Ref. Ares(2025)6243710 - 31/07/2025

Climate-Resilient Development Pathways in Metropolitan Regions of Europe

Deliverable 8.6 - Data Management Plan (DMP) - Interim 2

July 2025

Grant Agreement Number 101137851

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Deliverable No:	8.6
Deliverable nature:	Report
Work Package and Task:	WP8 – Task 8.2
Dissemination level:	PU – Public
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Contractual submission date:	31 July 2025
Actual submission date:	31 July 2025

Technical References

Project title	Climate-Resilient Development Pathways in Metropolitan Regions of Europe
Project acronym	CARMINE
Grant agreement number	101137851
Instrument	Horizon Europe
Call	HORIZON-CL5-2023-D1-01
Starting date of the project	1st February 2024
Project duration	48 months

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Document history

Version	Date	Description
1.1	16 July 2025	First draft submitted for consortium review
1.2	28 July 2025	Second draft submitted for consortium review
1.3	29 July 2025	Final review
1.4	31 July 2025	Layout review

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Abbreviations

Abbreviations	Full wording
A&M	Adaptation and Mitigation
API	Application Programming Interface
CA	Consortium Agreement
CEN	European Committee for Standardisation
CSA	Case Study Area
CENELEC	European Committee for Electrotechnical Standardisation
CRAFT	Climate Resilience Assessment Framework Tool
D	Deliverable
DT	Digital Twin
DEM	Digital Elevation Model
DMP	Data Management Plan
DoA	Description of Action
DPO	Data Protection Officer
DSS	Decision Support System
ET	CARMINE Ethics Team
EAB	CARMINE Ethical Advisory Board
FAIR	Findability', 'Accessibility', 'Interoperability' and 'Reusability' principles
FDMS	Federated Data Management System
GA	Grant Agreement
GDPR	General Data Protection and Regulation
IDSS	Impact-based Decision Support System
IPR	Intellectual Property Rights
LL	Living Lab
LAU	Local Administrative Units
M	Month

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MRE	Metropolitan Regions of Europe
MS	Milestone
NbS	Nature-based Solutions
NUTS	Nomenclature of Territorial Units for Statistics
OA	Open Access
OGC	Open Geospatial Consortium
PIs	Principal Investigators
PIDs	Persistent Identifiers
SDG	Sustainable Development Goal
SC-Hub	Stakeholder Community Hub
T	Task
UWG	Urban Weather Generator
WP	Work package

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Executive summary

This second interim version of the CARMINE Data Management Plan (DMP) presents the project's evolving strategy for the management, interoperability, and reusability of data generated and processed within the project framework. It builds upon the foundations laid in the first version of the DMP (D8.5) and integrates critical advancements resulting from work packages WP1, WP2, WP3, and WP4 activities, as well as stakeholder-driven developments such as the Living Labs (LLs) and the Stakeholder Community Hub (SC-Hub).

The DMP outlines the protocols, formats, standards, and repositories employed in the collection, processing, analysis, and dissemination of project data. It reflects the diversity and specificity of datasets required for CARMINE's Case Study Areas (CSAs), ranging from historical and projected climate data to urban exposure and socio-economic indicators. These datasets are sourced from authoritative repositories (e.g., Copernicus, Eurostat, national agencies) and further refined through harmonisation and downscaling protocols developed in the project (task T2.2).

This deliverable incorporates insights from the CSA protocols (milestone MS20), the modelling framework (MS19), and the Digital Twin (DT) architecture (D4.2), ensuring alignment between local-scale data requirements and the system-wide architecture of the Federated Data Management System (FDMS). It also describes the integration of datasets into the Impact-based Decision Support System (IDSS), highlighting their roles in scenario simulation and co-design processes in the Living Labs (deliverable D1.7 – Living Labs creation in case studies).

The updated DMP further elaborates on the application of FAIR principles (Findable, Accessible, Interoperable, Reusable) in data documentation and curation, detailing practices for ensuring findability, accessibility, interoperability, and reusability across all data lifecycle stages. Ethical and legal compliance, including General Data Protection and Regulation (GDPR) considerations, are also addressed in relation to both quantitative and qualitative data from stakeholder engagement activities (deliverables D1.1 – Target groups (stakeholders) engagement strategy and D1.8 – Functionalities of a Stakeholder Community Hub (SC-Hub)).

D8.6 serves as a dynamic instrument to guide data governance across CARMINE's interdisciplinary and multi-scale activities. It will be updated further in the final version to reflect integration of data needs related to the SC-Hub platform, DT operation, and the emerging data outputs from urban climate modelling and adaptation scenario design.

Key words

Data, format, FAIR, digital twin, living labs, stakeholder engagement, nature-based solutions, physical modelling, socioeconomic modelling, vulnerability, work packages, tasks, data flow, open access.

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Summary of updates

Deliverable D8.6 represents a significant advancement of the CARMINE Data Management Plan, expanding upon the foundations established in D8.5. It integrates key developments from the project's technical work packages and stakeholder activities, particularly those related to the DTs, the IDSS, and the SC-Hub. The document reflects improved alignment with FAIR principles, expanded data typologies, and enhanced metadata and interoperability practices (Fig. 1). Notable updates include a more detailed description of data types generated by modelling activities (WP2–WP3), enriched stakeholder-derived data inputs from LLs and SC-Hub (WP1, WP6), and implementation details of the FDMS (WP4). New sections also cover data format standardisation (e.g., NetCDF, GeoTIFF, GeoParquet), improved metadata protocols using ISO and INSPIRE standards, and licensing strategies for open data reuse. Furthermore, D8.6 outlines strengthening measures for ethical compliance, data security, and GDPR adherence, particularly in the context of stakeholder engagement. Roles and responsibilities for data governance have been clarified, including partner-specific infrastructures for secure storage and dissemination. Outputs such as modelling code, stakeholder interfaces, and simulation data pipelines are now described as reusable assets within the project's open-access and long-term data preservation strategy. Collectively, these changes reinforce CARMINE's commitment to transparent, ethical, and interoperable data management throughout the project lifecycle.

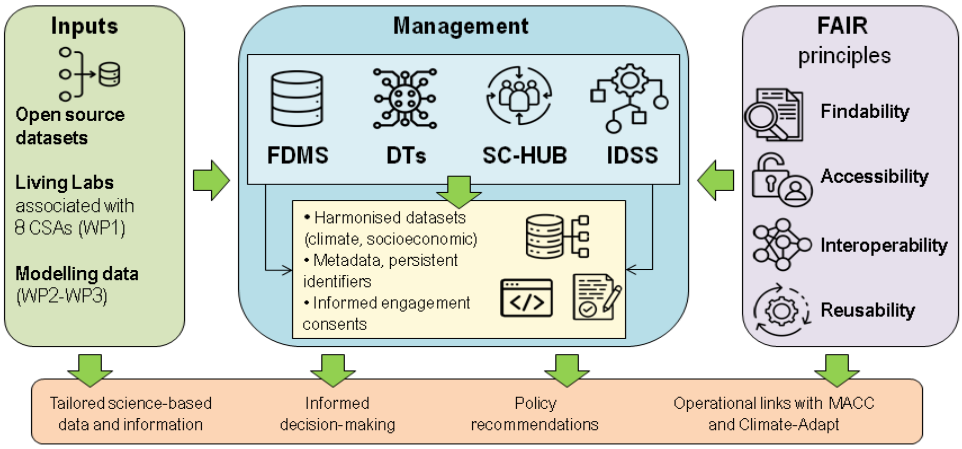

Figure 1. Graphical abstract of deliverable D8.6.

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Introduction

Deliverable 8.6 presents the second interim version of the DMP, providing a comprehensive update on how data is identified, acquired, structured, processed, and shared within the CARMINE framework. This version builds upon deliverable D8.5 (Data Management Plan – Interim 1) and reflects advancements achieved through WP1 (Stakeholder engagement and scenario co-design), WP2 (Climate and impact modelling), WP3 (Decision-support development), and WP4 (Digital Twin architecture and deployment).

The DMP aligns with FAIR principles and addresses data handling from multiple sources, including authoritative open datasets (e.g., Copernicus, Eurostat), stakeholder inputs from Living Labs (LLs), and simulation outputs from climate and impact models (e.g., ENVI-met, UWG). Special attention is paid to metadata harmonisation, data privacy (GDPR), and long-term usability of project-generated knowledge assets.

This deliverable ensures coherence between CARMINE's FDMS, DTs, the IDSS, and the SC-Hub, contributing to a shared architecture that supports both scientific integrity and societal impact. As a living document, this data management plan will be maintained and updated throughout the CARMINE project lifecycle, with changes and revisions made as necessary to reflect evolving project needs and address any emerging issues.

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1. DMP objectives and future updates

1.1. Objectives

This DMP defines the principles and procedures for handling data across the CARMINE project. It ensures that data generated, collected, and used within the project are managed in alignment with scientific standards, stakeholder needs, and FAIR principles.

The key objectives of the DMP are to:

- Establish a unified approach for data collection, documentation, harmonisation, and sharing across all CSAs, ensuring compatibility with the FDMS, DTs, the IDSS, and the SC-Hub.
- Ensure data interoperability using common standards and protocols, supporting integration of diverse datasets (e.g., climate, socio-economic, stakeholder input).
- Promote transparency, traceability, and reuse of datasets for scientific modelling, impact assessment, and decision support.
- Ensure compliance with legal and ethical standards, particularly regarding stakeholder engagement and LL activities.
- Enable long-term accessibility and transferability of data-driven outcomes for wider adoption across European metropolitan contexts.

1.2. Future updates

The DMP is a dynamic document that evolves alongside the CARMINE project to reflect the ongoing generation, use, and governance of data. It is continuously updated to incorporate new developments in data collection, processing, sharing, and reuse. Future iterations of the DMP will be delivered as D8.7 – Data Management Plan – Interim 3 (M36) and D8.8 – Data Management Plan – Final (M48), both of which will be made publicly available.

The final DMP will offer a comprehensive account of all data-related activities undertaken throughout the project, including data acquisition, storage, harmonisation, quality assessment, and strategies for post-project access and exploitation. Updates will also capture outputs from modelling activities, adjustments to data workflows, and ongoing integration with tools such as the IDSS. Furthermore, the DMP will be revised to reflect any changes in stakeholder needs, consortium policies, or relevant legal and ethical guidelines.

MeteoRo is the responsible partner for coordinating the drafting and maintenance of the DMP across the project timeline, ensuring it remains aligned with CARMINE's objectives and FAIR data governance standards.

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2. Data summary

The CARMINE project relies on the integration and processing of diverse datasets to inform climate risk assessments, support co-designed adaptation and mitigation (A&M) pathways, and enable digital innovations such as the FDMS, DTs, and the IDSS. This section provides an overview of the types of data collected, processed, and generated throughout the project, including their sources, formats, volume, and intended reuse. The data encompass a wide range of domains, from climate and environmental variables to socio-economic, infrastructural, and stakeholder-generated information, and are structured to meet both scientific and operational needs across the eight CSAs. By summarising the nature and flow of project-related data, this section ensures transparency in data handling practices and supports the long-term objective of making project outputs FAIR. This DMP supports the data strategy outlined in deliverable D4.1 (Data model and data management) by aligning data requirements with regional attributes such as urbanisation patterns, exposure profiles, and administrative boundaries. This ensures that the CARMINE data architecture remains responsive to the diversity of socio-climatic contexts across CSAs.

2.1 Data types

To fulfil its five specific objectives, the CARMINE project draws upon a diverse range of data from existing repositories, consortium members, and societal partners. Wherever possible, data are sourced under open or permissive licences. When additional data are required to implement and operationalise the co-designed methodologies, new datasets are generated at the CSA level through stakeholder engagement (WP1 and WP6 – LLs and SC-Hub), climate and impact assessments (WP2 and WP3), and urban-climate modelling activities (WP2). The project integrates and harmonises heterogeneous datasets and metadata from multiple sources and formats, including in situ observations, remote sensing, and model-generated outputs, across disciplines such as:

- Climate science (e.g., climate risk scenarios, hazard indicators, regional projections)
- Meteorology (e.g. weather forecast)
- Urban systems and land use (e.g., built-up area typologies, green-blue infrastructure)
- Administrative boundaries (e.g., LAU/NUTS)
- Topography (e.g., DEMs)
- Hydrology (e.g. rivers, lakes, watersheds)
- Transportation (e.g., roads, streets, sidewalks)
- Imagery (e.g., satellite, aerial)
- Statistics (e.g., demography, infrastructure components, perception analyses)
- Policy (e.g., qualitative and quantitative data from European, national and local policies)
- Economics and risk analysis (e.g., cost-benefit assessments, damage cost estimates)
- Data engineering (e.g., development of a harmonised, FAIR-compliant datasets)
- Stakeholder engagement (e.g., quantitative and qualitative data from LLs).

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A central focus of the project is tailoring model outputs and data workflows to match the knowledge needs identified through participatory processes conducted in the eight Metropolitan Regions of Europe (MREs). These co-creation activities produce actionable knowledge to inform the development of DTs and the IDSS.

As detailed in deliverable D4.1, the project undertakes a selection of regional indicators, including land use typologies, administrative structures, and socio-economic profiles, with direct implications for data selection and processing. As a priority, the project focuses on harmonised sources such as Eurostat's Urban Audit, the Urban Atlas, and CORINE Land Cover, which enable comparability across CSAs and cross-regional consistency. The data sources listed in this DMP are consistent with these pan-European databases, ensuring that regional datasets remain interoperable across project layers. The DMP reflects this by prioritising datasets compatible with the regional classification framework. Furthermore, common data standards (e.g., INSPIRE-compliant metadata, ISO geospatial protocols) are enforced to ensure quality across variable administrative and spatial data environments.

2.1.1. Data from available resources

The CARMINE project benefits from and further exploits the existing openly available data and knowledge. In line with the climate risk screening framework outlined in deliverable D1.2 (Report on climate change challenges), existing data sources integrated into the CARMINE project include gridded climate projections (e.g., EURO-CORDEX), reanalysis (e.g., ERA5), and national/European and global meteorological datasets. These data support hazard characterisation, especially for climate indicators such as heatwaves, droughts, extreme rainfall, and compound events. The milestone MS20 (Catalogue of climate data) emphasises the role of open-source geospatial data (e.g., CORINE Land Cover, GHSL, Urban Atlas, EU-DEM) combined with local administrative records (e.g., zoning, transport infrastructure, cadastral data) to define the baseline conditions. This process ensures high-resolution spatial coverage at the urban level (up to 100 m), critical for climate hazard mapping and vulnerability assessment.

Each CSA has conducted a detailed mapping of data needs and availability using a harmonised protocol established under the task T2.2. This protocol is documented in milestone MS20, which provides an inventory of core datasets across CSAs, covering:

- Climate data: historical observations (e.g., ERA5), regional climate projections (e.g., Copernicus Climate Data Store)
- Urban morphology and land cover: datasets from Urban Atlas, CORINE Land Cover, land use-land cover layers
- Exposure and vulnerability indicators: including population density, building stock, land use intensity, green space and infrastructure (water supply, sewage, health) availability.

A shared prioritisation matrix was developed across CSAs to identify the most relevant datasets for impact modelling, risk mapping, and policy assessment. This matrix supports consistency in data selection, ensuring local relevance and comparability across urban systems. To ensure technical compatibility and semantic consistency, the CSA protocol developed under T2.2 defines detailed methodological steps for accessing, processing, and harmonising baseline datasets, including:

- Retrieval from authoritative and open-access repositories (e.g., Copernicus, Eurostat, national archives)

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- Spatial harmonisation via resampling and reprojection (e.g., aligning resolutions and coordinate systems)
- Temporal interpolation/downscaling (e.g., converting daily data to hourly series)
- Thematic categorisation and alignment with the CARMINE metadata and tagging layer.

These procedures ensure that all inputs are compatible with the analytical requirements of the DT modelling engines and the stakeholder-facing SC-Hub platform (available at https://schub.carmine-project.eu/llm/#/llm/). They also enable traceability, reproducibility, and future reuse, in line with FAIR data principles.

The catalogue of available data resources over the CARMINE CSAs is presented extensively in the milestone MS20. This catalogue provides an integrated overview of climate datasets relevant to the CARMINE project. It serves as a pathfinder for identifying datasets that can support statistical model training, serve as benchmarks for model validation, and facilitate the testing of tools for urban modelling and hazard indicator assessment. For each dataset, the following technical details are included:

- Category: Type of dataset (e.g., reanalysis, dynamical/statistical downscaling, forecasts, gridded observations, station data, crowdsourced data, indicators),
- Domain & CSA Coverage: Geographic extent and relevant CARMINE CSAs,
- Description: Summary of the dataset,
- Spatial Resolution: Level of detail of datasets,
- Temporal Coverage & Frequency: Time span and data frequency (e.g., hourly, daily),
- Access Link: Direct link or contact information,
- Variables: Key climate variables available,
- Documentation: Technical notes or reference publications.

2.1.2. New data generated by the project

The CARMINE project generates new scientific data to support climate risk assessment and decision-making at local scale within the eight CSAs. These datasets are essential for developing DTs, the IDSS, and delivering core project outputs, including A&M pathways (WP1), climate hazard indicators (WP2), climate risk scenarios and the Climate Resilience Atlas (WP3), and science-informed policy recommendations (WP6).

New data are produced through downscaling of climate model outputs (WP2), socio-economic modelling (WP3), participatory engagement (WP1, WP6), and system integration via DTs (WP4). Together, these ensure that project outcomes are context-specific, scientifically robust, and co-designed with local actors. Main data generation streams are:

- Climate and urban modelling (WP2): Development of simulation chains for climate modelling (T2.2), Physical urban modelling at high spatial resolution, including Nature-based Solutions (NbS) for adaptation and mitigation (T2.3).
- Socio-economic modelling (WP3): Assessment of socio-economic vulnerability to climate change (T3.1), Modelling of climate-related costs and risks (T3.2, T3.3).
- Digital Twin operations (WP4): Data generation and harmonisation for integration into DT architectures.

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- Participatory co-design processes (WP1, WP6): Stakeholder-derived inputs through LLs, the SC-Hub and policy derived information (information from different policies).

As of M18, initial outputs include local climate risk indicators and first-stage parameterisation of urban physical processes (milestones MS19 and MS20). These inform the calibration of impact chains in WP3 and WP4 and support DT prototype development.

New datasets are also generated through stakeholder engagement activities conducted in LLs. These are defined in deliverable D1.7 and structured using harmonised metadata schemas, capturing stakeholder roles, thematic domains (e.g., urban flooding, heat stress, drought, water scarcity), and spatial attributes (e.g., urban green infrastructure components, land-use and land cover). Engagement-related datasets (deliverable D1.1) also include institutional affiliations and geographic influence, data responsibilities and prior project involvement, preferred communication channels and stakeholder relevance.

Each DT incorporates a tailored modelling pipeline for its associated CSA, fed by harmonised datasets from the FDMS. These data flows are structured via Application Programming Interface (APIs) developed in task T4.2 and allow seamless transmission of harmonised climate and socio-economic indicators into the DT engines. Outputs from these engines are used both internally (e.g., for IDSS integration) and externally (e.g., in stakeholder visualisation tools) (Fig. 2).

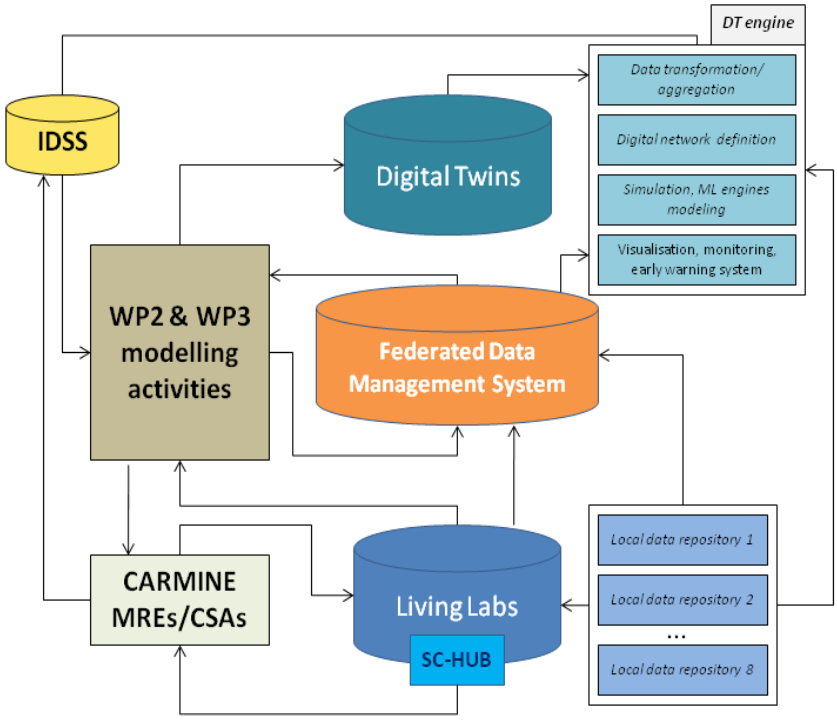

Figure 2. CARMINE data integration pathways.

The modelling framework established in WP2, as described in milestone MS19 (WP1 requirements input to the Modelling Framework of WP2 - Task 2.1), integrates both physical modelling (i.e., via Urban Weather Generator – UWG and ENVI-met) and system-based approaches (e.g., CRAFT – Climate Resilience Assessment Framework Tool). These models produce high-resolution datasets for climate hazard indicators (e.g., temperature extremes, heat

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waves) tailored for MREs. The outputs are essential for informing A&M pathways and are aligned with stakeholder priorities identified during co-creation processes.

2.1.3. Data derived from stakeholder engagement activities

Stakeholder engagement involves a wide range of activities designed to involve individuals, groups (also vulnerable), or organizations (public and private) who may affect or be affected by a project, policy, or decision, and are relevant for climate resilience building. In Carmine, these activities start with stakeholders mapping (the identification, profiling, and mapping of diverse stakeholder groups across all CSAs), communication and information sharing (platform of stakeholders, newsletters), consultation (workshops, interviews, surveys, focus group), collaboration and co-creation (geovisualisation activities for nature-based solutions prioritization), feedback and reporting (collecting feedbacks on different project results), and capacity building (increasing the awareness about integration of climate resilience in sectoral projects).

The extraction and use of data from these activities occur primarily through LLs and the SC-Hub, following the strategic approaches outlined in deliverable D1.1 and D1.6 (Living Labs Handbook). These mechanisms are essential to the identification of SE vulnerabilities (WP3) and DT co-development (WP4) which constitutes the basis for the co-design of the IDSS (WP5) and the formulation of policy recommendations (WP6).

While stakeholder engagement involves the collection of personal data (e.g., name, affiliation, contact information), CARMINE fully complies with EU data protection regulations (GDPR). No sensitive or special categories of data, as defined in Article 9 of the GDPR, are collected. Only data necessary for research and engagement purposes are gathered, and all processing activities follow ethical protocols, including the dissemination of a stakeholder consent form at the initial point of contact.

Each CSA hosts a context-specific LL, as described in deliverable D1.7, which serves as a participatory space for co-creation, scenario evaluation, and iterative feedback. These labs generate both qualitative and quantitative data on climate risks, local priorities, and adaptation pathways through structured activities such as stakeholder workshops, mapping exercises, and impact chain validations. Resulting data include survey results, transcripts, annotated maps, prioritisation matrices, and scenario rankings, all curated according to harmonised, CSA-specific templates.

Stakeholder interaction is further supported through the SC-Hub architecture (deliverable D1.8), which enables real-time data collection, participatory feedback on IDSS functionalities, and refinement of LL operational scenarios. This platform facilitates two-way data flows between stakeholders and the scientific teams, supporting both structured inputs (e.g., online feedback forms, scenario assessments) and unstructured contributions (e.g., workshop notes, discussion summaries). Beyond in-person engagements, this SC-Hub operates as a digital platform enabling stakeholders to upload evidence, interact with visualisations from climate and socio-economic models, and contribute knowledge continuously throughout the project. This ensures ongoing participation and dynamic data exchange across all metropolitan regions.

During the development of A&M pathways, stakeholders contribute structured and narrative data through mapping templates (deliverable D1.4), capturing interdependencies, perceived feasibility, and expected co-benefits. These contextualised inputs are integrated into the CARMINE knowledge base and used to tailor outputs to CSA-specific needs.

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The CARMINE consortium ensures data protection and integrity through well-defined protocols for recording, anonymisation, transcription, storage, and data lifecycle management. Personally identifiable information is securely stored separately from research datasets, with appropriate safeguards in place for CSA-specific information.

2.1.4. Data derived from communication and dissemination activities

As part of its communication and dissemination strategy, the CARMINE project collects limited personal data, including names and contact details, when individuals participate in public events (e.g., webinars, workshops, final events), subscribe to newsletters, or follow and interact with our social media channels. Information such as name, email address, and organisational affiliation is gathered through GDPR-compliant online registration forms. These forms include clear disclaimers regarding data usage, and all data is stored securely in designated folders within the project's SharePoint platform, accessible only to authorised consortium members. Collected data is used strictly for the purposes explicitly stated in the registration forms namely, for attendance tracking, event reporting, and, where explicit consent has been granted, for future communication and dissemination activities (e.g., newsletters, event invitations). No personal information is processed beyond the originally intended scope without prior user approval.

In addition, data obtained during events and workshops such as participant lists, discussion summaries, and interactive inputs is systematically archived and linked to stakeholder profiles in alignment with the methodologies defined in deliverables D1.1 and D1.7. This ensures traceability of stakeholder engagement and allows for the informed planning and adaptation of LL-related activities and communication strategies across CSAs.

2.2. Data formats

The CARMINE project generates, retrieves, and processes a wide variety of data formats to support interdisciplinary research across climate modelling, socio-economic analysis, stakeholder engagement, and DT development. The data formats in use include, but are not limited to:

- Tabular data: ASCII-based formats such as *.txt and *.csv, commonly used for time series, statistical summaries, and survey results.
- Multidimensional array data: Scientific formats such as NetCDF (*.nc), HDF (*.hdf), GRIB1 (*.grib), GRIB2 (*.grib2) and NumPy arrays (*.npy), used primarily for storing climate model outputs, gridded datasets, and spatial-temporal variables.
- Classic spatial data: Vector formats: ESRI Shapefile (*.shp), ESRI Geodatabase, GeoPackage (*.gpkg), KML (*.kml), GeoJSON (*.geojson), TopoJSON (*.topojson); Raster formats: GeoTIFF (*.tif); 3D models (*.obj).
- Cloud optimised formats: Cloud Optimised GeoTIFF/COG (.tif), Zarr (.zarr), Parquet/GeoParquet (.parquet), FlatGeobuf (.fgdb)
- Stakeholder engagement data: Structured survey forms, coded responses, and corresponding metadata; Quantitative results exported in *.csv and *.xlsx.
- Multimedia data: Audio: *.mp3; Video: *.mp4; Image: *.jpg, *.png used for documentation of stakeholder engagement, workshops, and outreach.

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- Code, scripts, and workflow metadata: Scripts for data harmonisation and modelling developed in Python and R; Version-controlled via Git (GitHub, GitLab) and deposited in open repositories (e.g., Zenodo).
- Project documentation: Text and presentation formats: *.txt, *.pdf, *.docx, *.pptx; Compressed archives: *.zip, *.rar.

In addition to standard formats, the project generates tool-specific model outputs. For example: UWG and ENVI-met tools produce data in *.epw (EnergyPlus Weather Format), *.ini (configuration files), *.csv (simulation outputs); Scenario modelling and DT simulations in WP2 use structured NetCDF-based multidimensional arrays. Furthermore, IDSS consumes and outputs JSON-based schemas for dashboard integration, REST-API formatted streams for real-time exchange, and harmonised CSV structures for KPI tabulations. Data ingest pipelines are configured to support real-time and batch-mode inputs, with standardisation layers based on ISO 19115 and INSPIRE-compliant metadata templates (see milestone MS10 - IDSS architecture and operational flow established).

All data formats are documented within the project's metadata schema, with references to source models, workflows, and associated deliverables, ensuring reproducibility and interoperability.

2.3. Data curation and storage

The CARMINE data, along with related outputs such as scripts, models, and harmonisation codes, integrates a wide range of observational and simulation data stemming from physical climate modelling, hazard assessments, and socio-economic risk modelling. The curation and preservation of this data follow rigorous standards for data quality, security, privacy, and compliance with EU regulations, notably the GDPR.

CARMINE implements a multi-layered research data management process, encompassing:

- Data organisation and structuring across WPs, especially WP2 and WP3.
- Secure storage and backup via institutional servers, project Teams SharePoint, and trusted open-access repositories (e.g., Zenodo).
- Quality assurance and metadata annotation through harmonised CSA protocols (as outlined in the milestone MS20).
- Persistent Identifiers (PIDs) to ensure long-term data traceability and reuse.
- Clear data licensing schemes, promoting transparency and future accessibility.

Each project partner contributes to this effort based on its technical capacity, institutional infrastructure, and domain-specific responsibilities (as described in the Grant Agreement (GA) and reaffirmed in milestone MS20). Institutions such as CMCC, MOHC, MITIGA and B-Kode, bring expertise in climate data processing, hazard modelling, or socioeconomic analysis and operate storage environments adapted to the data type and volume they handle.

A key element of the CARMINE architecture is the FDMS, being co-developed under WP4 (task T4.1). The FDMS facilitates data (and metadata) access and sharing through API endpoints for analytics. This system supports:

- Integration of external and internal data sources (e.g., Urban Atlas, Copernicus ERA5, CORINE).

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- APIs for automated data ingestion and output, supporting the DT engines (T4.2).
- Compliance with ISO, Open Geospatial Consortium (OGC), and European Committee for Standardization (CEN)/European Committee for Electrotechnical Standardization (CENELEC) data standards (deliverable D4.2 – Digital Twin Architecture).
- Connection between DTs and IDSS, enabling bidirectional data sharing.

The data managed within the FDMS and linked DT platforms include:

- High-resolution climate and hazard datasets (e.g., ERA5@2km, CERRA-Land, CWS).
- Meteorological data (e.g. weather forecasts from Global Forecasting Systems, GFS, and ECMWF IFS-NEMO, available through DestinE Extremes DT)
- Climate impact/risk indicators (as shown in milestone MS19).
- Engagement-related outputs (e.g., annotated maps, survey responses, workshop logs) from LLs and the SC-Hub (deliverables D1.7 and D1.8).

The IDSS is supported by a data organisation layer system that ensures data processing and functionalities including validation, metadata tagging, and timestamping of ingested datasets. These mechanisms are aligned with the CARMINE FDMS specifications and facilitate long-term curation through version control and access logging mechanisms embedded into the SC-Hub and DTs (see milestone MS10) (Fig. 3).

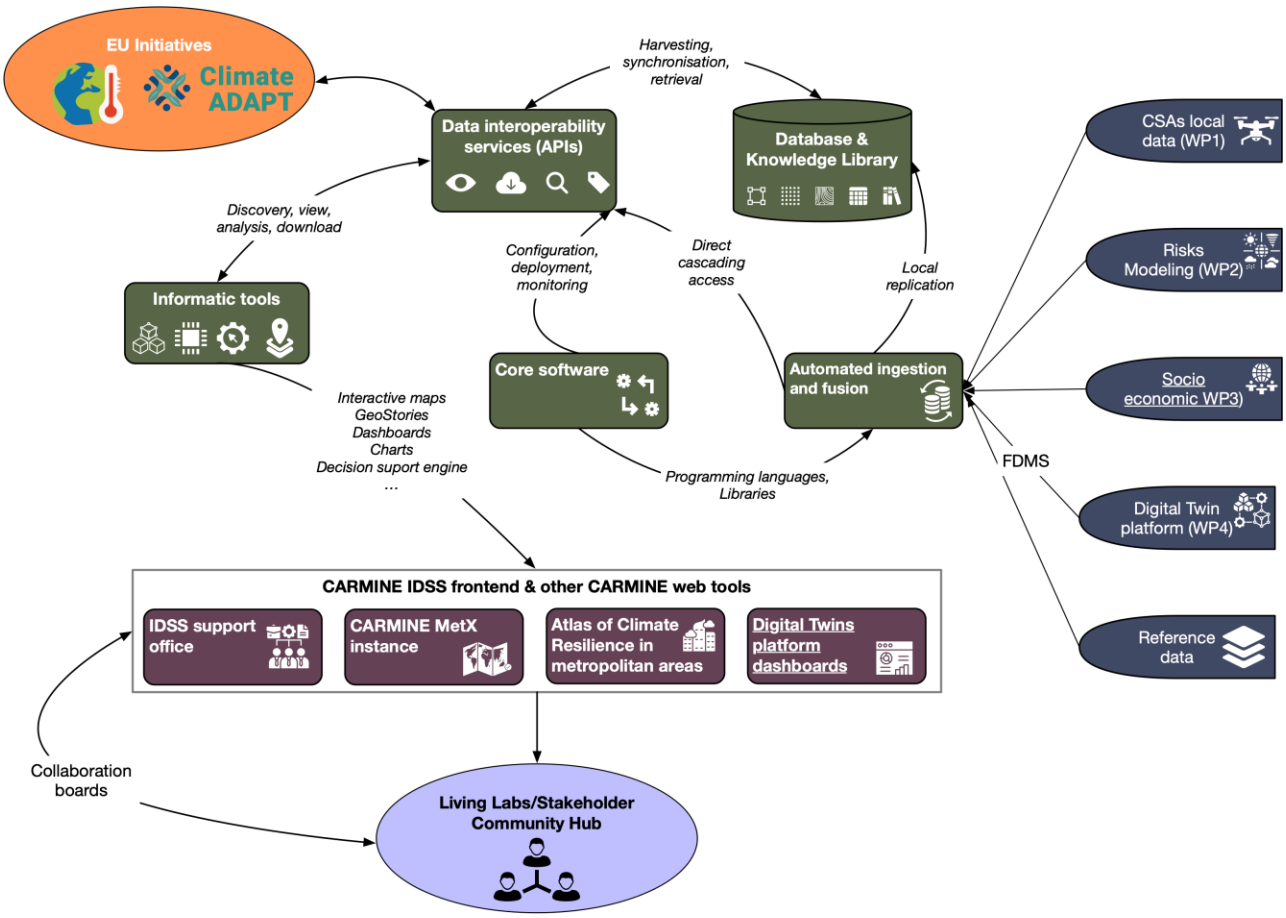

Figure 3. IDSS data flow.

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To ensure sustainability beyond project duration, critical datasets and documentation (e.g., urban adaptation scenario outputs, final model versions, indicators) will be deposited in trusted open-access archives such as Zenodo, or institutional data portals, depending on their type and usage constraints. Future updates of the DMP will further detail data retention periods, post-project maintenance responsibilities, and archival strategies based on FAIR principles and in alignment with Horizon Europe Open Science policies.

2.4. Roles and responsibilities

Within the CARMINE consortium, clearly defined roles and responsibilities have been established to ensure robust governance over all aspects of data lifecycle management, including data collection, processing, storage, sharing, and long-term preservation. These responsibilities also encompass strict adherence to Intellectual Property Rights (IPR), the GDPR, and Open Access (OA) principles throughout the project's duration.

In alignment with the provisions of the Consortium Agreement (CA), all partners are committed to cooperating in the fulfilment of legal obligations under applicable data protection laws, notably Regulation (EU) 2016/679 (GDPR) and relevant national regulations. The CA states: "The Parties shall cooperate in order to enable one another to fulfil legal obligations arising under applicable data protection laws […] within the scope of the performance and administration of the Project and of this Consortium Agreement." It also stipulates that, where necessary, "the Parties shall conclude a separate data processing, data sharing and/or joint controller agreement before any data processing or data sharing takes place."

The management of IPR during and after the project is governed by joint ownership agreements, which outline each partner's contributions and entitlements. All matters related to IPR follow the IPR Management Guidelines established during the Grant Agreement (GA) negotiations, ensuring consistent and equitable treatment across the consortium.

WP7 leads the coordination of communication, dissemination, and exploitation activities. The WP7 lead partner and task leaders operate in accordance with the CARMINE Dissemination, Exploitation & Communication Strategy (D7.1–D7.4) and the Communication Framework (D7.5–D7.7). These documents serve as key references for managing the visibility, accessibility, and responsible communication and dissemination of project outcomes and data. WP7 also oversees the project's visual identity and branding strategy, ensuring coherence across outputs while tracking progress through clearly defined performance indicators to enhance project impact.

Principal Investigators (PIs) from each partner institution are responsible for ensuring their teams are informed about and comply with the data management protocols detailed in the Data Management Plan (DMP) and relevant clauses of the GA. This includes safeguarding all forms of project-generated data, know-how, and information, regardless of its format or legal protection. PIs maintain ongoing communication with the Project Coordinator to resolve any data governance issues that may emerge during project execution.

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3. FAIR data

The science-derived data managed within the CARMINE project aims to follow FAIR principles, EU standards, and regulations. Adhering to FAIR principles helps in increased data sharing, collaboration, and reproducibility of research findings.

3.1. Making data findable

The CARMINE project ensures the findability of all research data by adhering to the FAIR principles and implementing a robust metadata and identification system, structured across multiple data types, CSAs, and thematic domains. The findability of CARMINE data is ensured through:

- *Persistent Identifiers (PIDs).* Every dataset published or made available through the project will be assigned a persistent and unique identifier, such as a DOI (Digital Object Identifier). These PIDs are valid throughout the project lifecycle and beyond, facilitating rapid and reliable access by researchers, policy stakeholders, and the public. Datasets versioned over time will carry version IDs, traceable through the metadata system.
- *Metadata catalogues and standards*. Metadata entry is mandatory at the time of dataset creation or ingestion. All metadata are catalogued within a centralised metadata repository, developed under the DT architecture (see deliverable D4.2), and aligned with international standards, including INSPIRE Directive, ISO 19115 for geographic information, DCAT (Data Catalogue Vocabulary). Metadata is publicly accessible and licensed under Creative Commons Public Domain Dedication (CC0) or equivalent, except where data privacy or proprietary constraints apply. Each metadata record includes dataset title and description, creator(s) and institutional affiliations, temporal and spatial coverage, access conditions and licensing, Related grants (e.g., Horizon Europe, CARMINE GA #101112863), persistent identifiers for datasets, related publications, authors, and institutions. Where applicable, metadata includes links to policy domains, societal impact themes (e.g., climate adaptation, urban resilience), and Sustainable Development Goals (SDG) or Mission Adaptation targets (as discussed in deliverable D1.2 and reinforced in deliverable D4.1).
- *Search and retrieval functionalities.* Users can perform multi-criteria searches within the metadata catalogue via: Free-text keywords, Filterable fields (e.g., CSA, thematic area, variable type, stakeholder group), Temporal or spatial constraints. This functionality is being implemented in the SC-Hub interface (see deliverable D1.8), which serves as an intuitive front-end for accessing datasets relevant to both science and policy users.
- *Tagging, semantic annotation, and CSA-specific metadata*. To improve data traceability and contextual relevance: LL-generated datasets are tagged using CSA and session codes (e.g., CSA_Bologna_LL2), stakeholder engagement inputs are annotated with tags for role (e.g., PolicyMaker, NGO), engagement format (e.g., survey, workshop), and thematic domain (heat, flooding, land use), A&M pathway data (from D1.4) are indexed using geospatial tags (e.g., GeoJSON, KML) and structured using taxonomies (e.g., NbS) aligned with European adaptation strategies (Fig. 4).
- *Integration with DT and SC-Hub.* The metadata framework is interoperable with the FDMS and supports: seamless linkage between inputs (e.g., climate indicators,

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exposure data) and modelling feeds (WP2/WP3), dynamic updates based on stakeholder interactions via the SC-Hub, discovery of datasets for policy co-design and local implementation (deliverables D1.7 and D4.1).

- *Support for reproducibility and impact tracking.* By ensuring metadata completeness, cross-referencing datasets with models, indicators, and policy applications, and documenting dataset provenance, the CARMINE system promotes (i) reproducibility of results and (ii) traceability of stakeholder contributions.

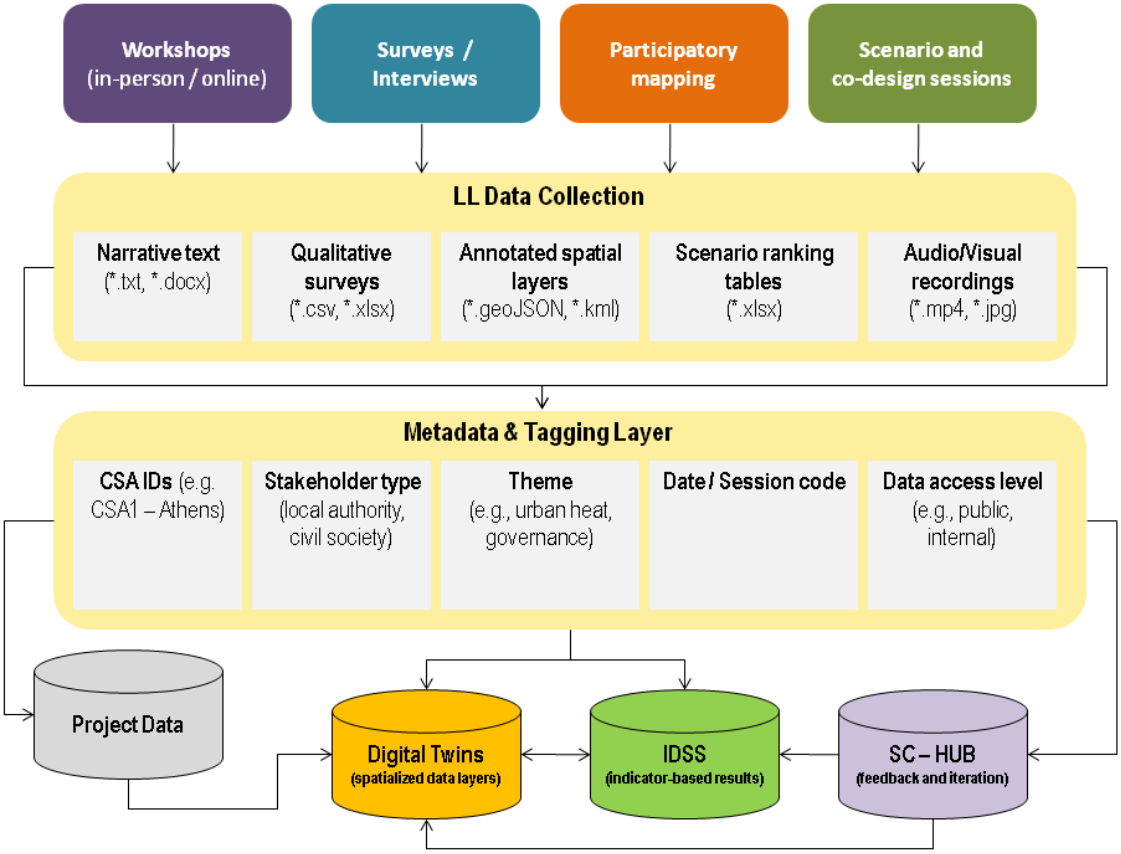

Figure 4. LL data flows and formats across CSAs.

In addition, the IDSS enables keyword- and theme-based data search functionalities, integrated into the SC-Hub interface. Metadata associated with each dataset is indexed with CSA tags, thematic codes, stakeholder relevance levels, and usage timestamps, supporting advanced filtering and semantic search. The IDSS will interface with the FDMS to allow federated queries across the eight CSAs.

3.2. Making data openly accessible

All science-based CARMINE data (both from existing sources and newly generated) will be harmonised, ensuring compliance with the European Open Science Cloud (EOSC) and alignment with the FAIR principles. Exceptions are made for data subject to legal, ethical, or licensing restrictions, particularly where access is regulated by third-party agreements or privacy regulations.

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The data will be openly accessible using standardised data-sharing protocols (e.g., OGC-compliant services), with each dataset retrievable via persistent and unique identifiers (DOIs or dataset IDs). Metadata will be openly published under a Creative Commons Public Domain Dedication (CC0), ensuring long-term findability and reuse of project outputs by researchers, stakeholders, and policy actors. User support or documentation (e.g., tutorials, data access guidelines) will be provided to facilitate external stakeholders' use of the database.

CARMINE is deploying a FDMS under WP4 to enable secure and scalable access to harmonised datasets across the consortium and towards external users. This system is structurally integrated with: (i) the CARMINE DTs at CSA level, each of which draws from and feeds into the FDMS, (ii) the IDSS under WP5, which accesses curated data for impact assessments and policy modelling, and (iii) the SC-Hub, offering user-driven access to data products, visual analytics, and feedback mechanisms tailored to stakeholder needs.

As highlighted in deliverable D4.1, this data infrastructure ensures interoperability with national and European climate data services, including Copernicus Climate Data Store, the Climate-ADAPT Platform, and other national open-data portals (e.g., RO-ADAPT). The FDMS accommodates multilingual datasets and region-specific requirements, as per the CSA prioritisation framework detailed in milestone MS20 and deliverable D4.1.

To ensure sustained value of the project's scientific outputs, the Project Coordinator together with WP leads will define clear post-project data governance procedures, including: (i) allocation of hosting and long-term preservation responsibilities, (ii) use of trusted open-access repositories (e.g., Zenodo, EOSC-recommended archives) for data and model code archiving and (iii) persistent access to metadata and selected datasets through the SC-Hub public interface with user-specific access controls (e.g., stakeholder, policymaker, researcher).

From M1 to M18, the project issued several public documentations supporting data accessibility for users through key deliverables and milestones published under open licences and linked to relevant datasets where possible. Examples of documentation supports include:

- D1.7: Living Labs creation in case studies (July 2024),
- D1.4: Geo-designed A&M pathways – version 1 (January 2025),
- D1.2: Report on climate change challenges (April 2025),
- D1.8: Functionalities of a Stakeholder Community Hub (SC-Hub) (July 2025),
- D2.1: Report on the modelling framework (July 2025),
- D4.1: Data model and data management (February 2025),
- D4.2: Digital Twin Architecture (July 2025),
- D5.6: IDSS architecture (July 2025),
- MS19: WP1 requirements input to the Modelling Framework of WP2 (December 2024),
- MS10: IDSS architecture and operational flow established (January 2025),
- MS20: Catalogue of climate data (January 2025).

In addition, as outlined in deliverable D1.8, the SC-Hub serves as a bidirectional access and interaction interface, allowing users to: browse, download, and comment on selected datasets, visualise DT/IDSS outputs tailored to their region or theme of interest, and provide feedback for iterative system improvement. This dynamic gateway enhances transparency, traceability, and societal impact by linking scientific datasets with local decision-making processes, thus aligning

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data outputs with the EU's Climate Adaptation Mission and the SDG framework (as outlined in deliverable D4.1).

Furthermore, the CARMINE IDSS architecture defines a clear governance mechanism for integrating heterogeneous data sources, workflows, and stakeholders into a coherent operational decision-support system. As outlined in milestone MS10, IDSS operationalisation follows principles of traceability, modularity, and reproducibility, supported by robust data access, ownership attribution, and stakeholder-driven validation loops

Research data made available to the CARMINE project through specific agreements with third parties will remain subject to the terms and conditions set by the original data providers. Access to such datasets will require prior written permission from the data owners and will be governed by well-defined access control mechanisms, including authentication and authorisation. protocols. These protocols will ensure that the use, storage, and dissemination of third-party data comply with legal, ethical, and licensing requirements.

Project management-related data such as partner contact information, financial records (expenses and resource allocations), meeting minutes, and participant lists are securely stored in a dedicated SharePoint environment and made accessible to all consortium members. This access is unrestricted unless the data includes confidential or sensitive content. Such internal data cannot be shared with third parties outside the consortium unless all the following conditions are met: (i) the shared content does not include confidential, personal, financial, or commercially sensitive information; (ii) explicit permission has been granted by the relevant beneficiaries or stakeholders; (iii) the disclosure does not compromise the project's communication, dissemination, or exploitation plans, nor does it violate any applicable Intellectual Property Rights (IPR) or data protection regulations, including the GDPR. These safeguards ensure responsible data handling practices within the CARMINE consortium, while upholding transparency, legal compliance, and the protection of stakeholder interests.

3.3. Making data interoperable

All CARMINE data (i.e., sourced from existing repositories, newly generated through research and stakeholder engagement) will conform to widely recognised standard data formats to ensure seamless interoperability. Standard and open formats (e.g., CSV, NetCDF, GeoTIFF, GeoJSON, SHP, Zarr, GeoParquet, FlatGeobuf) will be prioritised. Where proprietary or uncommon formats are unavoidable, clear documentation and format specifications will be provided to support reusability.

The CARMINE GA defines specific provisions regarding ownership rights, data usage, and conditions for dissemination, ensuring long-term preservation and compliance with FAIR principles. These provisions support the strategic objective of enhancing the reproducibility, usability, and policy relevance of CARMINE's outputs.

Each dataset, resulting from WP2 climate modelling, WP3 socio-economic modelling, or WP1/WP6 stakeholder engagement activities, will be accompanied by detailed metadata. Metadata includes data origin, standards, formats, vocabularies, processing lineage, access conditions, citation instructions, digital object identifiers (DOIs), and references to associated research. Metadata will use formal, accessible languages (e.g., XML, ISO 19115 standards) and follow FAIR-compliant vocabularies, ensuring semantic alignment across platforms and maximising machine-actionability.

The SC-Hub modules and visual layers are developed through modular, API-based architectures, supporting full interoperability with external platforms and repositories. Integration

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with the FDMS ensures metadata harmonisation, shared vocabularies, and standardised tagging schemas for cross-consortia and stakeholder usage. This architecture allows SC-Hub to interoperate with local/regional planning systems and initiatives such as Climate-ADAPT.

The DT uses a multi-layer architecture in which the data harmonisation layer transforms all incoming datasets into interoperable structures. Transformation pipelines are built using OGC standards and structured metadata protocols. These pipelines facilitate both horizontal and vertical integration between data layers, from raw input to visualised decision-support outputs.

Interoperability is also enabled through modular APIs connecting IDSS components to DT simulations, SC-Hub visual dashboards, and external planning platforms. Standardised ontologies and taxonomies ensure semantic alignment across domains. The IDSS employs harmonisation modules that convert inputs from local sources into interoperable forms usable by CARMINE's core modelling infrastructure. Standardised modelling frameworks such as UWG, ENVI-met, and CRAFT are designed to follow climate and geospatial data conventions (e.g., NetCDF CF-compliance), ensuring that model outputs are directly reusable by downstream tools like the DT engines and the IDSS without requiring post hoc transformations. A unified data preparation workflow across CSAs relies on: (i) EPSG:4326 reprojection, (ii) harmonisation of attribute fields (e.g., land use classes), (iii) unified variable naming conventions, and (iv) ISO-compliant metadata application. As outlined in deliverable D4.1 and milestone MS10, the DT and IDSS architectures support:

- Harmonised ingestion of climate, socio-economic, and physical exposure data using shared geospatial reference systems (EPSG:4326 or EPSG:3035),
- Interoperable formats for risk and impact indicators,
- Cross-regional metadata conventions that facilitate comparison and transferability across CSAs.

3.4. Increase data use from available sources

The CARMINE project ensures that both existing and newly generated science-based data alongside project management and stakeholder engagement-related data, are accessible, interoperable, and reusable within the consortium. Emphasis is placed on maximising the utility of trusted scientific sources, while supporting the seamless ingestion, exploration, and reuse of these data via the co-designed functionalities of the DTs and the IDSS. These tools allow end users to search for, visualise, and download tailored datasets, enriched with standardised metadata layers relevant for evidence-based decision-making at CSA level.

All datasets curated within the CARMINE project are annotated using a shared open metadata framework compliant with FAIR principles, leveraging established metadata standards (e.g., ISO 19115, INSPIRE). Metadata transformation procedures are applied to harmonise imported data and integrate them into the FDMS, enabling consistent discoverability and semantic traceability across platforms.

To ensure long-term reuse and legal clarity:

- Project-generated datasets will be assigned appropriate licenses (e.g., CC-0, CC BY-NC-ND 4.0) based on intended openness and consent by data owners,
- Third-party datasets will retain their original licensing conditions and will not be made openly reusable if the data owner is a private or non-public entity,
- Embargo periods may apply to some datasets, as defined in their metadata.

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In alignment with Open Science (OS) principles, the consortium is committed to publishing datasets and research outputs through open-access platforms, including Open Research Europe (ORE). Dedicated resources have been allocated for publication costs to ensure that results are disseminated under 'green' and 'gold' standards of OS. These efforts support reproducibility, transparency, and knowledge sharing across disciplines and borders.

Reusability features are embedded in multiple components of the CARMINE architecture:

DT simulation outputs (e.g., climate risk profiles, adaptation forecasts, spatial overlays) are stored in open and interoperable formats such as GeoTIFF, NetCDF, and CSV. These are made accessible through the SC-Hub and IDSS, enabling interactive policy design and stakeholder decision-making.

Harmonised and downscaled datasets developed under task T2.2 are reused for:

- Calibrating local climate models (e.g., for UHI, flooding, wildfires),
- Generating impact indicators for IDSS dashboards,
- Supporting participatory scenario design in LLs (WP1),
- Enabling cross-CSA comparison and transferability.

Each dataset is accompanied by clear lineage documentation (e.g., data source, processing steps, version history), supporting traceability and auditability. The modular architecture of the IDSS (see milestone MS10) allows component-level reuse, meaning tools, indicators, and visualisations can be adapted to different geographic and policy contexts with minimal reconfiguration.

Furthermore, regional relevance remains central to the reuse strategy. As highlighted in deliverable D4.1, data presentation, formats, and access controls are tailored to match the governance scales and operational capacities of regional institutions. This contextual sensitivity ensures that project outputs are not only technically reusable, but also institutionally actionable across different urban and metropolitan realities.

To enable the long-term accessibility and transferability of data-driven outcomes, the CARMINE project ensures that all data products, particularly those integrated in DTs and IDSS, are curated using interoperable formats and harmonized metadata standards. Simulation workflows and climate indicators developed through the project's CSAs are structured for reuse across metropolitan areas in Europe, supporting adaptation planning beyond the original study sites. LL co-development protocols and simulation chains ensure that data, tools, and models are context-aware yet transferable. These outputs will be deposited in trusted repositories, supporting adoption by researchers, policymakers, and climate resilience networks after the project ends.

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4. Other research outputs

In addition to datasets, the CARMINE project generates a wide range of other research outputs that support the delivery, usability, and scalability of its scientific and policy-oriented objectives. These outputs primarily consist of source code repositories, scripts, harmonisation tools, and data visualisation components, all of which contribute to the processing, analysis, and dissemination of project results.

To ensure accessibility, transparency, and reproducibility, these outputs will be made available in open and trusted repositories such as GitHub and GitLab. Open access will be prioritised for all partners involved in WP2-WP5, especially those contributing to physical hazard assessment, socioeconomic modelling, climate risk analyses, and the co-development of DTs and IDSS.

Key categories of research outputs are:

- *Simulation workflows*: As described in milestone MS19, these workflows support dynamic modelling of climate hazards at local and regional scales, enabling seamless integration of heterogeneous datasets into predictive modelling chains.
- *Custom code libraries:* Derived from milestone MS20, these libraries underpin the local-scale modelling of urban climate hazards and socio-economic exposure, including downscaling, interpolation, and time-series disaggregation routines.
- *Data harmonisation and metadata tools:* Scripts developed to ensure the compatibility of CSA-specific datasets with the FDMS, following FAIR principles and project-wide metadata protocols.
- *Interactive SC-Hub modules:* As part of WP5, the SC-Hub incorporates several dynamic components to foster real-time interaction with end-users, such as:
  - LL directory: Mapping and filtering of LLs across MREs based on engagement level, thematic focus, and output type.
  - Stakeholder feedback repository: Structured collection of qualitative and quantitative feedback from workshops and scenario testing.
  - Engagement tracker: Monitoring and logging of engagement sessions, participation metrics, and co-production outcomes.
- *Visualisation templates and APIs:* Tools that translate complex modelling outputs into intuitive maps, indicators, and dashboards suitable for stakeholder interpretation and decision-making at multiple governance levels.

All outputs are curated to enhance transferability across CSAs and to support replication of methods in other EU metropolitan contexts beyond the CARMINE project lifecycle.

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5. Allocation and resources

The lead partner of WP8 (MeteoRo) oversees the overall project coordination and management for CARMINE. This includes facilitating effective collaboration among project partners, steering the consortium toward the successful achievement of project objectives, safeguarding the scientific integrity and quality of research outputs, and minimising project-related risks.

Compliance with the CARMINE DMP will be ensured through the following coordinated measures:

- WP leaders are directly responsible for implementing the DMP provisions within their respective WPs. This includes ensuring data practices meet agreed standards and are aligned with project-wide data governance procedures.
- Principal Investigators (PIs) of each consortium member organisation are accountable for the implementation of DMP requirements within their institutions. They are expected to support WP8 in all matters related to research data management and ensure that all staff engaged in CARMINE have read and adhere to the DMP principles outlined in this document.
- The primary data providers and collectors, particularly those involved in WP1, WP2, and WP3, contribute to ensuring that all data is managed in line with the DMP, including compliance with GDPR and IPR obligations.
- For all WPs, no additional costs are foreseen for data storage beyond what is already in place as part of standard institutional practices. However, provisions for long-term data preservation will be defined and agreed upon as the project progresses.
- Stakeholder co-development teams operating in each CSA, as defined in deliverable D1.7, are also responsible for ensuring that data collected through field activities and engagement sessions aligns with the DMP. Their involvement contributes to enhancing metadata quality and reinforcing the contextual relevance of scenario assumptions used throughout the project.

This structure of shared accountability ensures a robust, transparent, and legally compliant approach to data stewardship across all levels of the CARMINE project.

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6. Data security

The CARMINE consortium recognises that both scientific and project management data collected, processed, and shared throughout the project may include sensitive or confidential information. To ensure the integrity, confidentiality, and security of such data, the consortium employs secure servers and multi-level encryption protocols. These systems are designed to mitigate risks related to data breaches, including theft of data servers, unauthorised administrative access, and vulnerabilities in network infrastructure.

Comprehensive data protection measures are in place, covering secure data storage, controlled access, encrypted transfers, and robust recovery protocols in case of data loss or system failure. Consortium partners are advised to coordinate with their respective institutional IT departments to ensure appropriate security frameworks are applied, and that organisational safeguards align with the project's data protection requirements.

A full and continuously updated description of the security and confidentiality protocols for handling any project dataset will be provided over the course of the project, as part of the evolving DMP.

Data is being securely stored in centralised repositories, ensuring accessibility for authorized project members while maintaining data integrity and accuracy. During the project implementation, data is being stored on third party cloud services like Teams. Access to Teams Share Point project folder is provided by the project coordinator to consortium members. This platform provides robust security measures, including password authentication to enhance account security, single sign-on capabilities for seamless access, and strong encryption protocols for data both in transit and at rest. It adheres to strict security standards and practices.

Data can also be stored/backed up in the server of the organisations collecting the data. The storage of data reflects its sensitivity, with appropriate levels of storage security established. CARMINE project enforces data security measures that guarantee the security of sensitive information, such as regular monitoring for security threats and implementing strong access control when it comes to the online platform.

Robust measures have been established to protect data privacy, including adherence to GDPR and other relevant regulations (Switzerland, UK, etc.). Furthermore, security protocols are in place to safeguard data against unauthorized access, breaches, and loss, ensuring that sensitive information is handled with the utmost care.

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7. Ethical aspects and GDPR compliance

The CARMINE consortium acknowledges the potential sensitivity and confidentiality of both scientific and project management data collected, processed, or shared throughout the project. All ethical and legal issues impacting data sharing are addressed in alignment with the project's ethics review procedures and relevant EU legislation, including the GDPR.

The project adheres to high ethical standards, guided by principles that ensure responsible conduct and compliance with relevant ethical guidelines and regulations. Ethics methodologies were established to supervise the ongoing activities.

The Research Ethics Committee of the University of Bucharest is an external body, responsible with monitoring the project's adherence to research ethics principles and norms. The main aim of the commission is to evaluate the submitted documents within the project and to approve and authorising them (e.g. amendment, introduction of new research instrument: a questionnaire, survey, etc).

The scientific activities within the CARMINE project, submitted for ethical evaluation, received initial approval from the Committee via Decision no. 91 dated July 2, 2024. These activities are carried out throughout the project's timeline, spanning from February 1, 2024, to January 31, 2028. Decisions issued by the Commission are accessible in accordance with the provisions outlined in the GA. The Commission oversees the implementation of the approved documents and monitors progress, with the study coordinator providing semi-annual reports, or additional updates upon request, regarding both the implementation status and the conduct of the studies. From an ethical governance standpoint, the central body responsible is the CARMINE Ethical Advisory Board (EAB).

All the CARMINE project partners commit to upholding ethical research standards, including the European Code of Conduct for research integrity (*The European Code of Conduct for Research Integrity*, available at https://allea.org/code-ofconduct/). All partners are committed to delivering high-quality scientific outputs and to being transparent, ensuring the deliverables' reliability and impact. These features of the deliverables are validated as part of the quality management procedures.

Stakeholder engagement is central to the collection of CSA-level data through LLs, supporting the development of physical hazard assessments (WP2), socioeconomic risk models (WP3), adaptation policy mapping (WP6), and the co-design of DTs (WP4) and the IDSS (WP5). To ensure ethical compliance, stakeholder engagement follows informed consent protocols. These forms capture only non-sensitive information (e.g., name, organisation, contact details, engagement type, and frequency) and are stored securely as physical hard copies by each responsible partner organisation. These forms are not shared externally or analysed and will be destroyed one year after project completion. Copies may be provided to the project coordinator upon request under secure conditions.

Project meetings (including WP-specific and consortium-wide events) and stakeholder dialogues may be recorded with prior consent. Transcripts derived from audio recordings exclude any direct or strongly indirect personal identifiers. These transcripts are securely stored by the data-collecting partners and are accessible only to authorised personnel. Audio files and transcripts are encrypted and not uploaded to unsecured cloud services. All recordings and transcripts will be deleted one year after the project's end.

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CARMINE partners are committed to safeguarding stakeholder privacy and preventing misuse of stakeholder-generated data. Confidentiality and data protection procedures are enforced at every stage of stakeholder interaction. All informed consent forms clarify how personal data will be stored, used, and anonymised, and outline the right to withdraw consent at any time and to have their data permanently deleted. Only authorised project personnel can access encrypted personal data.

Face-to-face interviews conducted in CSAs are governed by local ethical approval procedures and are preceded by the delivery of information sheets and consent forms. Interviewees are assured of confidentiality, data protection, and their right to withdraw at any time. In some CSAs, interviewees may opt-in to be contacted for follow-up research post-project. Furthermore, online questionnaire data collection also follows GDPR requirements, ensuring anonymisation and secure storage. No respondent-level identifiers are linked to survey responses.

In accordance with the engagement strategy defined in deliverable D1.1, all stakeholder data collection activities include explicit informed consent. Participants are clearly informed about data use, storage, anonymisation, and the possibility to withdraw. Special attention is paid to vulnerable or underrepresented stakeholder groups, and internal data sharing is permitted only when explicit consent is granted.

All LL activities follow strict ethical guidelines ensuring voluntary participation, anonymisation of data, and informed consent. Protocols for ethical data handling specific to each CSA are outlined in deliverable D1.7.

During the co-development of A&M pathways (deliverable D1.4), stakeholders provide consent for the use of their anonymised contributions in visual tools and policy simulations. Identifiable preferences or institutional positions are only disclosed with prior agreement.

The SC-Hub complies with GDPR by collecting anonymised usage data (e.g., login credentials, interaction logs, and user feedback). All information is encrypted and securely stored. Online consent forms clearly define the intended use and scope of collected data. Participants may request data deletion at any point.

To protect spatially granular data that could reveal socio-economic vulnerabilities (e.g., flood-exposed low-income areas), the DT employ aggregation and anonymisation routines. Access to disaggregated data is controlled via role-based permissions in the DT platform, as detailed in deliverable D4.2.

In accordance with the provisions of the Grant Agreement No. 101137851 for the CARMINE project, and specifically the requirements outlined in the Description of Action (DoA), Part B, concerning the ethical dimensions (Humans, Personal Data, Non-EU Countries), the partners filled in the GDPR EU/UK template.

By completing this document, partner organisation declares that:

• it is fully compliant with the provisions of EU GDPR 2016/679;

• it has established internal data protection and security policies;

• it has appointed a Data Protection Officer (DPO), as required under the GDPR.

This declaration is essential for ensuring compliance with the ethical requirements of the project and supporting its legal and ethical commitments.

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8. Other issues

No further issues are foreseen at this stage.

References

CARMINE project, deliverable D1.1: Target groups (stakeholders) engagement strategy

CARMINE project, deliverable D1.2: Report on climate change challenges

CARMINE project, deliverable D1.4: Geo-designed A&M pathways – version 1

CARMINE project, deliverable D1.6: Living Labs Handbook

CARMINE project, deliverable D1.7 - Living Labs creation in case studies

CARMINE project, deliverable D1.8 - Functionalities of a Stakeholder Community Hub (SC-Hub)

CARMINE project, deliverable D2.1: Report on the modelling framework

CARMINE project, deliverable D4.1 - Data model and data management

CARMINE project, deliverable D4.2 - Digital Twin Architecture

CARMINE project, deliverable D5.6: IDSS architecture

CARMINE project, deliverable D8.5 - Data Management Plan – Interim 1

CARMINE project, deliverable MS10: IDSS architecture and operational flow established

CARMINE project, deliverable MS19: WP1 requirements input to the Modelling Framework of WP2

CARMINE project, deliverable MS20: Catalogue of climate data

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