ALPINE DROUGHT OBSERVATORY

D.T3.3.1 – Integrated Risk Assessment

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ADO - Alpine Drought Observatory (ASP*940)*

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Summary

1. Introduction

As defined by the International Panel on Climate Change in the 5th Assessment Report, risks can be defined as the potential for consequences where something of value is at stake and where the outcome is uncertain (...). Risks result from the combination of hazard, vulnerability, and exposure."(IPCC, 2014). While the hazard usually refers to climate-related physical events or trends, vulnerability and exposure relate to assets, people or ecosystems which have a social or economic value, and which might be potentially affected. In particular, vulnerability is a characteristic of the exposed elements and is defined as "the propensity or predisposition to be adversely affected"; it "encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2014). Sensitivity is determined by physical, social, economic, and cultural attributes factors that directly influence the consequences of a hazard (e.g., type of soil on agriculture fields, age structure, income structure). Capacity, on the other hand, refers to the ability of societies and communities to prepare for and respond to current and future climate impacts. This comprises coping capacity and adaptive capacity.

To assess such risks an integrated assessment is therefore required, considering both the analysis of climate-related hazards and of the potentially affected social systems. Multiple interlinked environmental, socio-economic factors need to be investigated to obtain an overview of the risks. However, no fixed rule to define which factors to consider exists, nor of the methods used to quantify them. Different approaches can be indeed adopted to carry out a risk assessment.

Quantitative approaches are based on standardised composite indicators and allow for comparison of different risks across different spatial regions or monitoring and evaluating risks through time. Being data driven, they are subject to data availability, which can be scarce at the local scale, especially as far as socio-economic factors are concerned. Qualitative approaches on the other hand can overcome this challenge, basing the assessment on mainly qualitative information and narratives. This bottom-up approach makes comparison of different regions and time periods challenging. Mixed-method approaches also exist, such as the Impact Chains.

The **Impact Chains** approach aims integrates qualitative and the quantitative aspects and has been widely used for risk assessments in the framework of climate change adaptation planning from the local to the national level. An impact chain is an analytical tool to better understand, systemize and prioritise the factors that drive risk in the system of concern (GIZ & Eurac, 2017). The structure of the impact chain, developed according to the IPCC AR5 risk framework, is based on the understanding of risk and its components (Figure 1). The systematic and participatory approach underlying the Impact Chains can help to overcome some of these barriers and allows to focus not only on climate as a risk driver but also on non-climatic drivers such as the vulnerability of the exposed elements.

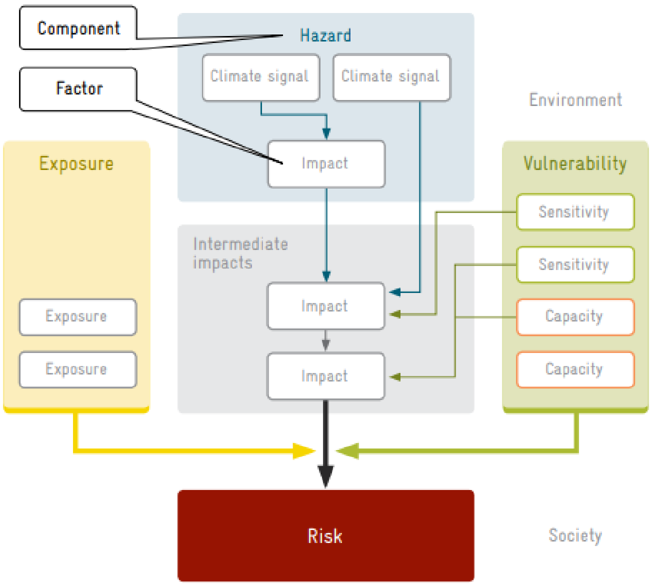

FIGURE 1. THE IMPACT CHAINS APPROACH, AN OPERATIONAL TOOL TO IDENTIFY THE COMPONENTS (HAZARD, EXPOSURE AND VULENRABILITY) AND UNDERLYING FACTORS WHICH MAKE UP THE RISK (SOURCE: GIZ & EURAC, 2017).

Further information on drought risk assessment and on the respective risk components can be found in Deliverable D.T3.3.2 – Assessment of economic drought impacts.

2. Application of Impact Chains within ADO Case Studies

During the ADO project meeting, held online on the 24th September 2020, 11 impact chains were developed with a flexible group interview. These impact chains were focused on the case study regions within ADO and the further specified for the by drought most affected sectors. Agriculture was the sector mentioned almost by every case study region during the group interviews (Thurgau, Podravska). Additionally, the hydropower production (Orco), tourism (Vercors), public water supply (Upper Austria) and the development of forest fires (Ticino) were mentioned as affected by drought.

Subsequently, we focused the further analyses on agriculture, also because this sector is also among the most important economic sectors across the Alpine Space which has been identified by various studies to be impacted by drought. As drought as a hazard has been analyzed, for example with the help of drought indices, the vulnerability component is usually underrepresented in risk assessments due to its complex nature. To identify the conditions that make a system vulnerable to drought is a challenging task and differs regionally due to the region-specific predisposition and different past experiences with drought. This can also be seen in the impact chains below, where the exposure and hazard components are represented by a few and easily quantifiable factors, while the vulnerability component encompasses a larger variety of more complex factors.

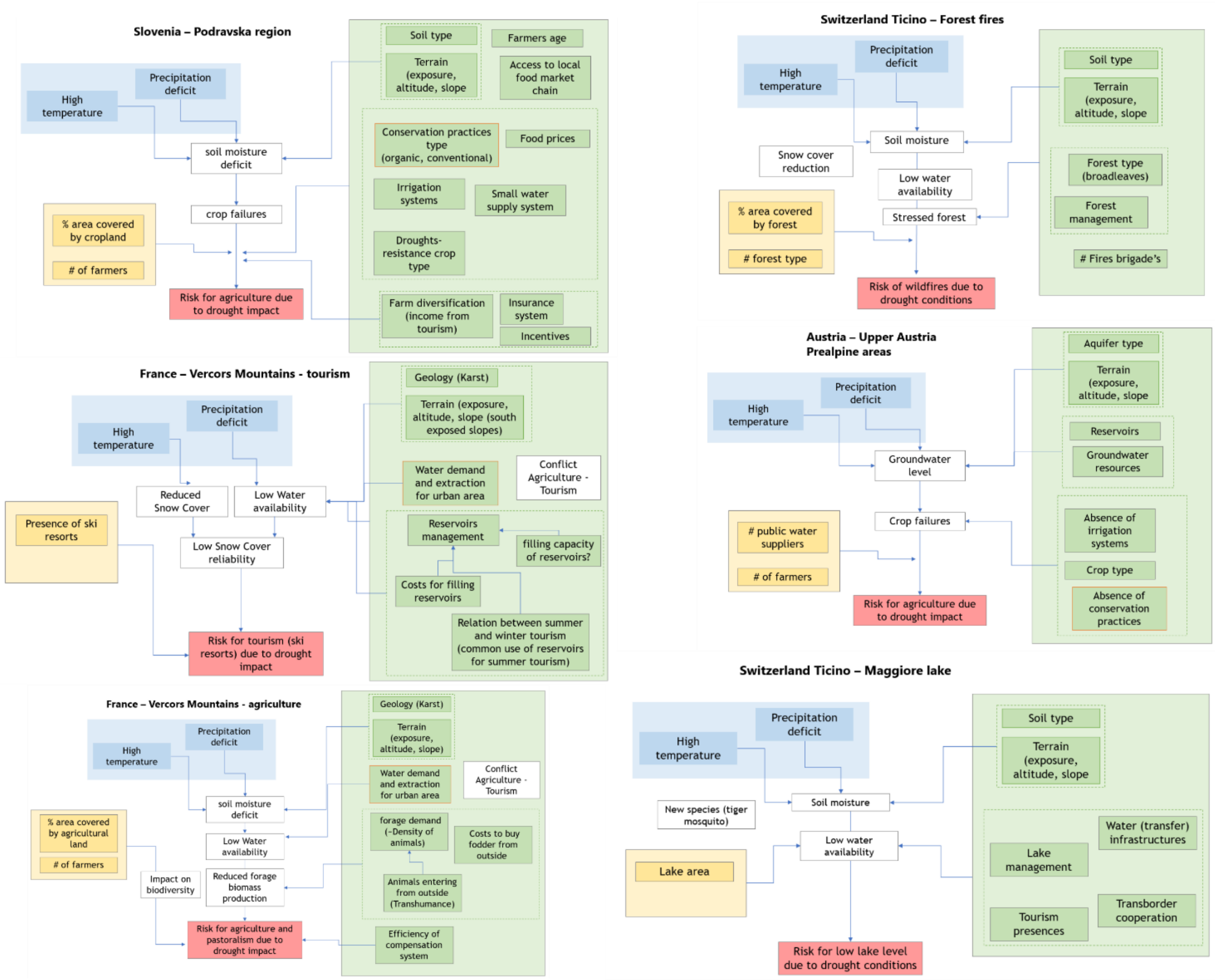

FIGURE 2. EXAMPLARY IMPACT CHAINS DEVELOPED FOR THE CASE STUDY REGIONS DURING THE ADO PROJECT MEETING HELD ONLINE ON THE 24TH SEPTEMBER 2020.

3. Focus on vulnerability factors for selected case studies

The two case studies of Thurgau in Switzerland (Figure 3) and Podravska in Slovenia (Figure 4) were selected given the importance attributed by the experts during the participatory creation of the impact chain to drought in agriculture as well as the increasing number of droughts impacts in the agricultural sector that have been reported in the past (Stephan et al., 2021). This is particularly relevant since although both regions are located in the proximity of the water-rich European Alps area they are considered vulnerable to drought. In particular, Stephan et al., (2021) shows how most of the drought impacts collected in the Alpine Drought Impact report Inventory (EDIIALPS) points to agriculture and livestock farming as those mostly impacted sectors. In addition, EDIIALPS shows that most of the impacts were reported in 2015 and 2018 for Thurgau, claiming a reduced productivity in annual and permanent crop cultivation and shortages of feed and water for livestock. For Podravska most of the impacts refer to 2003 and 2017 claiming a reduced productivity of annual crop cultivation, often with yield losses ≥ 30%. Due to these reasons and as the hazard component is analyzed by other work packages, we focused the following analyses on the vulnerability component. Therefore, we focused on the case study regions Thurgau and Podravska to understand better the region-specific conditions contributing to agriculture's vulnerability to drought.

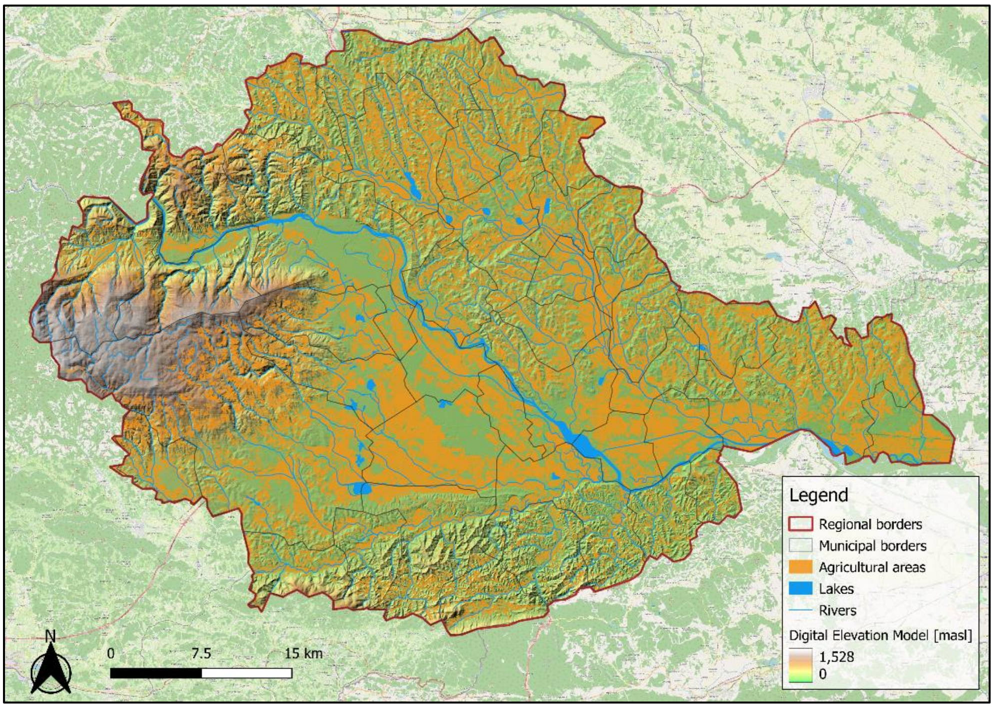

FIGURE 3. MAP OVERVIEW OF THE SLOVENIAN CASE STUDY IN THE PODRAVSKA REGION. BASEMAP FROM © OPENSTREETMAP CONTRIBUTORS, CC-BY-SA.

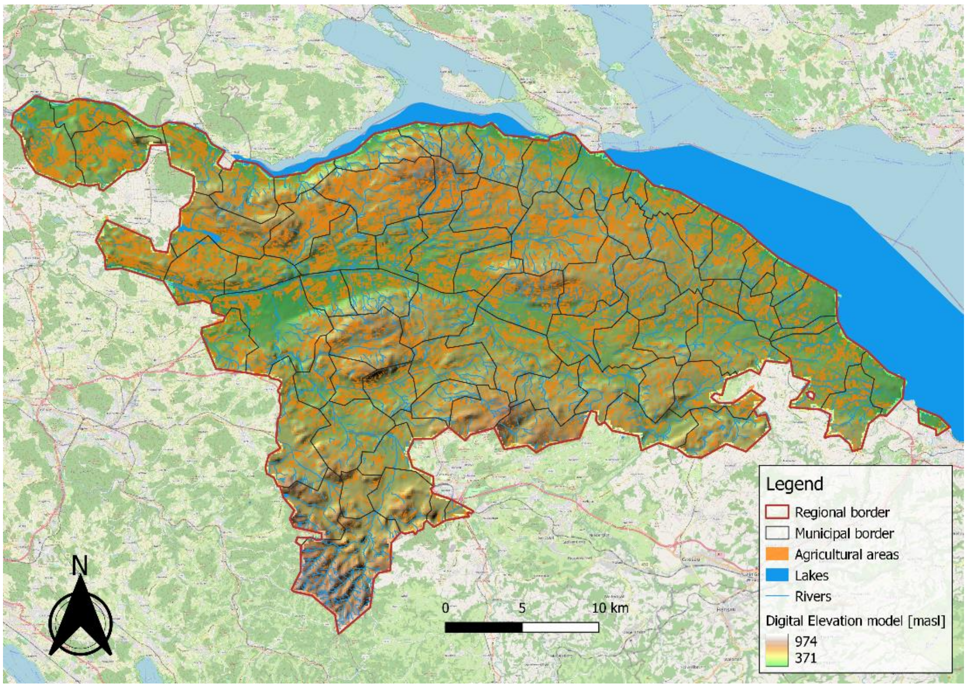

FIGURE 4. MAP OVERVIEW FOR THE SWISS CASE STUDY OF THE CANTON THURGAU. BASEMAP FROM © OPENSTREETMAP CONTRIBUTORS, CC-BY-SA.

During semi-structured interviews project partners and external experts were asked to identify the most important factors contributing to the overall vulnerability of their case study region. In addition, they determined, whether the factor has an increasing or decreasing effect on the final vulnerability in order to be able to quantitatively describe the vulnerability component. They identified 10 common factors for both study regions, whereas they identified 6 factors solely for Thurgau and 13 factors solely for Podravska (see Figure 5) briefly described why the factor contributes to the region-specific vulnerability.

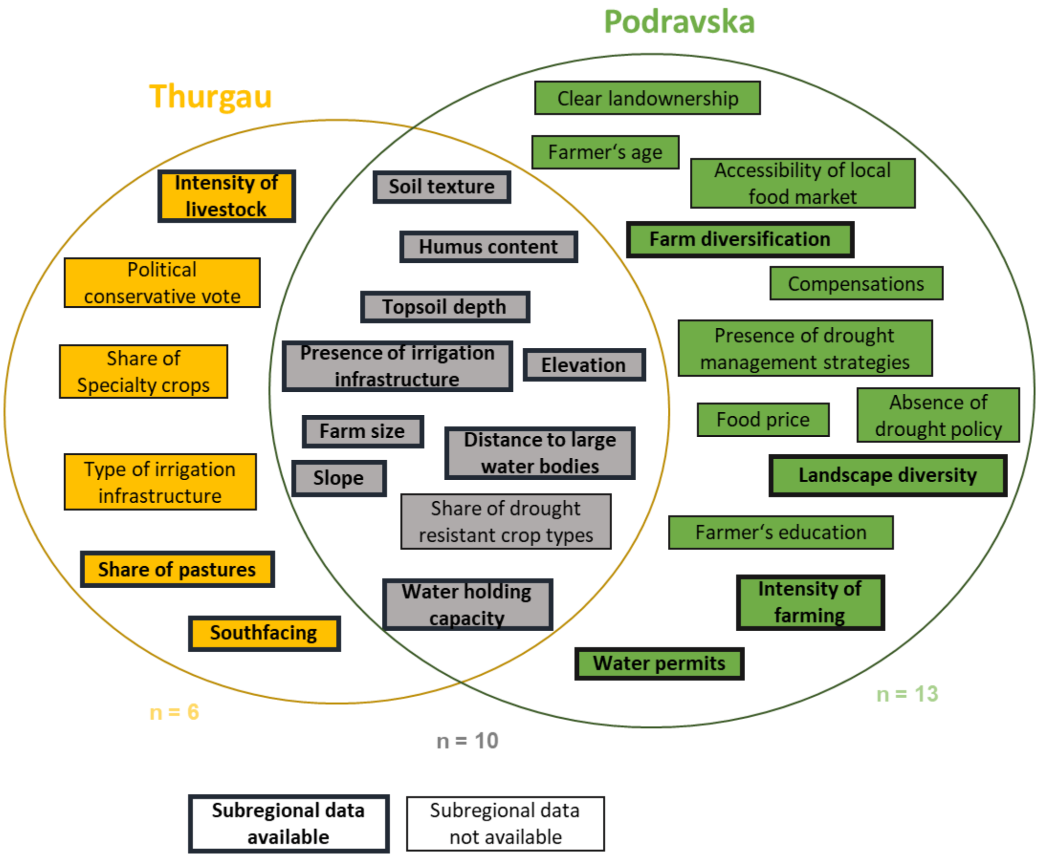

FIGURE 5. THE FACTORS IDENTIFIED BY PROJECT PARTNERS AND EXTERNAL EXPERTS CONTRIBUTING TO THE AGRICULTURE VULNERABILITY TO DROUGHTS IN THURGAU (YELLOW) AND PODRAVSKA (GREEN). COMMON FACTORS ARE PRESENTED IN GRAY. FACTORS PRESENTED IN BOLD ARE FACTORS FOR WHICH SUBREGIONAL DATA IS AVAILABLE.

For all factors we identified indicators that could describe the conditions quantitatively as a proxy variable. We looked for open and accessible data to support the indicators and found subregional data for a majority of 16 factors. The factors we could not support with data are mostly describing socio-economic conditions, such as compensations or farmer's education. Further, we could support more factors in Thurgau compared to Podravska, as most of Thurgau's factors describe topographic and static conditions, such as Elevation, Southfacing area etc. This collection of factors describing agriculture's vulnerability to drought was used to develop first vulnerability maps across the case study regions. For further details read Stephan et al. (2022).

4. Focus on vulnerability at Alpine Space level: the ADO portal

Based on the previous analyses gathering a range of vulnerability factors with focus on the agriculture, we gathered data with the spatial extent of the Alpine Space. Therefore, we looked for data with a spatial resolution of at least NUTS 2 regions. Compared to the regional analyzis, this coarser resolution offered other sources with suitable data and in some cases other indicators (see Table 1).

This step can be seen as an extrapolation of two case study regions within the Alpine Space to the Alpine Space as a whole. This step comes along with the following limitation.The factors we looked for data have been identified by regional experts from two regions. Their applicability for other parts of the Alpine region can be questioned especially when considering the differences between the case study regions highlighting the region-specific character of vulnerability. However, the factors presented here and on the platform can be seen as a first estimate how vulnerable the agriculture across the Alpine Space is. This means that the presented factors concentrate on one sector – namely the agriculture- and not other sectors that have been affected by drought, such as public water supply.

Information on the vulnerability factors and their main characteristics collected and reported on the «Monitoring Alpine Drought Observatory» webplatform is reported in Table 1. Within the table, 13 factors are listed with information on their (i) contribution to vulnerability (an increase of the factor value increase or decrease vulnerability to drought), (ii) the indicator(s) applied to describe each factor, (iii) their unit of measure, (iv) the data source and their underlying link, (v) the latest year of update of each data, (vi) the spatial data type being either rasterfile or shapefile and (vii) the description of the indicators shown on the webplatform.

The (i) contribution to vulnerability of each factor was defined during the participatory semi-structured interview with key experts as described in Section 3. The (ii) indicators used to describe each factor were selected in agreement with the key experts opinion and according to the available spatial datasets and information. The (iv) data sources used spanned across a different set of existing european data portals and have been cropped to the boundary defined in the EU Strategy for the Alpine Region (EUSALP). In case of shapefiles, data from EuroStat have been linked to the spatial feature both of Nuts 3 and Nuts 2.

TABLE 1 - SUMMARY OF THE VULNERABILITY FACTORS AND THEIR MAIN CHARACTERISTICS AVAILABLE ON THE ADO WEBPLATFORM "MONITORING ALPINE DROUGHT OBSERVATORY ". IN YELLOW THE FACTOR DESCRIBING THE RELATED EXPOSED SECTOR.

Factor	Contribution to vulnerability*	Indicator	Units of measure	Data source	Latest update	Data type	Description
Slope	The steeper the land, the more it is vulnerable	Slope	-	EEA	2000	Rasterfile	This dataset shows the slope derived from the Digital Elevation Model.
Soil texture	The coarser the soil, the more the agricultural land is vulnerable	Topsoil physical properties for Europe	-	ESDAC	2006	Rasterfile	This dataset shows the USDA soil textural classes derived from clay, silt and sand.
Humus content	The higher the humus or organic carbon content, the lower the vulnerability of the land	Topsoil organic carbon content	Topsoil organic carbon [%]	ESDAC	2006	Rasterfile	This dataset shows the topsoil organic carbon (%) in the surface horizon of soils in Europe.
Distance to large water bodies	The closer the land is to water sources, the less it is vulnerable	Distance to large water bodies	[m]	Hydrosheds	Static	Rasterfile	This dataset shows distance [m] calculated at each location to the nearest lakes, water reservoirs and rivers. Rivers were filtered to Strahler order > 3.
Water holding capacity (AWC_TOP)	The higher the possible soil moisture, the lower the vulnerability of crop cultivation (soil moisture is dependant on water holding capacity)	Topsoil available water capacity	[adimensional]	ESDAC	2006	Rasterfile	This dataset shows the water holding capacity at a resolution of 500 meters.

Presence of irrigation infrastructure	The presence of irrigation infrastruture decreases the vulnerability of the agricultural land	Permanently irrigated agricultural land	-	Copernicus Land Monitoring Service	2018	Rasterfile	Permanently irrigated agricultural land is based on the Corine Land Cover 2018 (CLC) from Copernicus, extracting Class 12 (Permanently irrigated). The output is a binary raster, whereas 1 corresponds to permanently irrigated land and 0 corresponds to not permanently irrigated land.
Landscape diversity	The more diverse is the landscape, the lower will be the vulnerability			Copernicus Land Monitoring Service			This database is based on Shannon eveness index which provides information on area composition and richness ranging from 0 to 1. It is calculated considering 9 Corine Land Cover classes of numeric matrices using a moving window algorithm of 5 pixels side and dividing this result by its maximum.
Farm input intensity	The higher the farm input intensity, the higher the vulnerability (intensive farming leads to a higher vulberability)	1) Hectares of high input utilised agricultural area	[ha]	Eurostat	2019	Shapefile	This dataset shows the hectares and the percentage of utilised agricultural area (UAA) managed by high-input farms. The inputs considered are purchased fertilisers and soil improvers, plant protection products such as pesticides, traps, bird scarers, anti-hail shells, frost protection etc. High intensity level means that the input level is greater than the 66th UAA quantiles.
		2) Percentage of high input utilised agricultural area over total utilised agricultural area	Percentage of utilised agricultural area [%]				

Production intensity	The higher the production intensity, the higher the vulnerability (intensive farming leads to a higher vulberability)	Crop production in standard humidity per hectare	[t/ha]	Eurostat	2020	Shapefile	This factor is calculated dividing the sum of crop production of cereals, dry pulses and protein (t) by the area of cultivation (Ha)
Farm size	The smaller the farm, the higher its vulnerability to droughts	Average utilised agricultural area per agricultural holding [ha]	[ha]	Eurostat	2013	Shapefile	This factor has been calculated by dividing the total number of holdings with the utilised agricultural area (Ha)
Livestock density	The higher the livestock density or the intensity of livestock farming, the higher the vulnerability	Livestock units per hectare	[units/ha]	Eurostat	2016	Shapefile	This factor has been calculated by dividing the total number of livestock units by the hectares of permanent grassland (livestock/Ha).
Share permanent grassland	The higher the share of permanent grassland, the higher the vulnerability.	Percentage of permanent grassland [%]	permanent grassland [%]	Eurostat	2016	Shapefile	This factor is calculated by substracting agricultural grassland not in use (Ha) to permanent grassland (Ha), and then dividing by the total utilised agricultural area.
Share utilised agricultural area	Exposure factor	1) Utilised agricultural area	[ha]	Eurostat	2016	Shapefile	This factor shows the hectares of utilised agricultural areas and the share calculated by dividing the utilised agricultural area by the total area at each NUTS2 region.

		2) Percentage of utilised agricultural area over the total NUTS2 area	[%]				

The ADO webplatform currently provides the possibility to choose among a list of information (e.g., indices, impacts, hydro; red box #1 in Figure 6). The set of indices that are currently available includes indices commonly used to identify and analyse drought conditions (e.g. SPEI-1, SPI-1, SMA, VCI; red box #2 in Figure 6). For each of these indeces different years can be selected in order to visualize changes in time across the EUSALP (red box #3 in Figure 6) and for each of them a coloured legend is shown (red box #4 in Figure 6).

A Tab (in red box #1) regarding vulnerability and exposure in the risk context will be also available. The indices described in Table 1 will appear in red box #2. Therefore in the future the ADO webplatform will show indices not only describing the hazard and impacts components of the impact chains but also the vulnerability component, especially focussing on the agricoltural sector.

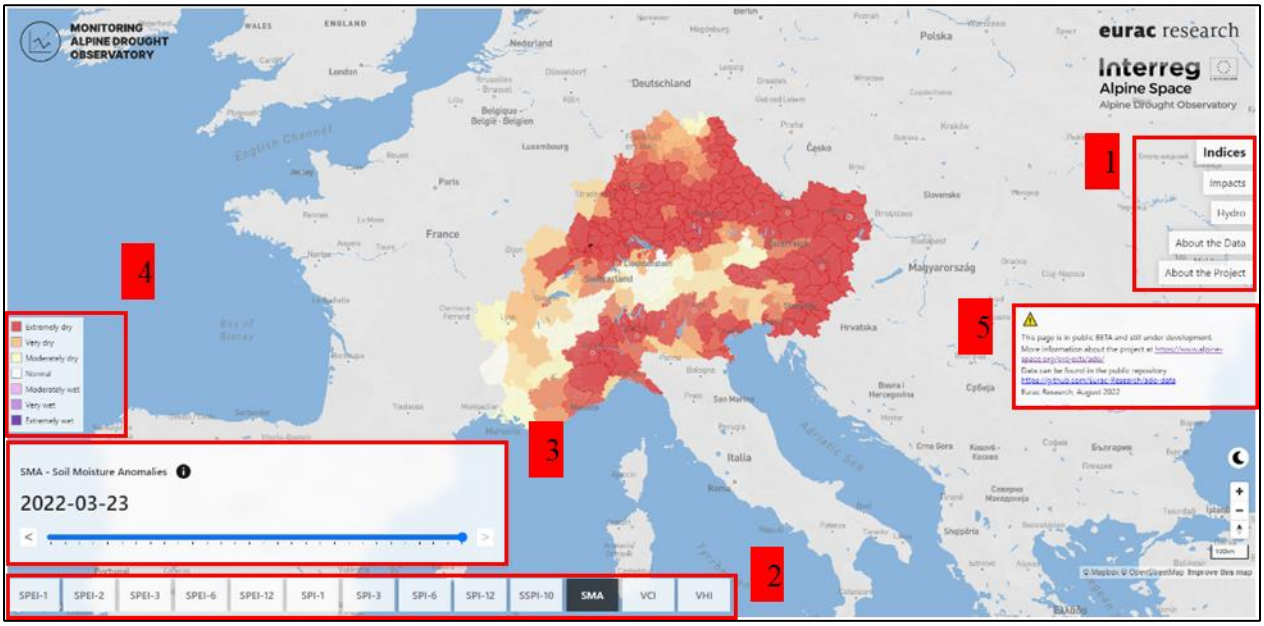

FIGURE 6. THE ADO WEBPLATFORM « MONITORING ALPINE DROUGHT OBSERVATORY ».

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