Ref. Ares(2026)5514212 - 30/05/2026

VALIDATED LOCAL RISK ACTIONABLE DATA FOR ADAPTATION



D4.9
Final Data Management Plan Compliant with FAIR Principles

Marcus Zanacchi
European Centre for Medium-range Weather Forecasts

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

HORIZON-MISS-2022-CLIMA-01

Grant Agreement No 101112873

Start Date of the Project: June, 01 2023

Duration: 01.06.2023 – 31.05.2026

DELIVERABLE REPORT

Deliverable ID	D4.9
Deliverable name	Data Management Plan Compliant with FAIR Principles

WP	4	Development of data manipulation tools
Task	T4.4	Data Management Plan compliant with FAIR principles

Dissemination level[1]	PU
Nature[2]	DMP

Due delivery date (Annex 1)	30/04/2026
Actual delivery date	20/05/2026

Lead beneficiary	ECMWF
Contributing beneficiaries	Hereon, TerraNIS, (HCU previous versions)

[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.

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

Version Management			
Filename	VALORADA_D4.9_final		
Author(s)	Marcus Zanacchi, Samuel Almond		
Approved by partner reviewer (ECMWF)	Nils Hempelmann, Angel Lopez	Date	19/04/2026
Approved by WP leader	Marc Tondriaux	Date	22/05/2026
Approved by coordinator	Dr. Cristóbal Reveco Dr. Jörg Cortekar	Date	22/05/2026
Authorized by coordinator	Dr. Cristóbal Reveco Dr. Jörg Cortekar	Date	22/05/2026

Version	Date	Author(s)	Modification[3]
V1	15/04/2026	ECMWF	Creation
V2	20/05/2026	ECMWF	Submitted

EC-Grant Agreement	101112837
Project acronym	VALORADA
Project title	Validated Local Risk Actionable Data for Adaptation
Instrument	HORIZON Research and Innovation Actions
Programme	HORIZON-MISS-2022-CLIMA-01
Start date of project	01/06/2023
Duration	36 months

Coordinator – Administrative information	
Project coordinator name	Dr. Jörg Cortekar
Project coordinator organization name	Helmholtz-Zentrum Hereon GmbH
Address	Max-Planck-Straße 1, 21502 Geesthacht
Phone Numbers	+49 (0)40-226 338-445
Email	joerg.cortekar@hereon.de
Project web-site	https://valorada-project.eu/

[3] Creation, Modifications, Final version for evaluation, Revised version following evaluation, Final.

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

TABLE OF CONTENT

1. EXECUTIVE SUMMARY 6
2. INTRODUCTION 6
2.1 About VALORADA 6
2.2 Purpose and scope 7
3. DATA SUMMARY & MANAGEMENT 9
4. ADDRESSING THE FAIR PRINCIPLES IN THE CONTEXT OF VALORADA 19
5. HOW HAS VALORADA ADOPTED FAIR PRINCIPLES? 21
GeoNetwork metadata catalogue 22
GitHub – VALORADA Catalogue 22
Jupyter Notebooks 23
Visualisation Tools (TerranNIS) - Climate dashboard (ArcGIS Online): 25
Recommendations & Next Steps 25
6. PRACTICAL FAIR GUIDANCE FOR VALORADA PARTNERS 27
7. CONCLUSIONS 29

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

Acronym list

DSS – Copernicus Climate and Atmosphere Data Store Service
CDS – Climate Data Store (dedicated instance of DSS for C3S)
CF – Climate and Forecasting
CII - Climate Impact Indicator
CLS – Copernicus Land Service
DMP – Data Management Plan
EEA – European Environment Agency
ECA&D - European Climate Assessment & Dataset project
ECMWF – European Centre for Medium-Range Weather Forecasts
ETC-CCA - European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation
ETCCDI - Climate Change Detection and Indices
ET-SCI - Sector-Specific Climate Indices
ECV – Essential Climate Variable
EU – European Union
FAIR – Findable, Accessible, Interoperable and Reusable
GDPR – General Data Protection Regulation
GCOS – The Global Climate Observing System
GEOSS – Group on Earth Observations
NetCDF - Network Common Data Form
NUTS - Nomenclature of Territorial Units for Statistics
IPCC – Intergovernmental Panel on Climate Change
OGC – Open Geospatial Consortium

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

Summary of updates

Date	Change	Version
	Initial version	1.0
23.10.2024	Update to v2 in text Inclusion of Remote sensing imagery as an identified data source from the VALORADA Results Inventory deliverable (D6.3) Inclusion of Socioeconomic data as an identified data source from the VALORADA Results Inventory deliverable (D6.3) Inclusion of VALORADA Interim Data Catalogues (D2.3) Enhanced traceability of project's output through version control Interoperability between climate and socioeconomic data is updated Updated text on Zenodo as a preferred open-access repository	
15/04/2026	Updates to sections 1-4 Inclusion of section 5 - How has VALORADA adopted FAIR principles? Inclusion of section 6 - Practical Guidelines for VALORADA partners[	1.1

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

1. Executive summary

This document presents the third and final version of the Data Management Plan (DMP) as set out in the deliverable No. 4.4.3 of the VALORADA project. The DMP describes the overall strategy for managing the data collected, generated, used, and modified during the project, and aims to ensure that it is achieved whilst adhering to the "FAIR" principles[4] (Findable, Accessible, Interoperable and Reusable). This third iteration has been developed as a living document reaching a mature state focused on the VALORADA project. In addition, the DMP will identify the open source and commercially sensitive data and tools generated or used in the scope of the project whilst also providing information on the measures to be taken to guarantee the protection, privacy and security of (sensitive) data during the entire lifecycle of the project.

The information in this DMP about data governance, like metadata structure and data format, is intended to provide the guidelines to make the project output compatible with the standards used by the climate community and by the Copernicus Climate Data Store (CDS), wherever appropriate. The DMP will also identify and recommend the internationally recognised standards that are applicable to climate data holdings and open-source software. Such standards must be open or managed by recognised international standardisation bodies. This will ensure that data or software tools developed by the project could make full use of the datasets freely available in the climate community, especially those in the CDS, or be easily considered for inclusion in the CDS in the instances where sufficiently strong user demand is identified.

2. Introduction

2.1 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 customizable 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. In a rigorous transdisciplinary approach, the respective risks of climate change are analysed in five demonstrators in Europe with the local actors. 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. "Analyst toolbox" will be composed of software tools

[4] https://www.go-fair.org/fair-principles/

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

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 Climate Data Store where practicable and aligned to the CDS open-source implementation strategy.

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.

2.2 Purpose and scope

The purpose of developing a data management plan (DMP) for the project is threefold. Firstly, it undertakes an assessment of good practice and FAIR principles relevant to VALORADA. Secondly, it provides guidance to the project partners on how to collect, generate, use, and preserve data and software tools during the course of the project's lifetime. Such guidance should be used by project partners to ensure project output adheres to the aims and objectives outlined in the project proposal. Thirdly, the report provides external parties who are interested in the project with information on the data and software tools collected and generated in the project.

It provides a framework to all relevant parties to produce and re-use the data and software in a manner that is consistent, respectful and meeting all relevant community standards whilst adhering to the FAIR principles (Findable, Accessible, Interoperable and Reusable). It will also guide the partners in the proper handling of information respecting the principles laid down by the General Data Protection Regulation (GDPR) and ethics strategy of the project.
A priority objective of the DMP is to contribute to making the data output, indicators and software tools FAIR compliant in order to maximise its value and ensure efficient data management throughout the project's development so that data is prepared for short and long-term preservation. The goal is that the data-manipulation tools, developed as open-source software in the project, consume and produce output in standard formats with proper metadata, while their storage and access will be efficient and machine-readable. Documentation complements the set of internal metadata of the data for its better interpretation and access. Equivalently, the FAIR principles will also be applied to the set of software tools produced as part of the project in order to preserve their long-term use, reuse and further development and thereby maximising the success of the project.

This is the third and final version of the DMP which has been continuously revised during the project within Task 4.4 included in WP4. The DMP was designed as a living document that was

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

adjusted to the needs of the project and altered as VALORADA progresses. This version seeks to outline data management strategies based on the input data, primarily identified to be climate data sourced from the CDS. Additional non-climate related data, for example socioeconomic data from the local regions, will also play an important role in VALORADA. The coupling of climate and non-climate data is envisaged to raise specific issues related to the interoperability of the vocabularies used under the different community standards. The DMP will work towards mitigating these issues by forming the data management framework which will induce interoperability and reduce the incompatibilities.

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

3. Data summary & management

3.1 Data collection and generation

The VALORADA project has produced a wide range of results and outputs, including reports, software tools and data catalogues. The majority of which will be produced using data from existing portals that are already community or EU-resourced and targeted to societal applications. Of particular relevance to climate adaptation is the EU's Earth observation programme Copernicus, which includes space-based imagery, from the Sentinel satellites and supporting missions, as well as the Copernicus services (C3S, CAMS, CLMS etc.), Other EU initiatives, such as Climate ADAPT, and Horizon 2020, Horizon Europe projects and local, socio-economic data (EUROSTAT e.g. NUTS and associated socioeconomic data) are also valuable resources. VALORADA will develop different types of data-manipulation tools to create catalogues of climate-resilience information. The catalogues will be accompanied by specific metadata needed to understand the data and respective analysis. This data will be made public following the FAIR principles at all levels (data-citation metadata, domain-specific metadata, file-level metadata) taking into considerations restrictions or privacy issues.
In this final version of the DMP we consider the complete range of output from VALORADA and ensure interoperability under the FAIR principles (see How has VALORADA adopted FAIR principles?).

3.2 Data catalogues

Data catalogues providing resilience information are developed as an output of the VALORADA project primarily to aid the user in understanding the role of specific datasets in measuring climate risks. The catalogues connect the indicators used to measure climate risk and the data sources available and needed by the tools also developed in the project. It is envisaged that [5]-compliant metadata fields are included for each indicator in the catalogue. INSPIRE metadata refer specifically to structured metadata for geospatial datasets or services. This makes datasets searchable and understandable by both humans and machines and is largely aligned with OGC standards. It was first published as the INSPIRE Directive by the European Parliament in 2007 and is an essential element of the European Strategy for Data.
The data catalogue will take the form of a spreadsheet, in an accessible and open format such as CSV. It shall also contain a readme file or a dedicated metadata sheet for the data catalogue itself which will be compiled in line with the FAIR principles. Such metadata should aid the users in purposing the data catalogues using standard metadata formats, for example Dublin Core. Once published in an open and trusted repository under an open licence, the catalogue shall be assigned a persistent identifier e.g. DOI.

[5] https://knowledge-base.inspire.ec.europa.eu

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

3.3 Climate data from Copernicus Climate Change Service

The CDS (Climate Data Store) is an EU-funded data access portal providing free and open data on the Earth's past, present and future climate. It is managed by the Copernicus Climate Change Service[6] and is implemented on behalf of the EU by the European Centre for Medium-Range Weather Forecasts[7] (ECMWF). The CDS can be accessed programmatically through the CDS Application Programming Interface (API) and is also available through a web-interface via a download form on the CDS catalogue page (https://cds.climate.copernicus.eu/datasets).

The CDS has adopted the FAIR principles in order to facilitate the discovery, access and usability of data and services, including software tools developed at ECMWF as part of the open-source Python project called earthkit[8]. Earthkit provides a format-agnostic Python interface for geospatial data with a focus on meteorology and climate science. It offers multiple interoperable software components built on top of well-established open-source Python libraries like numpy, pandas, and matplotlib allowing users to read, inspect, and slice data from a wide range of geospatial input types and offer the technology and flexibility to combine data types from various sources including locally hosted data (socio-economic) in various formats, including (geocoded) tabular or coverage.json[9] (suitable for spatially aggregated time series information) which could be of use in VALORADA. The interface is designed to be high-level in order to provide common tools. Its design takes scalability into account and allows for contributions to the project from external partners.
The CDS contains many categories of climate data which amount a vast amount of climate information, including reanalysis, satellite and ground-based observations, climate projections, seasonal forecasts, as well as derived climate indicators and sector specific climate information. The CDS also provides seasonal forecasts though these will not be addressed in this DMP since we consider it to be out of scope for long-term climate adaptation strategies. The most relevant datasets to VALORADA are described below.

3.3.1 Reanalysis data available in the CDS

ERA5 and ERA5-Land reanalysis are the global atmospheric reanalysis datasets produced by the European Centre for Medium-Range Weather Forecasts (ECMWF). Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics. The datasets provide a comprehensive view of the Earth's atmosphere, for the period 1940 to present for ERA5 (resolution 0.25 degrees) and 1959 to present for ERA5-Land (0.1-degree resolution). The data files are in GRIB2 format but may be converted to NetCDF format in the CDS. Both reanalysis data sets are widely used in climate research, weather forecasting, and other applications. ERA5 also includes an ensemble component at half the resolution to provide information on the synoptic uncertainty of its

[6] https://climate.copernicus.eu/

[7] https://www.ecmwf.int/

[8] https://github.com/ecmwf/earthkit

[9] https://docs.ogc.org/cs/21-069r2/21-069r2.html

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

products. ERA5-land parameter uncertainty currently can be accessed using the equivalent ERA5 fields.

The **UERRA** (Uncertainties in Ensembles of Regional ReAnalysis) dataset contains reanalysis data of the atmosphere, the surface, the near-surface, and soil for Europe. Essential climate variables are generated with the UERRA-HARMONIE and the MESCAN-SURFEX systems. UERRA uses a combination of advanced data assimilation techniques and high-resolution regional climate models to produce a climatology of the atmosphere over Europe at a resolution of 0.1 degrees, covering the period 1961-2019. In addition to the standard atmospheric variables, UERRA also provides uncertainty estimates for each variable, which can be used to assess the reliability of the data and quantify the level of confidence in any climate-related analysis or decision-making process. The data files are in GRIB2 format but may be converted to NetCDF format in the CDS.

The **CERRA and CERRA-Land** (Copernicus European Regional ReAnalysis Land) dataset provides regional reanalysis over the European domain on a Lambert conformal conical grid of 5.5 x 5.5 km over the period September 1984 to April 2021. The parameters contain atmospheric and land variables, with soil parameters provided on different soil depths. The data files are in GRIB2 format but may be converted to NetCDF format in the CDS.

3.3.2 Observations

E-OBS gridded observations is an ensemble dataset available at 0.1- and 0.25-degree regular grid for daily mean, minimum and maximum temperature, daily precipitation, daily mean sea level pressure, daily mean wind speed, daily mean relative humidity and global shortwave radiation flux. The dataset covers the European domain: 25N-71.5N x 25W-45E. The data files are in NetCDF-4 format. The dataset is calculated from station data acquired through the network of the European Climate Assessment & Dataset (ECA&D) project.

Satellite observations for a large selection of the GCOS Essential Climate Variables are provided through the CDS. These include: ECVs on atmospheric physics, including surface and upper-air radiation budgets, precipitation, cloud properties, and water vapour; ocean-related ECVs including daily and monthly gridded sea surface height; cryospheric ECVs, including glacier area, mass change, and ice-sheet velocity and elevation change. The CDS also contains lake water level and temperature ECVs, as well as one from the biosphere, soil moisture, ECV. The data files are in NetCDF-4 format.

3.3.3 Climate projections

CMIP5 and **CMIP6** climate data are global climate model simulations produced by international research institutions as part of the Coupled Model Intercomparison Project (CMIP). The datasets provide projections of historical periods and future climate change under different scenarios of greenhouse gas emissions. CMIP5 data covers the period from 1850 to 2100, while CMIP6 data covers the period from 1850 to 2300. The data files are in NetCDF-4 format.

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

EURO-CORDEX regional climate data is a dataset of high-resolution regional climate model simulations for Europe, produced by a consortium of European research institutions. The dataset provides projections of future climate change at a regional scale, with a resolution of 12.5 km. EURO-CORDEX data covers the period from 1950 to 2100 and is used in climate research, impact assessments, and adaptation planning at the regional level.

3.3.4 Climate impact indicators

The CDS also contains climate impact indicators, mainly produced from Sectoral Application activities within C3S. A Climate Impact Indicator (CII) is a measurable parameter or index computed from quantitative data from climate models and/or observation data that illustrate aspects of the historical state of the climate and/or of future climate change. These indicators help scientists, policymakers, and the public understand and monitor the impacts of climate change on society and the natural environment. CII are often based on defined criteria by expert teams (ETCCDI, ET-SCI, and ECA&D) and are based on well-known quantitative data derived from Essential Climate Variables (ECVs); gridded climate model data, reanalysis and/or observations.
Several activities undertaken in C3S have focused on the development of climate impacts indicators for the use in domain of climate adaptation. The datasets that underpin the European Climate Data Explorer are derived from reanalysis dataset and model simulations data hosted on the Copernicus Climate Data Store (CDS). These indicators describe how climate variability and change of essential climate variables can impact sectors such as health, agriculture, forestry, energy, tourism, or water and coastal management.

Those indices are relevant for adaptation planning at the European and national level and their development was driven by the European Environment Agency (EEA) to address informational needs of climate change adaptation national initiatives across the EU and partner countries as expressed by user requirements and stakeholder consultation. The indices cover the hazard categories introduced by the IPCC and the European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC-CCA). They are also made available interactively through CDS public visualisation apps on the European Climate Data Explorer hosted on EEA's Climate-adapt site and in the CDS applications catalogue.

The indices are either downloaded from the CDS where available or calculated through a specific python workflow. In this way both the calculations and the resulting data are fully traceable. As they come from different datasets the underlying climate data differ in their technical specification (type and number of climate and impact models involved, bias-corrected or not, periods covered etc.). An effort was made in the dataset selection to limit the heterogeneity of the underlying dataset as ideally the indices should come from the same dataset with identical specifications.

The indices related to temperature, precipitation and wind (20 out of 30) were calculated from atmospheric variables in the same datasets: 'Climate and energy indicators for Europe from 2005 to 2100 derived from climate projections', and 'ERA5 hourly data on single levels from 1940 to present'. The other indices are directly available from CDS datasets generated by specific theme projects.

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

The CIIs can describe impact of global climate change, trace climate hazards at regional to global scale, assess sensitivity of ecosystems and society to climate change, and can be used in raising awareness and informing climate change adaptation policies and actions. Together with socio-economic data, CII are commonly used to help inform climate risk assessments.

Depending on the outputs of the VALORADA gaps analysis and feedback from the demonstrator regions additional updates to the 'Climate and energy indicators for Europe from 2005 to 2100 derived from climate projections' may be possible. The dataset could be updated to include multi-model statistics, predefined reference periods and future scenarios in addition to additional data formats (included those commonly used in GIS) to facilitate use by the broader adaptation community. In addition, tools such as NETCDF to GeoTiff converter, as has been implemented in CLIMAAX, could convert NETCDF, to a format more commonly used in the geographical information system user community – GeoTIFF. In the future, to aid with data ingestion, the converter could be imbedded in the VALORADA GITHUB repository, and ultimately earthkit (non-VALORADA activity), and supported with Jupyter notebooks to allow further uptake of quality assured climate data. Such approaches could be further explorer in phase 2 of VALORADA, should this be taken forward.

3.3.4 Climate Atlas

The Copernicus Interactive Climate Atlas (C3S Atlas) is a web-based data visualization tool that enables users to explore past, present, and future climate data. Developed by C3S and Spanish researchers, it provides high-resolution reanalyses and projections, focusing on regional climate impacts to support policymakers, researchers, and the public.

Key features and capabilities that were relevant to VALORADA include:

- Data Sources: It utilizes data from the C3S Climate Data Store, including the ERA5 (global) and ERA5-Land (land) reanalyses, E-OBS (Europe observational), and CORDEX (regional projections).
- Regional Focus: It offers high-resolution projections for Europe (12.5 km) and global coverage (25 km), allowing users to create custom regional selections.

The Atlas was designed to complement the IPCC interactive atlas, offering more regular updates and specific European regional analysis.

3.3.5 Environmental remote sensing data

The VALORADA Results Inventory (Deliverable 6.3) lays out the typology of datasets that have so far been used in each of the demonstrator regions. Along with the processed climate indices, satellite remote sensing data has been identified as a main source of environmental data exploited. The results inventory has collated several open access satellite remote sensing data sources. These include Landsat-8, Sentinel 2 A/B satellite imagery providing multispectral imagery, thermal data and derived products; such as soil erosion, forest fire monitoring and coastline monitoring. Using open access sources positions FAIRness as a key framework in the

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

implementation of the demonstrators and extends the longevity and impact of the tools developed for climate adaptation and ensures a legacy is built around the project.
The results and output produced within the project harnessing such data will maintain this approach ensuring free and open access wherever possible in order to maximise the equity, efficiency, transparency and collaboration and to and empower the local regions to plan for a climate resilient future.

The spatial resolution, temporal frequency, and geospatial extent will be detailed in the documentation associated with each output of the project. The output developed by the tools will be utilizing the EO data at their core and will be developed further in the next iteration of the data management plan.

3.3.6 Socioeconomic data

Social and economic data pertaining to the local regions are an important and key aspect of the VALORADA project. These data are usually collected by the local or national agencies or may be sourced from European data platforms. Such data are usually more restrictive due to the sensitive nature of the data collected, for example local datasets on health or poverty and distributions of sensitive populations (age groups 0-15 years and 65+). As such, care must be taken to ensure restricted data remains in compliance with the licencing restrictions, local laws, and data agreements controlling the permitted uses of the data. Data should be aggregated and de-identified wherever possible and where required. The output should be tested for anonymity, and that any personally identifiable information cannot be re-engineered. The procedures and methods put in place to anonymize the data shall be well documented. In the case that the data cannot be shared, efforts must be made to ensure that the metadata describing them are openly accessible following the FAIR principles. This may be in the form of an independent machine and human accessible metadata file or alternatively as an entry in the data catalogue (Section 3.2) which will be created as a deliverable of the VALORADA project. Appropriate security measures in line with the Data Protection legislation should be enacted. These may include Privacy Impact Assessments, encrypting data, anonymising data or drawing up Data Sharing Agreements. Any personal data will be processed in full accordance with GDPR 2016/679.

Partners and downstream users of the VALORADA project's results should ensure that the use and exploitation of any restricted data forming part of the project output is in full compliance of the licencing requirements and align with the ethical guidelines. Access to such data should be limited to authorized personnel and the data encrypted for storage and transmission. The management plans of the output that will be produced as part of the project will be developed further in the next iteration of the data management plan alongside the implementation phase of the project.

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

3.4 Data formats and conventions

Common data formats for data held in the CDS, and those used in the climate science community, are NetCDF[10] and GRIB[11]. NetCDF is a format that is freely available and commonly used in the climate modelling community and GRIB is the WMO binary standard format for the international exchange of meteorological gridded data. The selection of these formats is based on the requirements of the archiving system (MARS) and the usual standards of the community. MARS requires data to be stored in GRIB format, whilst the NetCDF is a popular self-described file format favoured in the climate community. However, it is not expected that VALORADA partners or data users will require data in GRIB due to expertise in detailing with data in native GIS formats.

Although the above formats are preferred and fully supported, the CDS can serve other data formats. Comma separated values (csv) format is also offered for some tabular datasets in the CDS. The CDS does not currently contain any GIS related formats, however, data reformatting is possible with earthkit, allowing development of dedicated conversion tools if required (for example aggregating at NUTS 0-3 or other shapefiles, geojson or layers from GeoServers and other WMS sources).

In VALORADA, climate data inputs (i.e. those from CDS and other European portals) output will be encoded in NetCDF. However, outputs are expected to be CSV and GIS-related formats as these are the common formats used in the VALORADA demonstrators and are commonly used by those involved in preparation of adaptation plans / strategies at the local administrative level.

Table 1: recommended file formats to be used in the project for a number of common types of data.

Type of data	Recommended Formats
Geospatial data (static)	Geo-referenced TIFF (.tif, .tfw) ESRI Shapefile (.shp, .shx, .dbf, .prj, .sbx, .sbn optional) geojson
Geospatial data (dynamic)	NetCDF
Tabular data	Comma Separated Values (CSV)
Textual data	Markdown format (https://commonmark.org/) eXtensible Markup Language (XML)
Images	TIFF 6.0 uncompressed (.tif) JPEG or PNG
Audio	Free Lossless Audio Codec (FLAC) (.flac) MPEG-1 Audio Layer 3 (.mp3)
Video	MPEG-4 (.mp4)
Documents & Publications	PDF/UA, PDF/A or PDF (.pdf) MS Word & LaTeX

[10] https://www.unidata.ucar.edu/software/netcdf

[11] https://library.wmo.int/doc_num.php?explnum_id=11283

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

Data in CDS follow strict quality control and guidance when it comes to the FAIR principle and metadata. It is fully INSPIRE compliant. Access to these data is provided via standard interfaces and is provided in formats complying with OGC standards, CF standards and regular metadata documentation protocols.

3.5 Data and software repositories

The project aims to leave input datasets in their original repositories wherever possible. This avoids creating redundant copies of the data and increases the efficiency of data storage. The project focusses on developing the tools to access and use this data in their original formats. Where possible, the relevant programming scripts and methodologies that allow the required processed data to be unambiguously re-created from the source datasets will be made freely available.

The long-term plan for storage of the data produced in envisaged to be within the existing European data access portals. Here, data may be accessed long after the duration of the project and be searchable based on the available metadata. Should there be sufficiently strong user demand identified, a few selected datasets may be made available through the CDS repository. The final decision regarding publication rests with the C3S management and the formal acceptance process be successfully completed.

Software Repository and **Version Control**

Software tools developed within the VALORADA project have been released as open source as far as possible, in line with the principles of transparency, reproducibility, and reusability. The primary platform for hosting, managing, and disseminating the project's software developments has been GitHub, a widely used web-based platform that supports collaborative software development and distributed version control: https://github.com/valorada

Version control has been implemented through Git, enabling systematic tracking, documentation, and management of all changes to the software. Collaborative workflows have been facilitated through branches, pull requests, and issue tracking, ensuring transparency, peer review, and quality assurance throughout the development process.

The project has applied FAIR principles (Findable, Accessible, Interoperable, and Reusable) to software management wherever feasible. Repositories have been made findable through clear naming conventions, persistent URLs, and, where relevant, indexing and linkage to external catalogues. They have been accessible via open repositories with well-defined access conditions, ensuring that users can retrieve code and associated resources without unnecessary barriers.

To enhance interoperability, software has been developed using widely adopted programming languages, standard data formats, and documented interfaces where

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

applicable. Dependencies and environments have been explicitly specified to facilitate integration into external workflows and infrastructures. To ensure reusability, repositories include comprehensive documentation such as README files, installation instructions, usage examples, and guidance on configuration and extension. Software has been versioned following established conventions (e.g. semantic versioning), and stable releases have been preserved to support reproducibility.

Where appropriate, releases have been archived and assigned persistent identifiers (e.g. DOIs via Zenodo), enabling citation and long-term traceability of software outputs. Open-source licences have been applied wherever possible to clarify reuse conditions and encourage uptake beyond the project consortium.

GitHub has also provided a collaborative environment supporting community engagement, allowing users to follow repositories, report issues, and contribute improvements. This has fostered broader participation and increased the visibility and impact of VALORADA software outputs.

In cases where full open publication has not been possible (e.g. due to third-party dependencies, licensing constraints, or security considerations), restrictions and access conditions have been clearly documented.

The ECMWF software project, earthkit, is also available through GitHub and accepts contributions of open-source software tools where a strong use case is identified in which the benefits of the software contribution extend beyond the scope of the project.

3.6 Data security and ethical impacts

Most of the data used and produced in VALORADA was free and open access as much as possible thereby minimizing the security implications. Nevertheless, each partner was responsible for managing the security of their data and tools. Similarly, it was strongly encouraged that the software tools developed within the project should also be open source, as far as possible. It was envisaged that any data produced as part of the project will be deposited in a FAIR compliant and open access data repository for the duration of the project and into the future for a predefined number of years.

The majority of European data access portals, including the CDS, require users to sign up and agree to the data usage terms and conditions as well as setup password access to the data. Access to the CDS require user credentials to create a free account. This is to monitor usage statistics for reporting purposes and to prevent malicious use of the compute resources. Project partners in VALORADA will be expected to create an account to access data. User support is available if required.

In the case where the project is required to collect restricted data, including proprietary data from the demonstrator regions, a data sharing agreement was in place with the data provider,

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

detailing how the data will be accessed, shared, processed, and acknowledging any applicable restrictions or licences.

All restricted access data should have been uploaded to the VALORADA repository, together with the appropriate metadata and attribution, and stored in specifically created folders protected by authentication. The access rights to this folder were established by the manager of the repository and can be allocated or denied to specified user groups or individuals within the project.

Data collected, processed, and published as part of VALORADA followed procedures that comply with the General Data Protection Regulation (GDPR). GDPR applies in all member states of the EU. The procedures enacted by VALORADA complied with GDPR as a minimum, or with national/regional regulation and with local customs and values. Where legal stipulations of countries outside of the EU are more stringent, the stricter definition will be applied (which is not the case in VALORDA).

3.7 Version control

All appropriate outputs developed within the VALORADA project should have considered version control, especially the data and software tools, to enhance traceability of the project's output. Version control is a critical component of effective dataset and software management, as it provides a systematic mechanism for tracking changes, supporting collaboration, and ensuring reproducibility. By maintaining a secure and well-documented record of modifications, version control enables teams to identify, review, and, where necessary, revert to previous versions in the event of errors. It also prevents the accidental overwriting of work, preserves data integrity, and strengthens transparency and auditability throughout the project lifecycle. It was recommended that data files must be tagged with the version number in the filename and in the metadata. All tools and software will also be assigned versions and be made available through open access portals and if appropriate tagged with version control software.

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

4. Addressing the FAIR principles in the context of VALORADA

4.1 Making resources findable

Making data findable involves ensuring that data is discoverable and identifiable by a persistent identifier, and that rich metadata is provided to allow for easy discovery. In order to achieve this, the data should be deposited in a repository that will assign a globally unique and persistent identifier with a registry service (such as https://doi.org). The data produced in the project should also be accompanied by metadata that follows the domain-specific standards and includes the dataset's globally unique and persistent identifier in the metadata. The guidance will be provided to the pilot partners for their data management.
In cases where metadata standards do not exist, for example when creating cross disciplinary datasets, it was recommended that the project would outline what type of metadata will be created and how it will be created. Search keywords will also be provided in the metadata to optimise the possibility for discovery and potential reuse. Additionally, the metadata should be offered in a way that can be harvested and indexed. This will enable national and European data portals to index and harvest the metadata, which will make the VALORADA data more easily discoverable and accessible to a wider audience.
Ultimately, making data and other digital resources findable is crucial for enabling effective data sharing and reuse, which can lead to more impactful research and innovation during and after the project.

4.2 Making resources accessible

To make the data produced by the VALORADA project more accessible, all data collected and generated throughout the project will be stored on secure servers with proper backup procedures in place to prevent data loss or corruption. Unless partner institutions use local data that cannot be shared, all data generated by the VALORADA project will be publicly available by default.

The project's data and software tools will also be made available to the wider scientific community through open data platforms and repositories that include appropriate metadata and documentation to facilitate data reuse and citation. The metadata should persist even when the data are no longer retained or available to ensure continued provenance and traceability.

For depositing data which accompany research papers, we investigated different online repositories, including Zenodo[12] and Figshare[13]. Zenodo is OpenAIRE's open-access repository for EC-funded research that was developed with the FAIR principles at its core. Zenodo provides barrier-free access to research outputs by allowing the users to easily share datasets in various sizes and formats, whilst providing flexible licencing and access to the data. Meanwhile, Figshare allows users to make their research outputs available in a citable,

[12] https://zenodo.org

[13] https://figshare.com

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

shareable, and discoverable way. Both repositories provide data identifiers and services are available for uploading and downloading the data via open REST API.

Should any of the datasets produced during the project prove to be useful to the wider European community, they can be proposed to become deposited in well-established, domain-specific data repositories, for example, the CDS under the FAIR principles.

The project endeavours to make the data as accessible as possible. Care will be taken when selecting datasets to use in order to make sure the licencing restrictions allow the data to be open access, although certain data may not be openly available due to ownership or other constraints. Any data produced as part of the VALORADA project will be accessible through free and standardized access protocols, and efforts will be made to make the data both human and machine accessible.

All data produced or derived products will be complemented with rich metadata that is both human and machine readable. It will be deposited in publicly available repositories.

This final DMP recommends that for the final public deliverables, data and tools VALORADA utilises Zenodo OpenAIRE's open-access repository. Zenodo is purposely for EC-funded research and was developed with the FAIR principles at its core.

4.3 Making data interoperable

The project aims to make the data and software tools produced and used interoperable within and across disciplines. To achieve this, established community-endorsed best practices will be followed, such as using common and widely accepted standards and formats, providing rich metadata, using persistent identifiers, and making the data openly available wherever possible. The project will follow internationally recognised standards. Such standards must be open (i.e. non-proprietary), managed by recognised international standardisation bodies (e.g. ISO, WMO, OGC, etc.), and any de-facto standard open-source existing software should be able to read and write files of these standards.

By using controlled vocabularies, it will be easier to compare and combine data from different sources. Mappings to more commonly used ontologies should be provided in case project-specific ontologies or vocabularies need to be generated. The project will also make the generated ontologies or vocabularies openly available for reuse, refining, or extending. In addition, contextual knowledge of what is being offered in the dataset will be included in the metadata with the use of qualified reference. Links between datasets, including whether the dataset is built upon another dataset or complementary information is stored in other catalogues, would be shared in the qualified references, and ultimately leads to an enriched delivery of contextual knowledge of the dataset.

Ensuring interoperability between climatic and socio-economic datasets was identified as of particular significance in the context of the project. Wherever possible the project should ensure that domain specific standards with controlled vocabularies are used with

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

standardized terms for categorical data (e.g. ISO country codes, INSPIRE vocabularies), standardized formats for dates (e.g. ISO8601 YYYY-MM-DD) and geographical data are used. Additional efforts should be made to make consistent the spatial scales by converting data to a common coordinate reference system (WGS 84). For local regions in a European context, Nomenclature of Territorial Units for Statistics (NUTS[14]) is a geocode standard that divides the European Union (EU) into regions for statistical purposes and may be used to spatially harmonize climate and non-climate data. Boundary shape files should be attached or easily available should custom regions be used.

4.4 Increased data re-use

The aim of FAIR data is to optimize the reuse of data. To achieve this, metadata and data should be well-described so that they can be replicated or combined in different settings. This means that the data and metadata are richly described with a plurality of accurate and relevant attributes, are released with a clear and accessible data usage license, are associated with detailed provenance, and meet domain-relevant community standards.
To promote FAIR principles, we propose that the data usage licence shall be under a Creative Commons license[15], where practicable, allowing the creators to retain copyright whilst allowing others to legally share and reuse the data under copyright law. The specific Creative Commons licence shall be decided on an individual basis under the assumption that the effort is towards using the most permissive licence deemed acceptable, for example, CC-BY-4.0 or CC-BY-NC-4.0 (if non-commercial).

Making the project's output reusable not only encourages a shared responsibility for developing software tools, but also stimulates further uptake of the project's data in the wider community through continued use and uptake in new projects and community activities.

5. How has VALORADA adopted FAIR principles?

The effort required to make relevant data FAIR is included in the overall budget of the VALORADA project. TerraNIS, as tools work package lead, and HEREON, as project coordinator, hold overall responsibility for the successful delivery of the project and alignment with FAIR principles. ECMWF has primary responsibility for the preparation, maintenance, and delivery of the DMP. ECMWF's effort within VALORADA is largely dedicated to the implementation and regular updating of the DMP. All project partners contribute to the effective implementation of the data management plan, either by supporting its overall execution or by ensuring that their project outputs and contributions comply with the principles and requirements defined therein.

In this context, FAIR principles have been a central consideration in the VALORADA project since the mid-term review. The interim DMP has been used to guide the project partners to

[14] https://ec.europa.eu/eurostat/web/nuts

[15] https://creativecommons.org/share-your-work/cclicenses/

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

consider FAIRNESS when producing tools, data and catalogues, which are key, user-oriented outputs of the project.

The key project outputs considered in this version of the DMP, and that have considered FAIR principles are:

- GeoNetwork Metadata Catalogue
- VALORADA Catalogue
- Jupyter Notebooks
- Visualisation Tools (TerranNIS)

GeoNetwork metadata catalogue

The GeoNetwork metadata catalogue was developed considering compliance with the FAIR data principles. All datasets and services are documented using structured, standardised metadata in a searchable catalogue, ensuring they are easily **findable**. Metadata is **accessible** via an open web interface without restrictions, with direct links to data downloads where applicable. Interoperability is supported through the use of **INSPIRE-compliant geospatial metadata standards**, enabling integration and reuse across platforms. To maximise **reusability**, metadata records include clear information on data provenance, calculation methods (where relevant), ownership, update frequency, and applicable licensing or usage constraints, allowing users to confidently reuse the data.

GitHub – VALORADA Catalogue

GitHub provides a convenient platform for making data, code and other project outputs publicly accessible. Such an approach had been adopted in VALORADA. Within the scope of the VALORADA project, this repository is intended to serve as a central hub for all key resources that are mobilised, developed, or adapted over the course of the project. By consolidating these materials in a single, user-friendly space, the VALORADA GitHub repository ensures broad accessibility for a diverse range of stakeholders, including researchers, local and regional authorities, and practitioners facing similar challenges. This approach facilitates straightforward consultation and supports the effective reuse of project outputs and goes a long way to made VALORADA outputs FAIR.

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

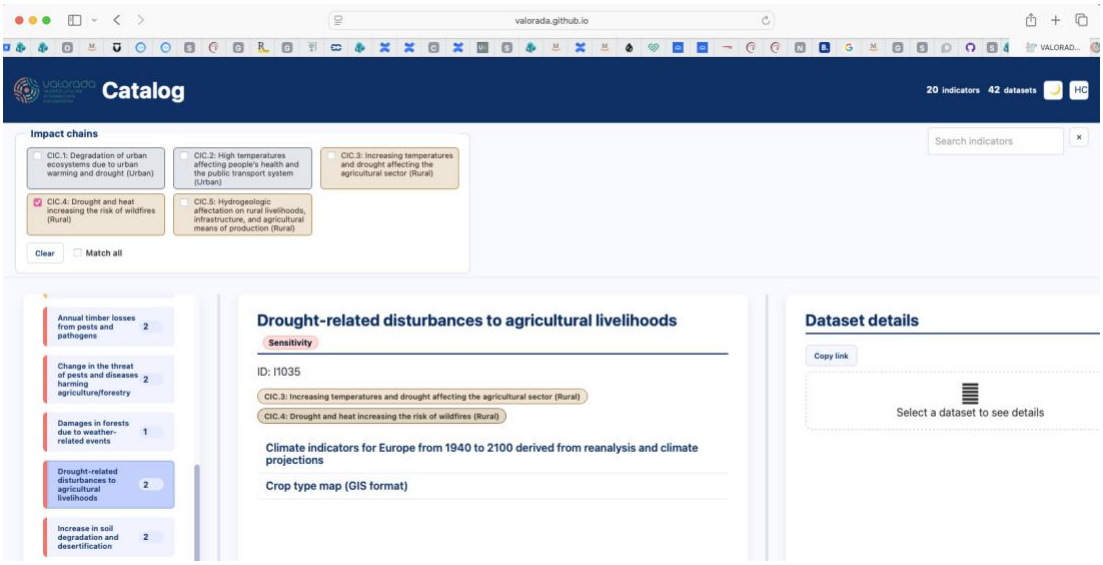


Figure 1. The VALORADA catlogue as prespected in the VALORADA GitHub repository.

Jupyter Notebooks

Jupyter notebooks have been developed in the context of VALORADA to support the use of climate data, promote good practice and showcase how open-source data can be used to support regional climate risk and vulnerability assessment. The notebooks, which have adopted DIATAXIS framework, which is a systematic, user-centric approach to technical documentation. It organises documentation into four distinct types based on the user's needs—**tutorials, how-to guides, technical reference, and explanation**—rather than just the structure of the software. This approach allows VALORADA to support intermediaries access climate data from C3S and showcase how the approach adopted in VALORADA can be made scalable to other regions and climate hazards.

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

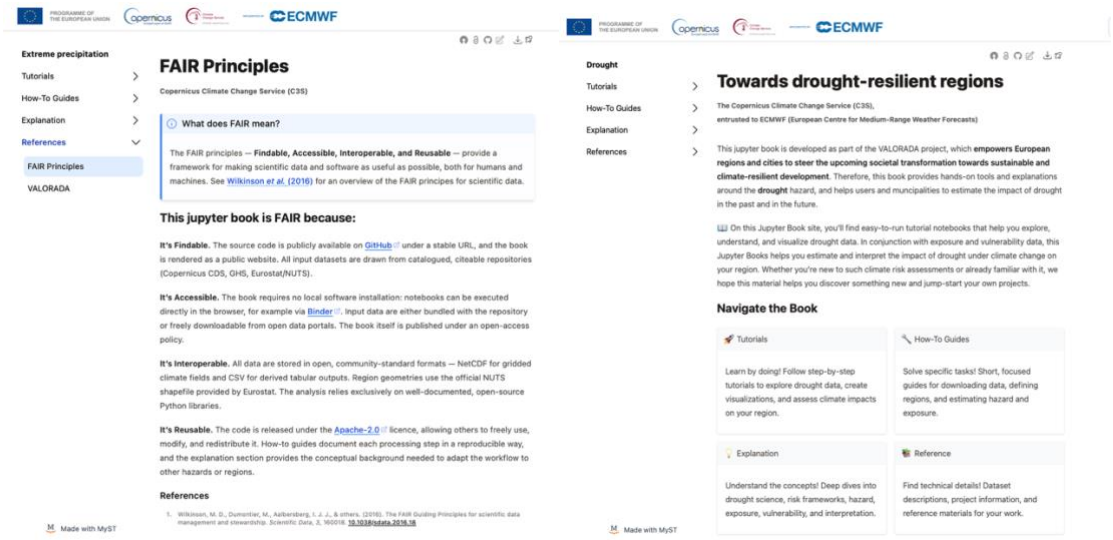


Figure 2. The Jupyter Notebook that has been developed as part of the VALORADA output, supporting project partners and intermediaries to adopt good practice, support them access climate data in the Climate Data Store, and undertake climate impact assessments.

Jupyter Notebooks are not inherently FAIR (Findable, Accessible, Interoperable, Reusable), but when developed following agreed best practices they can effectively support FAIR-aligned project outputs. Their ability to integrate code, results, and narrative makes them valuable for documenting workflows for various audiences provided that appropriate considerations are applied to ensure transparency and reproducibility.

Findability will be ensured in VALORADA by publishing the notebooks in public VALORADA GitHub repository and archiving stable versions in Zenodo, where they will be assigned persistent identifiers (DOIs). This enables reliable discovery, citation, and long-term access independent of the development platform (ecmwf-training.github.io).

Accessibility challenges related to proprietary environments or missing dependencies are addressed by using open formats, documenting software requirements, and managing execution environments through reproducible dependency specifications (e.g. Conda environments or containers). Public repositories have been used to ensure barrier-free access for users.

Interoperability is supported by adopting open standards and widely adopted tools, primarily Python. All notebooks include clear Markdown documentation describing the analytical logic, assumptions, and data usage, allowing workflows to be understood and transferred across disciplines and institutions.

Reusability, the most significant challenge for notebooks, is enhanced by enforcing linear, top-to-bottom execution, avoiding hidden state, and clearly referencing all data sources.

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

Comprehensive documentation and structured code ensured that the results can be reproduced and adapted beyond the original project context.

Visualisation Tools (TerranNIS) - Climate dashboard (ArcGIS Online):

The Climate Dashboard adheres to the FAIR principles by providing a publicly accessible and well-structured online platform. Information is findable through clearly organised themes, maps, indicators, and demonstrator areas that help users quickly locate relevant content. It is accessible via any standard web browser, with no specialist software required, and includes links to underlying data layers and metadata where available to ensure transparency. Interoperability is supported through the use of ArcGIS Online web services and standard geospatial formats, allowing integration with other GIS platforms. Reusability is enabled through clear indicator definitions and documented data sources, complemented by easy access to the GeoNetwork metadata catalogue for full dataset descriptions, supporting replication, stakeholder engagement, and further analysis by external users.

Recommendations & Next Steps

Governance of GitHub fork management in open-source projects is commonly based on transparent contribution processes, clearly defined maintainer authority, and technical controls that balance openness with code quality and project management. Within the VALORADA project, these principles have been implemented through documented contribution workflows and formal governance structures applied across both the ECMWF upstream repository, in case of the Jupiter notebooks, and the VALORADA GitHub fork. Contribution following the GitHub recommendation, have been established and made available within the repositories, specifying standards for code structure, documentation, testing, and submission procedures.

All proposed changes originating from forks have been required to be submitted via pull requests, ensuring full traceability and reviewability. These pull requests have been subject to structured peer review by designated maintainers and reviewers, supported where applicable by automated testing pipelines and continuous integration checks. Branch protection rules have been enforced to prevent direct modification of main or release branches, ensuring that only validated and approved contributions are merged. This has safeguarded the stability of the upstream repository while enabling distributed and collaborative development.

The governance model has defined clear roles and responsibilities, including maintainers responsible for overall repository integrity, reviewers ensuring technical and scientific quality, and contributors providing code, documentation, and issue reporting. Decision-making processes for accepting, requesting revision, or rejecting contributions have been explicitly codified, ensuring consistency, transparency, and accountability. In cases of conflicting proposals or complex changes, decisions have been documented through issue discussions and review records, maintaining a transparent audit trail.

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

Specific attention has been given to the management of forks to minimise fragmentation and ensure alignment with the main codebase. Regular synchronisation between the VALORADA fork and the ECMWF upstream repository has been maintained, and contributors have been encouraged to rebase or update their branches to reflect the latest upstream changes. Policies have been applied to discourage long-lived divergent forks unless justified by clearly defined use cases, thereby preserving coherence of the software ecosystem and reducing duplication of effort.

In line with FAIR principles for research software, governance processes have also supported **findability, accessibility, interoperability, and reusability**. All contributions, discussions, and decisions have been documented within GitHub's issue tracking and pull request system, ensuring that development history remains findable and accessible. Standardised workflows and coding practices have improved interoperability across components and facilitated integration with external tools and infrastructures. The rigorous review and documentation requirements have strengthened the reusability of the software by ensuring clarity, reliability, and consistency.

As recommended in GitHub's official documentation and well-architected governance guidance, these measures are supplemented by auditability mechanisms, consistent enforcement of review requirements, and regular policy revision, aligning fork management with wider open-source governance principles such as transparency, accountability, and community sustainability [16] [17] [18]

One of the core FAIR principles—F1—states that "(meta)data are assigned a globally unique and **persistent identifier**." This requirement is critical to long-term data accessibility and citability. If a dataset is cited and its storage location later changes (for example, if it is migrated from GitHub to another service, or data within a repository), the citation should continue to resolve to the correct resource. For this reason, direct links to repositories do not satisfy the persistence requirement. Instead, the dataset should be referenced using a persistent identifier, such as a Digital Object Identifier (DOI), which can in turn resolve to the current hosting location.

At present, many repositories, including GitHub does not natively assign persistent identifiers. Therefore, an external service must be used to obtain and manage such identifiers. GitHub does provides guidance on this process, including use of Zenodo to

---

[16] GitHub Docs, *Managing and standardizing pull requests*, GitHub, 2026. Available at: https://docs.github.com/en/pull-requests/collaborating-with-pull-requests/getting-started/managing-and-standardizing-pull-requests

[17] GitHub Docs, *Creating a pull request from a fork*, GitHub, 2026. Available at: https://docs.github.com/en/pull-requests/collaborating-with-pull-requests/proposing-changes-to-your-work-with-pull-requests/creating-a-pull-request-from-a-fork

[18] GitHub Well-Architected, *Governance checklist*, GitHub, 2025. Available at: https://wellarchitected.github.com/library/governance/checklist/

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

provide DOIs for GitHub repositories, as documented at: https://docs.github.com/en/repositories/archiving-a-github-repository/referencing-and-citing-content. This guidance supports recommendation made earlier in the DMP to promote the use of repositories such as Zenodo to maximise FAIR compliance.

It is important to consider that Zenodo can only archive publicly accessible GitHub repositories; therefore, any repository intended for archiving, including VALORADA data and metadata catalogues, must be set to public visibility prior to initiating the process. In cases where the repository is owned by an organization rather than an individual, additional administrative steps may be required, as the organization owner must approve access for the Zenodo integration before archiving can proceed. Furthermore, it is essential to include an explicit license file within the repository. Providing a clear license ensures that users understand the conditions under which the archived materials may be reused, redistributed, or adapted, thereby supporting transparency, legal clarity, and responsible reuse of the work, which is also aligned to FAIR principles.

It is also recommended that Zenodo is used to make other VALORADA public deliverables and data accessible and FAIR. This recommendation is outlined in 4.2 Making resources accessible.

6. Practical FAIR Guidance for VALORADA partners

The VALORADA project has produced a wide range of outputs, including reports, scientific articles, software tools and data catalogues. It is imperative to make these outputs - FAIR (findable, accessible, interoperable, reusable). Each may be approached in a slightly different manner. FAIR output is important as it is a pre-requisite for the European funding but also improves the scientific research environment and adds value to the VALORADA project output by making sure the longevity of the results and reaching a broader audience through machines readability.

This section provides a short checklist of practical actions to support VALORADA data, tools, notebooks, and public documentation outputs to comply with the FAIR principles and the FAIR for Software recommendations and increase the uptake of project outputs after the closure of the project. These guidelines apply to datasets, data catalogues, software tools, workflows, notebooks, and documentation produced within the project.

1. Findable

- Assign a persistent identifier (DOI) to all final public outputs.
- Use Zenodo to archive releases of GitHub repositories and mint DOIs.
- Reference outputs using the DOI, not a direct GitHub URL.
- Include rich metadata describing:
    - Title, description, authors, version, date
    - Funding information (Horizon Europe, VALORADA)
    - Keywords relevant to climate adaptation and regional risk

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

- Ensure metadata is both human-readable (README) and machine-readable whilst adopting standard formats.

✓ FAIR F1–F4 | FAIR-Software F1–F3

---

2. Accessible

- Store public outputs in trusted, open repositories (e.g. GitHub + Zenodo).
- Ensure repositories are public before archiving with Zenodo.
- Use open and standard access protocols (HTTPS, APIs where applicable).
- If some data cannot be shared, publish open metadata explaining what exists and why access is restricted.
- Ensure metadata remains accessible even if data are no longer available.

✓ FAIR A1–A2 | FAIR-Software A1–A2

---

3. Interoperable

- Use open, community-accepted formats, as defined in the DMP:
  - NetCDF (climate and gridded data)
  - CSV (tabular data, catalogues)
  - GeoTIFF / GeoJSON / Shapefile (geospatial data)
  - Markdown (documentation)
- Apply recognised standards and conventions:
  - ISO 8601 (dates)
  - WGS84 (coordinates)
  - NUTS codes (European regions)
- Use controlled vocabularies and clearly document any mappings when combining datasets from different domains.

✓ FAIR I1–I3 | FAIR-Software I1–I2

---

4. Reusable

- Include a clear licence with every output:
  - Data: preferably CC-BY-4.0
  - Software: recognised open-source licence (e.g. MIT, Apache-2.0, GPL)
- Document provenance:
  - How data were generated
  - Input sources and processing steps

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

- Apply version control:
  - Tag software releases
  - Record version numbers in data files and metadata
- Provide sufficient documentation to support reuse by third parties.

✓ FAIR R1–R1.3 | FAIR-Software R1–R2

---

5. Software-Specific Good Practice (FAIR for Software)

Every VALORADA software repository should include:

- A README explaining purpose, installation, and usage
- A CITATION file explaining how the software should be cited (with DOI)
- Clear versioning and release notes
- Documentation of inputs, outputs, and dependencies

✓ FAIR-Software F2, R1

---

6. Final FAIR Check (Before Publication)

Before releasing an output, confirm:

1. It has a DOI
2. It is in a trusted repository
3. Metadata and README are complete
4. Licence is explicit
5. Formats and standards are open
6. Version number is clear

If 1-6 are addressed, the output is **FAIR-aligned.**

7. Conclusions

The final version of the DMP builds on the principles defined in the interim DMP. This version set out the management of the datasets used and produced in the VALORADA project in the context of FAIR. In this iteration of the DMP, the initial details of the data and output used in the VALORADA project have been collated and the requirements tuned as the project has evolved and tangible outputs have been produced. It represents a transition from the more generic concepts to the more specific requirements for each of the VALORADA outputs that have been within the project.

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

In addition, the final version of the DMP provides a more detailed plan for the long-term plan for storage of the data and software outputs under the consideration of the FAIR principles to maximise the project's legacy and value after the successful closure of the VALORADA project. To this end, practical guidance and 'cheat sheets' have been introduced, which should support project partners with final preparations to ensure project legacy and FAIR compliance.

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