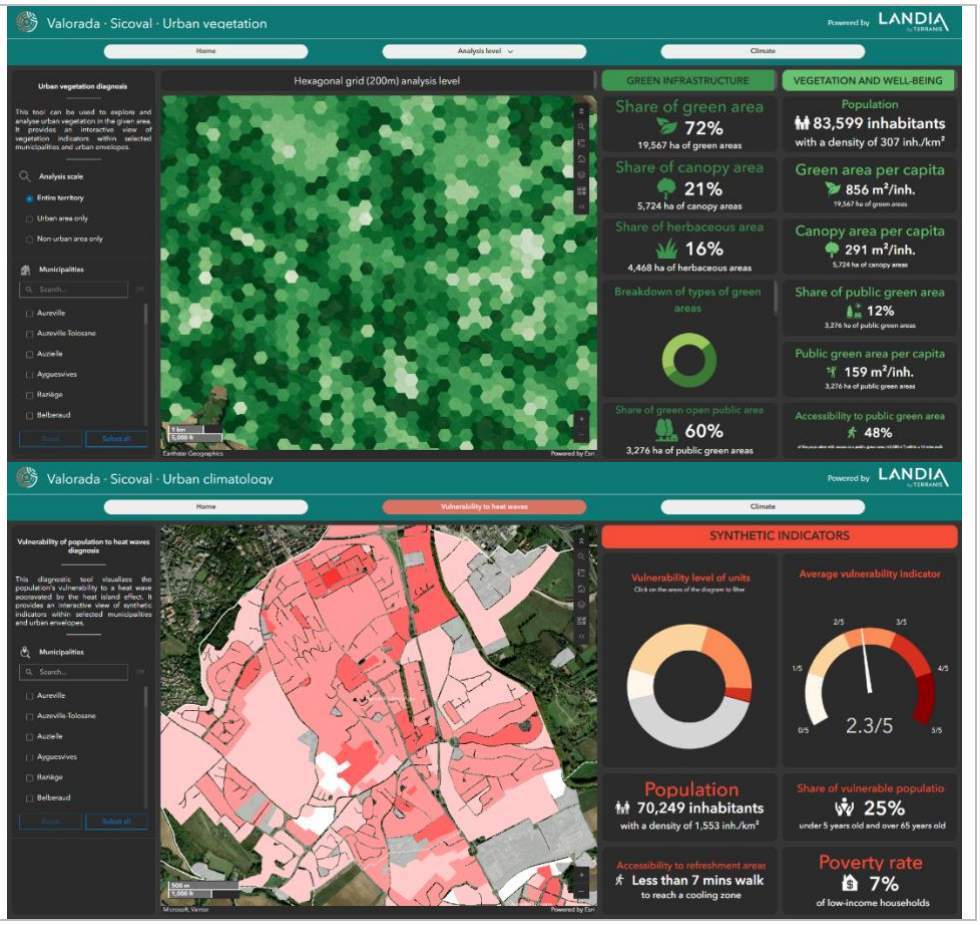
2. TerraNIS' tools

2.1 Tool #1: GreenCity / Landia

TOOL DESCRIPTION

Tool #1	GreenCity / Landia
Description	GreenCity / Landia is an urban vegetation and urban climate observatory dedicated to land use planning. The tool enables the visualization of vegetation cover in cities through a wide range of indicators related to green infrastructure and urban comfort provided by vegetation. It also integrates urban climatology indicators, such as the vulnerability of populations to heat waves. The tool therefore supports urban planners and decision-makers to manage and make informed decisions on their territory.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Share of green area Indicator #2 – Share of canopy area Indicator #3 – Share of herbaceous area Indicator #4 – Share of green open public area Indicator #5 – Green area per capita Indicator #6 – Canopy area per capita Indicator #7 – Herbaceous area per capita Indicator #8 – Share of public green area Indicator #9 – Public green area per capita Indicator #10 – Accessibility to public green area Indicator #11 – Population vulnerability linked to the typomorphology Indicator #12 – Population vulnerability linked to the age of residents Indicator #13 – Population vulnerability linked to the incomes of residents Indicator #14 – Population vulnerability linked to accessibility to cooling areas Indicator #15 – Population vulnerability to heat waves (composite)
Update	~~Automatic~~ / Manual + frequency on demand

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Examples of representation	

INDICATORS DESCRIPTION

Indicator #1	**Share of green area**
Description	Percentage of the surface area of the unit of analysis occupied by vegetation (private and public spaces combined).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification
Frequency	Status based on the most recent available data
Output / Unit	%

Indicator #2	**Share of canopy area**
Description	Percentage of the surface area of the unit of analysis occupied by wooded vegetation (private and public spaces combined) also called canopy index.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification
Frequency	Status based on the most recent available data
Output / Unit	%

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Indicator #3	Share of herbaceous area
Description	Percentage of the surface area of the analysis unit occupied by low vegetation like shrub and grassland (private and public spaces combined).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification
Frequency	Status based on the most recent available data
Output / Unit	%

Indicator #4	Share of green open public area
Description	Percentage of the analysis unit's public open spaces occupied by vegetation.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces
Frequency	Status based on the most recent available data
Output / Unit	%

Indicator #5	Green area per capita
Description	Average area of green space per inhabitant per analysis unit.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	m²/inh.

Indicator #6	Canopy area per capita
Description	Average area of canopy (surface area of trees seen from the sky) per inhabitant per unit of analysis.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	m²/inh.

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Indicator #7	**Herbaceous area per capita**
Description	Average area of low vegetation space per inhabitant per analysis unit.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	m²/inh.

Indicator #8	**Share of public green area**
Description	Percentage of the surface area of the analysis unit made up of public green spaces.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces
Frequency	Status based on the most recent available data
Output / Unit	%

Indicator #9	**Public green area per capita**
Description	Average area of public green space per inhabitant per analysis unit.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	m²/inh.

Indicator #10	**Accessibility to public green area**
Description	Proportion of the population with access to a relatively large public green space nearby (less than 10 minutes' walk).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces Data #4 – Isochrones
Frequency	Status based on the most recent available data
Output / Unit	% of the population with access to a public green area within a 10 mins walk

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Indicator #11	Population vulnerability linked to the typomorphology
Description	Vulnerability class of the unit of analysis to urban heat islands in relation to the local climate zone class to which it belongs.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #6 – Local Climate Zones (LCZ)
Frequency	Status based on the most recent available data
Output / Unit	Vulnerability level (score from 0 to 5)

Indicator #12	Population vulnerability linked to the age of residents
Description	Vulnerability class of the unit of analysis to urban heat islands in relation to the age of residents. It uses the sub-indicator 'Share of vulnerable population' which is the percentage of population sensitive to heat waves (under 5 and over 65 years old).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	Vulnerability level (score from 0 to 5)

Indicator #13	Population vulnerability linked to the incomes of residents
Description	Vulnerability class of the unit of analysis to urban heat islands in relation to the economic situation of residents. It uses the sub-indicator 'Poverty rate' which is the rate of low-income households (heat wave resilience index).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #5 – Population census and socio-economic data
Frequency	Status based on the most recent available data
Output / Unit	Vulnerability level (score from 0 to 5)

Indicator #14	Population vulnerability linked to accessibility to cooling areas
Description	Vulnerability class of the unit of analysis to urban heat islands in relation to the accessibility of residents to cooling areas (green open spaces, fountains…). It uses isochrones calculations.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces Data #4 – Isochrones
Frequency	Status based on the most recent available data
Output / Unit	Vulnerability level (score from 0 to 5)

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Indicator #15	Population vulnerability to heat waves (composite)
Description	Level of vulnerability of populations to a heat wave aggravated by the potential UHI (urban heat island) effect.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Vegetation mask and classification Data #2 – Open public spaces Data #3 – Green public spaces Data #4 – Isochrones Data #5 – Population census and socio-economic data Data #6 – Local Climate Zones (LCZ)
Frequency	Status based on the most recent available data
Output / Unit	Vulnerability level (score from 0 to 5)

DATA DESCRIPTION

Data #1	Vegetation mask and classification
Description	Geospatial dataset identifying vegetated surfaces within the area of interest and classifying them by vegetation type (e.g., trees, shrubs, grassland). It is typically derived from remote sensing imagery.
Format	Polygon vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #2	Open public spaces
Description	This dataset includes freely accessible open spaces (excluding buildings) within the territory. It comprises: • Public green spaces managed by local authorities, such as parks and public gardens. • Outdoor spaces accessible to everyone, whether publicly or privately owned, including commercial and business areas, cemeteries, university campuses, playgrounds, picnic areas, skate parks, multi-sport courts, and similar facilities. • The public right-of-way, obtained by combining accessible road networks with the inverse of cadastral building footprints, excluding water bodies and major highways.
Format	Polygon vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #3	Green public spaces
Description	This dataset corresponds to the intersection between open public spaces (excluding the road network) and the vegetation mask. It enables the identification and mapping of publicly accessible vegetated areas within the territory.
Format	Polygon vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

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Data #4	Isochrones
Description	Spatial dataset representing areas reachable within a given travel time from a specific location.
Format	Polygon vector layer
Availability	Open
Source	Heterogeneous data - consult metadata

Data #5	Population census and socio-economic data
Description	Statistical dataset providing demographic and socio-economic information for the area of interest, including population, age structure, and income levels.
Format	Grid layer or vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #6	Local Climate Zones (LCZ)
Description	The Local Climate Zone (LCZ) classification is a standardized framework developed by Stewart and Oke (2012) to describe and characterize the physical structure of urban and natural landscapes in a consistent and globally transferable way. The scheme was introduced to address the lack of a universal approach in urban climatology, particularly in studies of the urban heat island effect. The LCZ system comprises 17 distinct classes defined primarily by surface structure (e.g., building height and density, tree height and density) and surface cover characteristics (pervious versus impervious surfaces). Each LCZ represents a homogeneous area at the local scale, typically ranging from several hundred meters to a few kilometers in horizontal extent. This classification provides a robust basis for comparing urban form.
Format	Polygon vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

2.2 Tool #2: Pixagri Territories

TOOL DESCRIPTION

Tool #2	Pixagri Territories
Description	Pixagri Territoires is an agricultural decision-support tool dedicated to land use planning and territorial management. It enables the visualization of crop water demand at the territorial scale under several climate scenarios, providing a clear understanding of potential agricultural water needs across different landscapes and production systems. The tool supports planners, water managers and public decision-makers in designing resilient agricultural systems.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Potential crop water needs
Update	~~Automatic~~ / Manual + frequency on demand

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Example of representation	

INDICATORS DESCRIPTION

Indicator #1	**Potential crop water needs**
Description	The indicator estimates the theoretical water requirements of crops across a territory. It provides a spatialized assessment of agricultural water demand. The estimated water needs depend directly on the types of crops present within the territory. It then reflects the diversity of agricultural practices and production patterns at the territorial scale. In addition to current conditions, the indicator integrates multiple climate scenarios and time horizons to project future water requirements. This makes it possible to compare present and future potential needs, assess the impacts of climate change on agricultural water demand, and support strategic planning for sustainable water resource management.
Type / Technologies	Feature-level indicator / Python scripts for calculation
Input data	Data #1 – Local Land Parcel Identification System Data #2 – Precipitation Data #3 – Evapotranspiration Data #4 – Crop coefficients
Frequency	Annual / Monthly
Output / Unit	Volume of water (m^3)

DATA DESCRIPTION

Data #1	**Local Land Parcel Identification System**
Description	The Local Land Parcel Identification System (LPIS) is a geospatial database used to identify, delineate, and manage agricultural land parcels. It is primarily designed to support the administration and control of agricultural subsidies under the European Union's Common Agricultural Policy (CAP). LPIS contains detailed spatial information on the boundaries, location and type of individual land parcels.
Format	Polygon vector layer
Availability	Open / Local (country dependant)
Source	Heterogeneous data - consult metadata

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Data #2	Precipitation
Description	Mean of daily accumulated precipitation of liquid water equivalent from all phases.
Format	Grid layer
Availability	Open
Source	Copernicus Climate Change Service, ECMWF - ERA5-Land historical data, CORDEX-EUR-11 projected data https://atlas.climate.copernicus.eu/

Data #3	Evapotranspiration
Description	Mean potential evapotranspiration (Hargreaves method, 1985) is the rate at which evapotranspiration would occur under ambient conditions from a uniformly vegetated area when the water supply is not limiting.
Format	Grid layer
Availability	Open
Source	Copernicus Climate Change Service, ECMWF - ERA5-Land historical data, CORDEX-EUR-11 projected data https://atlas.climate.copernicus.eu/

Data #4	Crop coefficients
Description	Crop coefficients (Kc) are agronomic parameters used to estimate crop evapotranspiration by relating crop-specific water demand to reference evapotranspiration (ET_o). The Kc value reflects the crop type and its growth stage, accounting for variations in canopy development and water use over time. A monthly Kc value is required for each crop type identified in the LPIS (Local Land Parcel Identification System).
Format	Table
Availability	Local
Source	Heterogeneous data - consult metadata

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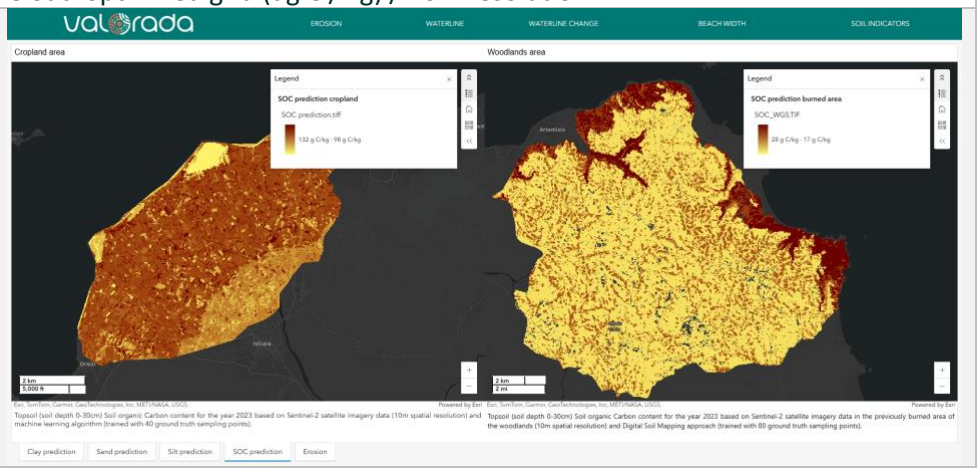
3. Aristotle University of Thessaloniki's tools

3.1 Tool #1: Land Degradation

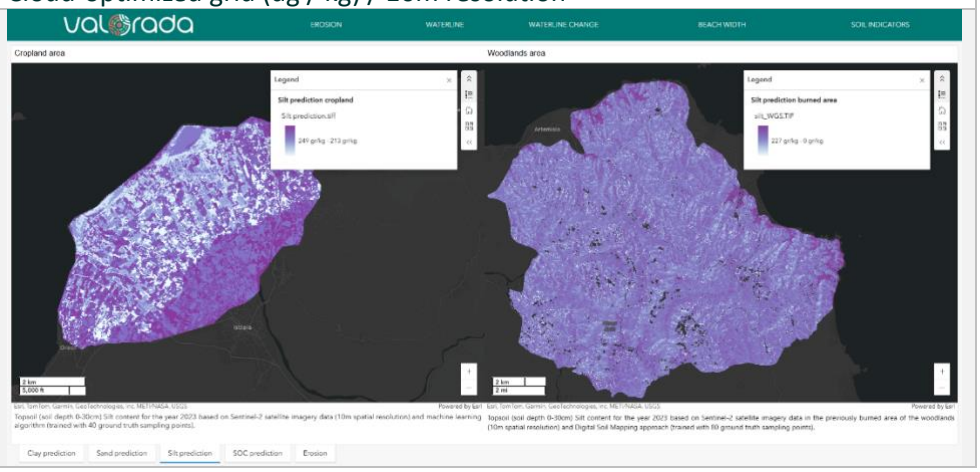
TOOL DESCRIPTION

Tool #1	Land Degradation
Description	Land Degradation is a monitoring system for specific (climate risk indicators) soil spatial explicit indicators. The tool could offer various geospatial outputs of soil erosion, SOC and soil texture, thus providing valuable information for decision-making and planning supporting the actual actors involved.
Type / Technologies	Grid or vector layer implemented into ArcGIS Online WebApplication/Dashboard / Open Data Cube
Output / Indicators	Indicator #1 – Soil organic Carbon (SOC) Indicator #2 – Soil texture (sand, silt, clay %) Indicator #3 – Soil erosion
Update	Automatic / Manual + frequency on demand

INDICATORS DESCRIPTION

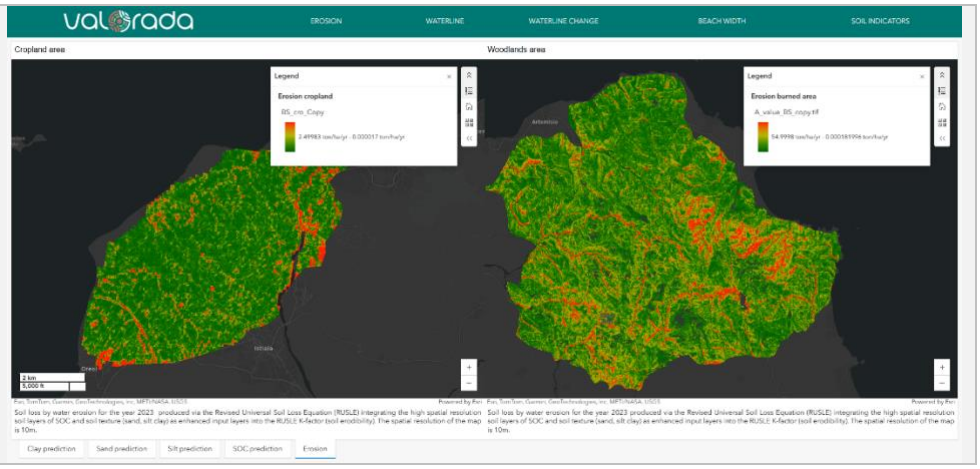
Indicator #1	Soil organic Carbon (SOC)
Description	Map of topsoil SOC content in croplands generated from multi-annual Copernicus multi-spectral data via digital soil mapping approaches.
Type / Technologies	Python and Google Earth Engine scripts
Input data	Data #1 – Sentinel-2 multi-temporal data Data #2 – Reference in situ soil data (SOC and texture values) in the area
Frequency	Annual product
Output / Unit	Cloud-optimized grid (dg C / kg) / 10m resolution
Example of representation	

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Indicator #2	**Soil texture (sand, silt, clay %)**
Description	Maps of topsoil soil texture (sand, silt, clay %) developed from multi-annual Copernicus multispectral data via digital soil mapping approaches.
Type / Technologies	Python and Google Earth Engine scripts
Input data	Data #1 – Sentinel-2 multi-temporal data Data #2 – Reference in situ soil data (SOC and texture values) in the area
Frequency	Annual product
Output / Unit	Cloud-optimized grid (dg / kg) / 10m resolution
Example of representation	

Indicator #3	**Soil erosion**
Description	Soil erosion map for cropland and woodland areas generated with the RUSLE equation.
Type / Technologies	Python and Google Earth Engine scripts
Input data	Data #1 – Sentinel-2 multi-temporal data Data #4 – MODIS multi-temporal data Data #5 – EU-DEM v1.1 Data #6 – OpenLandMap Precipitation Monthly Data #7 – ESA WorldCover Data #8 – European Support Practices factor (P-factor)
Frequency	Annual product
Output / Unit	Cloud-optimized grid (ton/ha/yr) / 10m resolution for croplands, 250m resolution for woodlands

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Example of representation	

DATA DESCRIPTION

Data #1	**Sentinel-2 multi-temporal data**
Description	Earth observation data from satellite constellation of Copernicus.
Spatial coverage	World
Spatial resolution	10m / 20m / 60m
Time period	Since 2017
Temporal resolution	3 to 5 days
Format	Grid layer JPEG2000
Availability	Open
Source	ESA / Copernicus

Data #2	**Reference in situ soil data (SOC and texture values) in the area**
Description	Point data with reference SOC and soil texture (sand, silt, clay) values. The soil properties area measured analytically in a chemical laboratory from the soil samples collected from the area. For VALORADA, a total number of 120 samples successfully collected (40 from croplands and 80 from woodlands).
Spatial coverage	Extent of area to be mapped, spanning part of Northern Evia, Greece
Spatial resolution	N/A
Time period	2023
Temporal resolution	On demand
Format	Table or vector layer
Availability	Local
Source	AUTh

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Data #3	Land Use and Coverage Area frame Survey (LUCAS)
Description	Topsoil point
Spatial coverage	European
Spatial resolution	Point
Time period	2009, 2015, 2018
Temporal resolution	Every 3 years
Format	Table or vector layer
Availability	Open
Source	EUROSTAT

Data #4	MODIS multi-temporal data
Description	Earth Observation data from NASA's MODIS satellite.
Spatial coverage	World
Spatial resolution	250 m / 500m / 1000m
Time period	Since 1999
Temporal resolution	16 days
Format	Grid layer
Availability	Open
Source	NASA

Data #5	EU-DEM v1.1
Description	Digital Elevation Model
Spatial coverage	Pan-European
Spatial resolution	25m
Time period	Since 2016
Temporal resolution	3 years
Format	Grid layer
Availability	Open
Source	ESA / Copernicus

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Data #6	OpenLandMap Precipitation Monthly
Description	Monthly precipitation based on SM2RAIN-ASCAT 2007-2018, IMERG, CHELSA Climate, and WorldClim.
Spatial coverage	World
Spatial resolution	1km
Time period	Since 1980
Temporal resolution	Annual
Format	Grid layer
Availability	Open
Source	OpenGeoHUB

Data #7	ESA WorldCover
Description	Land use and land cover maps.
Spatial coverage	World
Spatial resolution	10m
Time period	Since 2020
Temporal resolution	Annual
Format	Grid layer
Availability	Open
Source	ESA

Data #8	European Support Practices factor (P-factor)
Description	European map for support practice factor (P-factor).
Spatial coverage	European
Spatial resolution	100m
Time period	Since 2015
Temporal resolution	Only for 2015
Format	Grid layer
Availability	Open
Source	ESDAC

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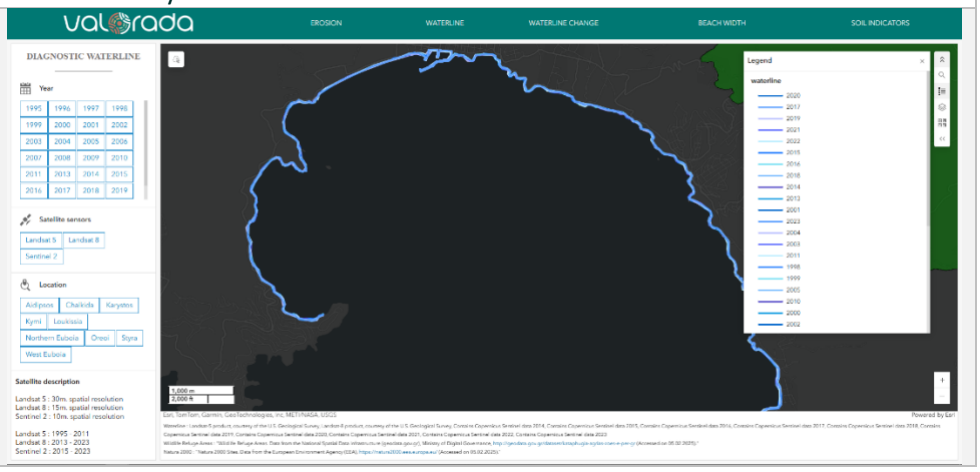
4. TerraSpatium's tools

4.1 Tool #1 : TerraCoast

TOOL DESCRIPTION

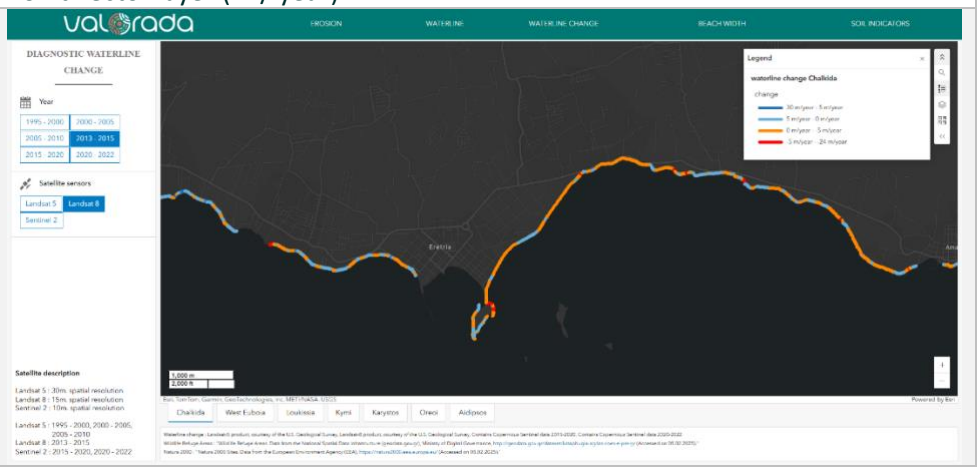
Tool #1	TerraCoast
Description	TerraCoast is a tool dedicated on microtidal coastline monitoring that combines different indicators, aiming at providing a multitemporal retrospective - can cover past 25 years operational picture for coastal managers. Tool is addressing Regions, Municipalities, Natura2000 managers, Coastal Observatories, and Insurance companies.
Type / Technologies	Erdas Imagine, ArcGIS Online WebApplication
Output / Indicators	Indicator #1 – Waterline (WL) Indicator #2 – Waterline Changes (WLC) Indicator #3 – Beach width (BW) Indicator #4 – Coastal vegetation boundary (CVB) Indicator #5 – Sea Level Rise Impact (SLRI)
Update	Automatic / Manual + frequency on demand

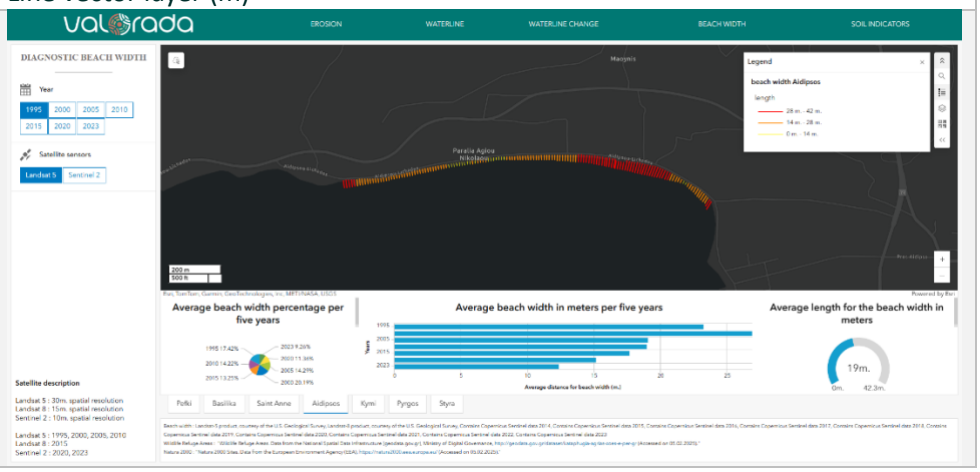
INDICATORS DESCRIPTION

Indicator #1	Waterline (WL)
Description	Waterline is the line between sea and land, or else the sea/land interface.
Type / Technologies	Erdas Imagine Model Builder
Input data	Data #1 – Landsat-5 satellite data Data #2 – Landsat-8 satellite data Data #3 – Sentinel-2 satellite data
Frequency	Annual
Output / Unit	Line vector layer
Example of representation	

Indicator #2	Waterline Changes (WLC)

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Description	It is the indicator that reflects the change of the waterline position between different periods and thus characterize the change on the coastline as erosion or accretion.
Type / Technologies	Erdas Imagine Model Builder
Input data	Data #1 – Landsat-5 satellite data Data #2 – Landsat-8 satellite data Data #3 – Sentinel-2 satellite data ➔ Indicator #1 for a full set of time-series
Frequency	It depends on the time-step of input data/indicator #1
Output / Unit	Point vector layer (m / year)
Example of representation	

Indicator #3	**Beach width (BW)**
Description	Beach width indicator is the indicator that depicts a zone between the waterline and the upper beach limit (upper boundary) which is most of the times fixed between different periods.
Type / Technologies	Erdas Imagine Model Builder
Input data	Data #1 – Landsat-5 satellite data Data #2 – Landsat-8 satellite data Data #3 – Sentinel-2 satellite data Data #4 – Upper boundary of the beach
Frequency	Every 3-5 years
Output / Unit	Line vector layer (m)
Example of representation	

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Indicator #4	Coastal vegetation boundary (CVB)
Description	Costal vegetation boundary is the limit between land and coastal vegetation. This indicator plays a critical role in the deterioration (or not) of coastal habitats.
Type / Technologies	Erdas Imagine Model Builder
Input data	Data #1 – Landsat-5 satellite data Data #2 – Landsat-8 satellite data Data #3 – Sentinel-2 satellite data
Frequency	Every 3-5 years
Output / Unit	Vector layer

Indicator #5	Sea Level Rise Impact (SLRI)
Description	It is the indicator that reflects the loss of land due to the sea level rise future projections. It uses different scenarios for sea level rise.
Type / Technologies	Erdas Imagine Model Builder
Input data	Data #1 – Landsat-5 satellite data Data #2 – Landsat-8 satellite data Data #3 – Sentinel-2 satellite data ➔ Indicator #1 for the most recent year Data #5 – Future projections of the sea level rise Data #6 – Digital Elevation Model
Frequency	It depends on the time-step of input data
Output / Unit	Vector layer

DATA DESCRIPTION

Data #1	Landsat-5 satellite data
Description	Earth observation data from satellites developed under a joint program between the USGS and NASA.
Spatial coverage	World
Spatial resolution	30m
Time period	1995-2013
Temporal resolution	16 days
Format	Grid layer
Availability	Open
Source	NASA

Data #2	Landsat-8 satellite data
Description	Earth observation data from satellites developed under a joint program between the USGS and NASA.
Spatial coverage	World
Spatial resolution	15m
Time period	Since 2013

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Temporal resolution	16 days
Format	Grid layer
Availability	Open
Source	NASA

Data #3	**Sentinel-2 satellite data**
Description	Earth observation data from satellites developed under the Copernicus EU Program.
Spatial coverage	World
Spatial resolution	10m / 20m / 60m
Time period	Since 2017
Temporal resolution	3 to 5 days
Format	Grid layer
Availability	Open
Source	EU – Copernicus Program

Data #4	**Upper boundary of the beach**
Description	It is the fixed (usually) upper boundary of a microtidal sandy beach. It is derived by line extraction from existing large scale ortho-imagery open for the Greek territory.
Spatial coverage	Greece
Spatial resolution	For 1998, 2009 and 2015
Time period	For 1998, 2009 and 2015
Temporal resolution	3 to 5 days
Format	Vector layer
Availability	Open / Local
Source	Open Greek data

Data #5	Future projections of the sea level rise
Description	Future projections of the sea level rise
Format	Grid layer or vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #6	Digital Elevation Model
Description	Digital Elevation Model
Format	Grid layer or vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

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5. VALORADA-specific tools

5.1 Tool #1: Flooding tool

TOOL DESCRIPTION

Tool #1	Flooding tool
Description	This tool provides spatial indicators related to flood exposure and vulnerability within a given territory, supporting risk assessment and resilience planning.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Share of flood risk area Indicator #2 – Share of people living in flood risk area Indicator #3 – Share of properties at risk from flooding Indicator #4 – Share of critical infrastructures in flood risk area
Update	~~Automatic~~ / Manual + frequency on demand
Example of representation	

INDICATORS DESCRIPTION

Indicator #1	Share of flood risk area
Description	Proportion of the total surface area of a city or region that is classified as being at risk of flooding, based on flood hazard maps or modelled flood scenarios.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Flood risk area
Frequency	It depends on the time-step of input data
Output / Unit	%

Indicator #2	Share of people living in flood risk area
Description	Percentage of the total population of a city or region residing within areas identified as flood-prone.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Flood risk area Data #2 – Population census
Frequency	It depends on the time-step of input data
Output / Unit	%

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Indicator #3	Share of properties at risk from flooding
Description	Percentage of the total number of properties within a city or region that are located in flood-prone areas. The indicator may be disaggregated by property type (e.g., residential, commercial, industrial, public buildings).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Flood risk area Data #3 – Buildings
Frequency	It depends on the time-step of input data
Output / Unit	%

Indicator #4	Share of critical infrastructures in flood risk area
Description	Percentage of critical infrastructure assets (e.g., hospitals, schools, emergency services, transport facilities, energy infrastructure) located within flood-prone areas. The indicator may be disaggregated by infrastructure type.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Flood risk area Data #4 – Critical infrastructures
Frequency	It depends on the time-step of input data
Output / Unit	%

DATA DESCRIPTION

Data #1	Flood risk area
Description	Geospatial dataset identifying areas prone to flooding, based on hydrological modelling, historical flood events, or official hazard maps. It provides the spatial extent of flood-prone zones.
Format	Vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #2	Population census
Description	Statistical dataset providing demographic information for the area of interest, including population.
Format	Grid layer or vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

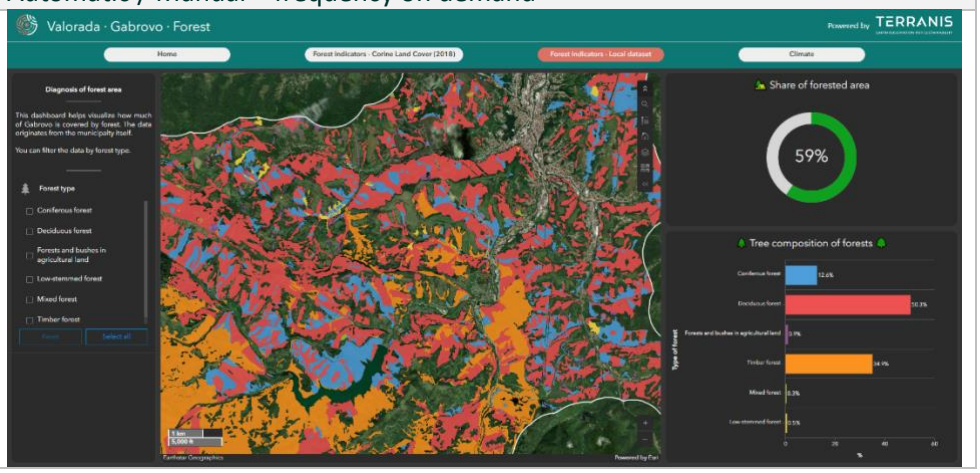
Data #3	Buildings
Description	Spatial dataset containing the location, footprint, and, when available, function of buildings within the territory.
Format	Vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

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Data #4	Critical infrastructures
Description	Geospatial dataset identifying essential facilities and services, such as hospitals, schools, energy and water supply infrastructure, transportation hubs, and emergency services.
Format	Vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

5.2 Tool #2: Forest tool

TOOL DESCRIPTION

Tool #1	Forest tool
Description	This tool delivers indicators on forest cover and composition within a territory, supporting biodiversity monitoring, ecosystem management, and climate-related analyses.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Share of forested area Indicator #2 – Tree composition of forests
Update	~~Automatic~~ / Manual + frequency on demand
Example of representation	

INDICATORS DESCRIPTION

Indicator #1	Share of forested area
Description	Percentage of the total surface area of the unit of analysis that is covered by forests.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Land Cover or forest data
Frequency	It depends on the time-step of input data
Output / Unit	%

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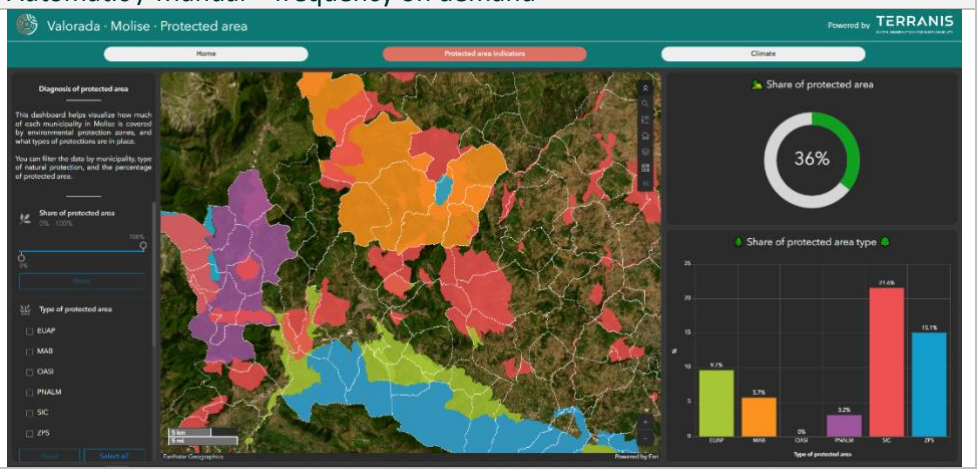
Indicator #2	Tree composition of forests
Description	Percentage distribution of forest area by forest type within the unit of analysis (e.g., broadleaf, coniferous, mixed forests).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Land Cover or forest data
Frequency	It depends on the time-step of input data
Output / Unit	% of each type

DATA DESCRIPTION

Data #1	Land Cover or forest data
Description	Geospatial dataset describing land cover types, including forests. It can either be a dedicated forest dataset with detailed forest type classification (e.g., coniferous, broadleaf, mixed), or a broader land cover dataset with a forest class and subcategories.
Format	Grid layer or vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

5.3 Tool #3: Protected area tool

TOOL DESCRIPTION

Tool #1	Protected area tool
Description	This tool assesses the extent and structure of protected areas within a territory, supporting conservation planning and environmental governance.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Share of protected area Indicator #2 – Share of types of protected area
Update	~~Automatic~~ / Manual + frequency on demand
Example of representation	

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INDICATORS DESCRIPTION

Indicator #1	Share of protected area
Description	Percentage of the total surface area of the unit of analysis designated as protected area under national or international protection schemes.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Protected area data
Frequency	Status based on the most recent available data
Output / Unit	%

Indicator #2	Share of types of protected area
Description	Percentage distribution of protected area by protection category within the unit of analysis (e.g., national parks, nature reserves, Natura 2000 sites).
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Protected area data
Frequency	Status based on the most recent available data
Output / Unit	% of each type

DATA DESCRIPTION

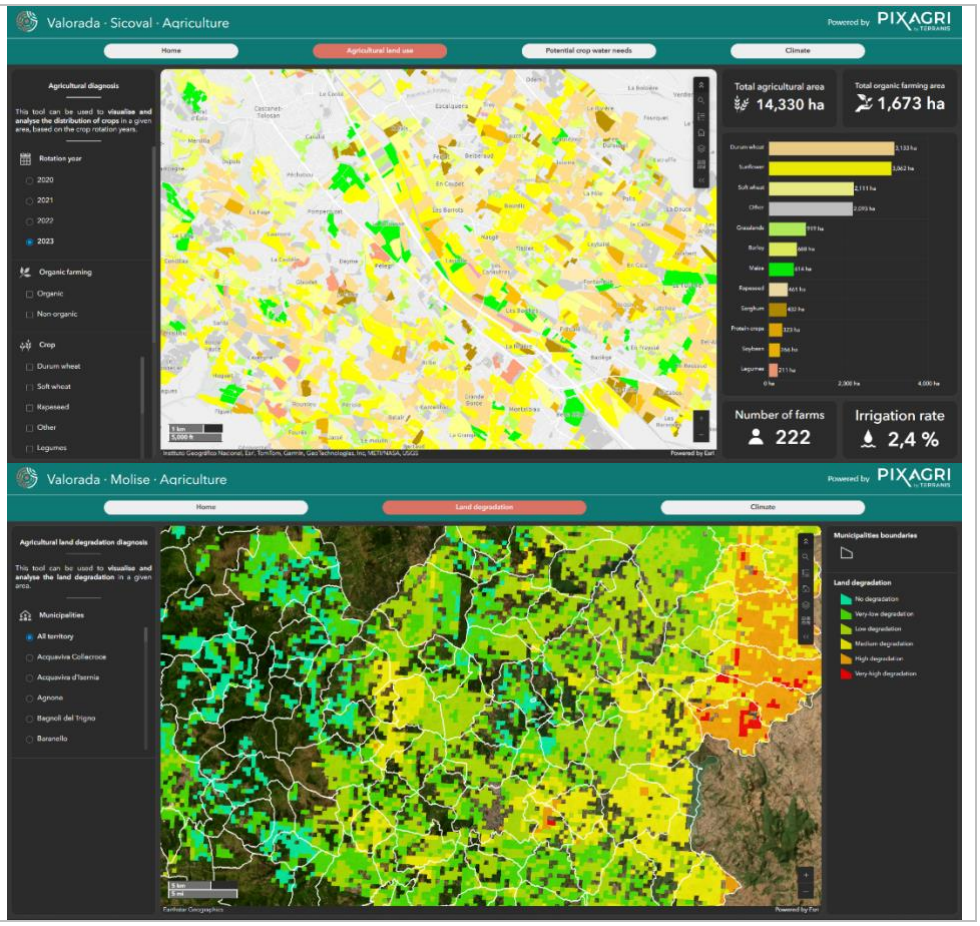
Data #1	Protected area data
Description	Dataset delineating areas designated for conservation, such as national parks, nature reserves, or Natura 2000 sites.
Format	Vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

5.4 Tool #4: Agriculture tool

TOOL DESCRIPTION

Tool #1	Agriculture tool
Description	This tool provides indicators related to agricultural land use and land condition, supporting sustainable land management and food system analysis.
Type / Technologies	ArcGIS Online WebApplication/Dashboard
Output / Indicators	Indicator #1 – Share of agricultural area Indicator #2 – Agricultural land degradation
Update	~~Automatic~~ / Manual + frequency on demand

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Examples of representation	

INDICATORS DESCRIPTION

Indicator #1	**Share of agricultural area**
Description	Percentage of the total surface area of the unit of analysis occupied by agricultural land. When available, the indicator may include a breakdown by crop type expressed as a percentage of total agricultural land.
Type / Technologies	Normalized indicator in a vector-type analysis unit / Python scripts for calculation
Input data	Data #1 – Land Use Land Cover or Local Land Parcel Identification System
Frequency	It depends on the time-step of input data, mostly annual
Output / Unit	%

Indicator #2	**Agricultural land degradation**
Description	The Land Multi-degradation Index (LMI) is an indicator applicable to arable and agricultural land. It is calculated by combining 12 soil degradation processes: water erosion, wind erosion, soil organic carbon loss, soil salinization, soil acidification, soil compaction, soil nutrient imbalances, soil contamination by pesticides, soil contamination by heavy metals, vegetation degradation, groundwater decline, and aridity. It has been made available by the European Soil Data Centre (JRC).
Type / Technologies	Vector-type indicator or grid-type indicator
Input data	Data #2 – Land Degradation in Europe (Land Multi-degradation Index)
Frequency	It depends on the time-step of input data
Output / Unit	Level of degradation (in 6 classes)

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DATA DESCRIPTION

Data #1	Land Use Land Cover or Local Land Parcel Identification System
Description	Geospatial dataset describing land use and land cover. It can either be the LPIS, providing detailed information on agricultural parcels, crop types, and management units, or a more general LULC dataset including agricultural classes.
Format	Vector layer
Availability	Open / Local
Source	Heterogeneous data - consult metadata

Data #2	Land Degradation in Europe (Land Multi-degradation Index)
Description	Dataset providing the Land Multi-degradation Index (LMI) for Europe, integrating 12 soil degradation processes: water and wind erosion, loss of soil organic carbon, salinization, acidification, compaction, nutrient imbalances, contamination by pesticides or heavy metals, vegetation degradation, groundwater decline, and aridity.
Format	Grid layer
Availability	Open
Source	JRC https://esdac.jrc.ec.europa.eu/content/land-degradation-europe

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6. GeoNetwork-based metadata catalogue

A metadata catalogue is a structured repository that stores descriptive information about datasets (including indicators datasets), enabling users to access and understand data efficiently. In the context of VALORADA, the metadata catalogue has been implemented using GeoNetwork, an open-source cataloging system specifically designed for geospatial information. GeoNetwork allows storing, managing, and sharing metadata in a standardized format, supporting interoperability and integration with the developed tools within the project.

In VALORADA, the GeoNetwork catalogue contains two primary types of metadata records:

- Dataset records document the data used in the project, either for the computation of indicators or for direct visualization in the tools. Each dataset record includes a description, keywords, access restrictions under "License and Conditions," lineage (i.e., the source of the data), and general information such as points of contact. Each dataset record is demonstrator-specific, reflecting variations in data sources across regions. For example, the "Population census" dataset is represented as a point vector layer from the Czech Statistical Office for Přerov and Mladá Boleslav, whereas for Gabrovo and Burgas it is represented as an open-source grid layer from the Global Human Settlement Layer of Copernicus Emergency Management Service.
- Indicator records describe the computed indicators available in the tools, also tailored for each demonstrator. Each indicator record contains a description, keywords, access restrictions, general information such as points of contact, and lineage information which links both to the input datasets used for the calculation and their associated metadata records, and a description of the method used to calculate the indicator when it does not come from a proprietary tool.

The metadata catalogue has been designed to comply with the FAIR principles. All records are structured according to the ISO 19115/19139 metadata standards and are INSPIRE-compliant. To support discovery and manipulation, the catalogue uses controlled vocabularies and thesauri represented as keywords, including:

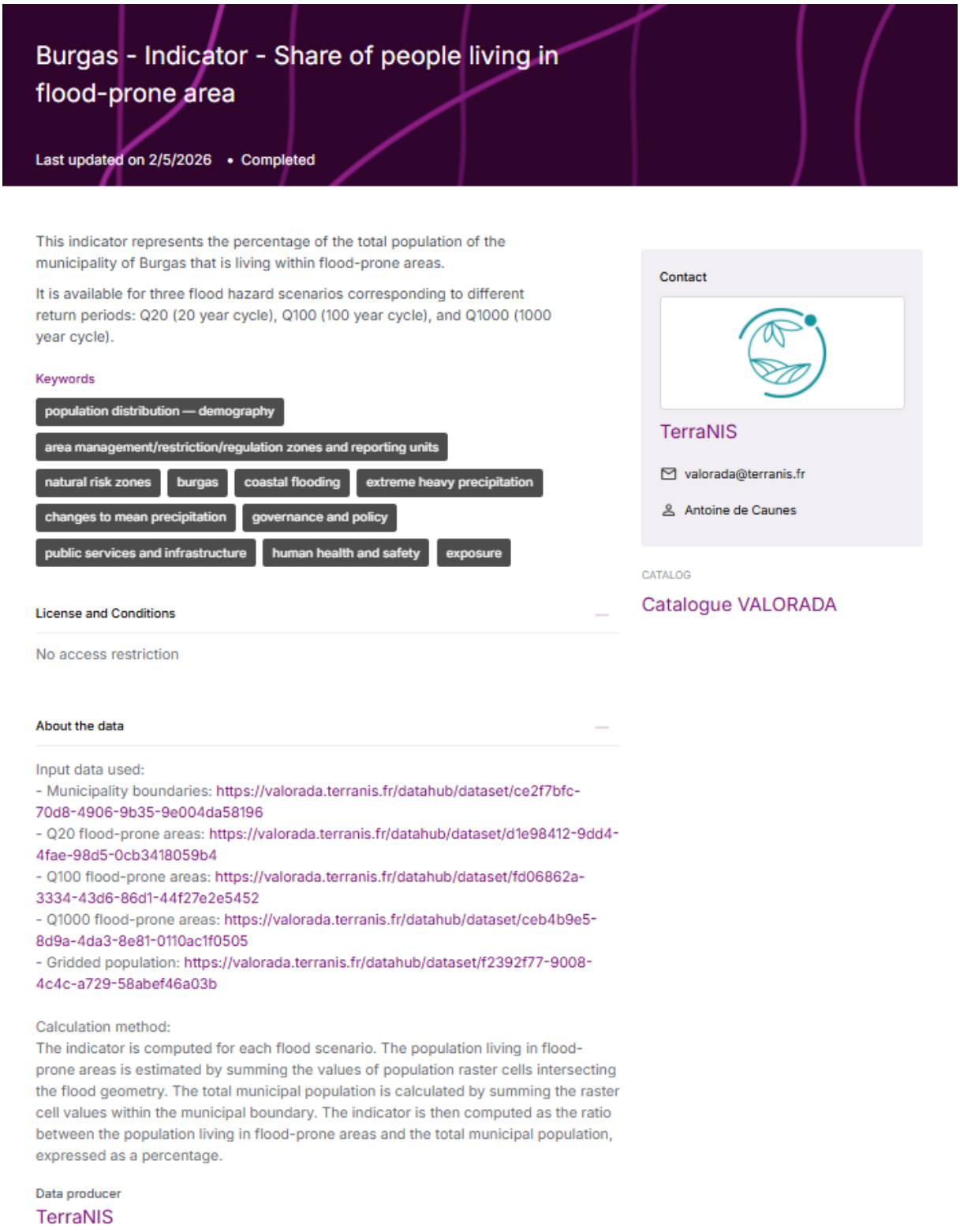
- For both dataset and indicator records:
  - GEMET and INSPIRE themes for general geospatial classification,
  - Demonstrator's name,
- For indicator records:
  - Hazard (Changes to mean precipitation, Coastal erosion, Coastal flooding, Drought, Extreme heat waves, Extreme heavy precipitation, Increase in mean temperatures)
  - Vulnerability component (Adaptive capacity, Exposure, Sensitivity)
  - VALORADA-specific theme (Agriculture, Business and economy, Ecosystem and environment, Governance and policy, Human health and safety, Public services and infrastructure)

This structured approach allows users to locate and understand metadata efficiently, supports consistent use across the regional demonstrators, and facilitates reuse of both datasets and indicators for further studies or applications.

The GeoNetwork metadata catalogue is fully integrated with the VALORADA tools and provides several key benefits. It offers immediate contextual information about the datasets and indicators visualized in the tools, helping users understand their origin, scope, and limitations. At the same time, it ensures transparency and traceability by documenting the sources, calculation methods, and access restrictions for each record. Finally, it supports data reuse by enabling users to identify datasets and indicators that can be applied in other analyses or adapted to different demonstrators.

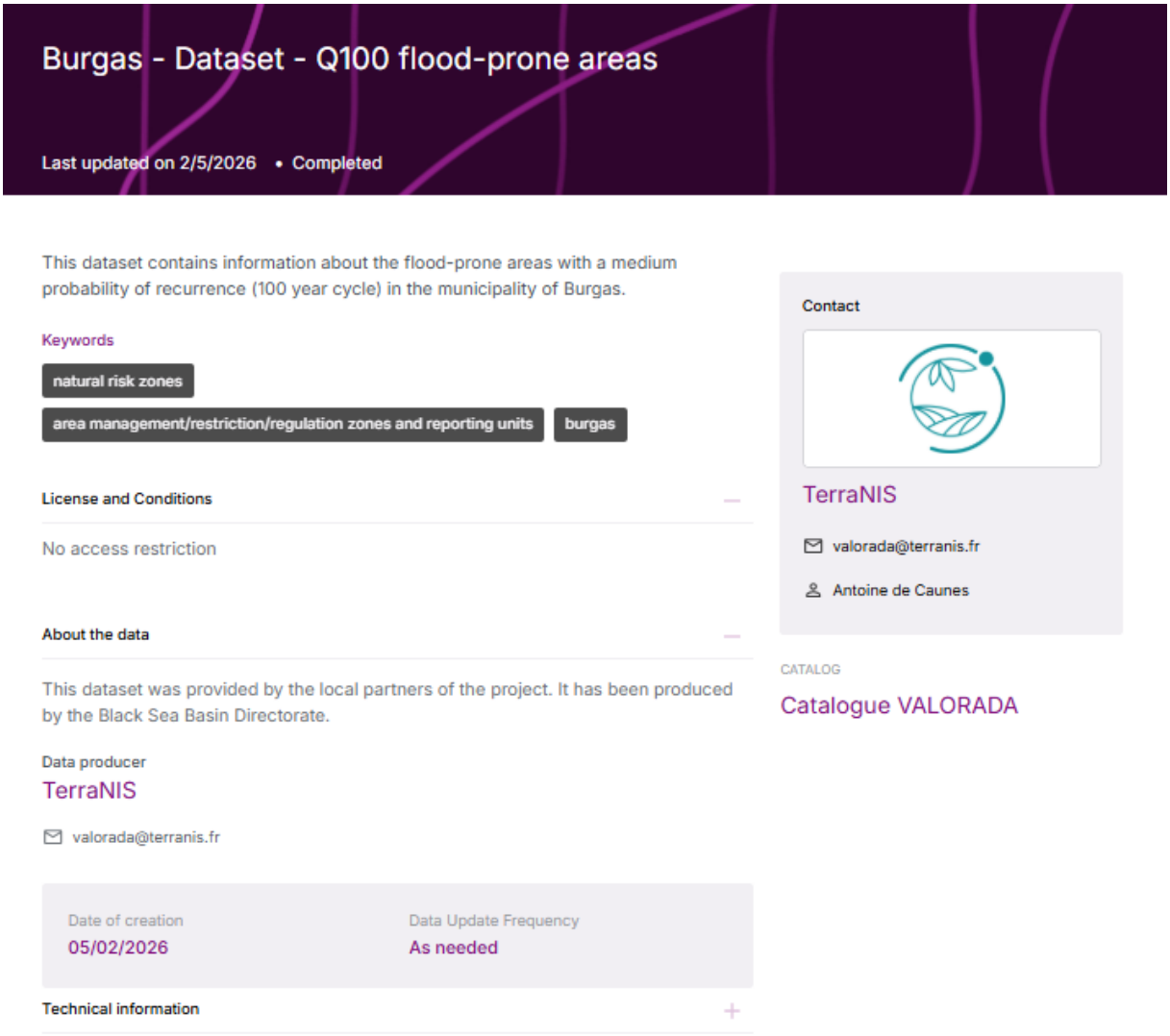
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These examples illustrate the detailed metadata records for both datasets and indicators, highlighting the demonstrator-specific approach and the rich contextual information available to end-users:



Example of an indicator record for Burgas

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Example of a dataset record for Burgas

The population of the GeoNetwork metadata catalogue followed a structured approach. Open and well-documented datasets were easily integrated into the catalogue. For local datasets, data were collected and transmitted to TerraNIS during the first semester of 2025. Project partners providing local data were required to complete an information form, detailing the metadata for the submitted datasets. This information form served a dual purpose: it allowed the production team in TerraNIS to understand and properly use the data for indicator calculations, and it also provided the content to populate the GeoNetwork catalogue with accurate and consistent metadata for each local dataset.

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7. Conclusion

In conclusion, the implementation of the VALORADA tools within WP4 has demonstrated practical value for supporting local stakeholders in the different demonstration regions. By enabling the ingestion, harmonization and analysis of heterogeneous climate and non-climate datasets, the tools have facilitated the production of locally relevant indicators that help better understand climate risks and vulnerabilities.

Through their integration into accessible web-based applications and dashboards, the tools have improved the availability, accessibility and usability of complex geospatial information. This has supported more informed discussions among regional actors and strengthened their capacity to explore, interpret and use climate-related data in their decision-making processes.

The deployment phase also confirmed the importance of adapting tools to local data contexts and stakeholder priorities. While based on a common methodological framework, the tools were successfully customized to reflect the specific characteristics, needs and data availability of each demonstrator. Feedback collected during the evaluation phase contributed to refining the tools and improving their usability.

Overall, the tools developed and implemented in WP4 represent a significant step toward enabling regional stakeholders to better integrate climate and local data in their assessments. They contribute to strengthening local capacities for climate risk analysis and support the broader objective of empowering regions and cities to advance toward more climate-resilient development.

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