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Executive Summary

To facilitate the development of the data market and the general capitalisation of data, the European Commission (EC) is investing in common European data spaces in strategic economic areas and areas of public interest, such as health, the Green Deal, transport and security and law enforcement. The data spaces bring together data, data infrastructures and governance structures to facilitate secure data pooling and data sharing, a pre-condition for wider availability of data across the economy and society. Under the Work Programme 2021-2022, the basis was laid for the development of 14 data spaces in line with the European data strategy. The work on the data spaces is accompanied by a review of the policy and legislative framework for data access and use, with Data Governance Act and a proposal for a Data Act adopted on 23 February 2022, as well as the Implementing Act on High-value datasets under the Open Data directive adopted on 22 December 2022.

The green and digital transition is a core political priority of the European Commission. Several actions in the current Digital Europe Work Programme are expected to make a concrete contribution supporting those priorities. Some actions are expected to contribute directly to climate mitigation (e.g. measures that focus on the causes of climate change and limit the scope of its long-term effects), climate adaptation (e.g. measures to help ensure preparedness for and find solutions to the adverse effects of climate change, and to prevent or minimise the damage climate change can cause or to take advantage of opportunities that may arise) or to prevent environmental degradation (biodiversity preservation, zero pollution).

Such is the case of the Green Deal Data Space (GDDS), the data ecosystem of the strategies and actions plans for the European Green Deal, which will offer access to a variety of data related to the environment and the EU's climate objectives, for/from the private and public sector. This will for example include detailed data on geospatial systems, localised water, soil and air pollution, but also detailed geo-localised systems, energy supply and consumption. The Destination Earth initiative, which will develop a very high precision digital model of the Earth to enable visualising, monitoring and forecasting natural and human activity on the planet will be main contributors to the Green Deal Data Space. The GDDS will serve as a trusted and secure platform for accessing and sharing high-value environmental data across Europe, facilitating data-driven decision making to support the goals of the European Green Deal.

This document addresses the high-level Green Deal Data Space creation roadmap and the related actions towards its implementation and operational deployment. This Roadmap Version 1.0 expands the work initiated by the EC, the Data Space Support Center and the JRC policy report on European Data Spaces - Scientific Insights into Data Sharing and Utilisation at Scale in the context of the EU's Green Deal strategy and the European Data Strategy.

This implementation roadmap deliverable is complemented by the technical blueprint, the governance blueprint and the data scope that were defined during the first phase of the project. The expected result of the roadmap execution will be to deploy an operational Green Deal Data Space which can connect to the various data spaces and share and reuse its data for/from the private and public sector. The execution of this roadmap will be funded by a grant under the Digital Europe Work Programme 2023-2024.

- Initial Blueprint of the GDDS Reference Architecture
- Phase 1 Governance Requirements and Endorsed Governance Scheme
- EGD Prioritised Data Sets and Gaps (Initial Inventory plus Phase 1 Reference Use Cases)

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I. Introduction

The "Green Deal Data Space Foundations and its Community of Practice" project ("GREAT" Project) is a coordination and support action (CSA) funded by the Digital Europe programme of the European Commission (EC), preparing for the implementation of the common pan-European data space related to the European Green Deal, namely the Green Deal Data Space (GDDS). The creation of the GDDS was introduced in the European Strategy for Data.

This document addresses the high-level Green Deal Data Space creation roadmap and the related actions towards implementation in the context of the Green Deal Strategy and the European Strategy for Data. This Roadmap Version 1.0 expands the work initiated by the EC, the Data Space Support Center and the JRC policy report on European Data Spaces - Scientific Insights into Data Sharing and Utilisation at Scale, and the input from stakeholders, use case references and many data sharing initiatives.

A. Background

The European Strategy for Data

Data-driven innovation plays a key role in the digital transformation of our society and organisations[1]. The priority "A Europe fit for the digital age"[2] guides the European Commission's policy agenda for the period of 2019-2024, culminating in the EC's vision for Europe's digital transformation "2030 Digital Compass: The European way for the Digital Decade"[3] which sets ambitious targets aimed at strengthening digital sovereignty through specific actions on data, technology and infrastructures. The Annual Single Market Report[4], published in 2023, marks the 30th anniversary of the Single Market, and highlights the ambition to create a single EU data economy through a data-driven Single Market where interoperability within and across data spaces is ensured.

In February 2020, the European Commission (EC) published a Communication introducing "A European strategy for data"[5] (ESD) for the creation of "a single European data space – a genuine single market for data, open to data from across the world". The strategy to achieve this vision is structured around four main pillars:

- A cross-sectoral governance framework for data access and use;

[1] Granell, C., Mooney, P., Jirka, S., Rieke, M., Ostermann, F., Van Den Broecke, J., Sarretta, A., Verhulst, S., Dencik, L., Oost, H., Micheli, M., Minghini, M., Kotsev, A. and Schade, S., Emerging approaches for data-driven innovation in Europe: Sandbox experiments on the governance of data and technology, EUR 30969 EN, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/511775.
[2] European Commission, Directorate-General for Communications Networks, and Content and Technology, Shaping Europe's digital future, Publications Office, 2020, https://data.europa.eu/doi/10.2759/091014
[3] European Commission, Directorate-General for Communications Networks, Content and Technology, 2030 digital compass – The European way for the digital decade, Publications Office, 2021, https://data.europa.eu/doi/10.2759/425691
[4] European Commission, Commission Staff Working Document 2023 Annual Single Market Report: Single Market at 30, SWD(2023) 26 final, 2023, https://op.europa.eu/s/yXTN
[5] European Commission, "A European strategy for data." COM(2020) 66 final 2020. https://eur-lex.europa.eu/legalcontent/EN/TXT/HTML/?uri=CELEX:52020DC0066&from=EN

- Enablers: Investments in data and strengthening Europe's capabilities and infrastructures for hosting, processing and using data, taking interoperability considerations into account;
- Competences: Empowering individuals, investing in skills and in SMEs;
- Common European data spaces in strategic sectors and domains of public interest.

According to the ESD, Data Spaces should foster an ecosystem (of companies, civil society and individuals) that will facilitate the creation of new products and services, based on more accessible data. In addition, what distinguishes the Common European Data Spaces from other data sharing initiatives is its focus on preserving European values, balancing the flow and wide use of data, while preserving high privacy, security, safety and ethical standards. One of the fourteen proposed common European data spaces is the GDDS. The GREAT project is charged with developing an implementation roadmap for the GDDS, including a governance scheme, technical blueprint, and priority datasets.

To support the ESD, in November 2020, the EC proposed a Data Governance Act[6] aiming at increasing trust in data sharing and facilitating data reuse. In February 2022, the EC proposed a Data Act[7] to make more data available for use in line with EU rules and values. The Data Governance Act creates the processes and structures to facilitate data exchange, while the Data Act clarifies who can create value from data and under which conditions. Finally, in the framework of the Open Data Directive[8], the European Commission adopted in December 2022 an Implementing Act[9] focused on high value datasets, which provide important benefits for society, the environment and the economy. Those "High Value Datasets" will have to be made available free of charge, in machine-readable format, by public sector organisations.

The European Green Deal

In parallel with the "digital transition" described above, there is an equally important "green transition." The European Commission demonstrated unprecedented leadership in December 2019 when it unveiled its flagship action plan[10] to tackle climate change, the European Green Deal. Through this strategy, the European Union (EU) aims to become the first resource-efficient and competitive economy without net emissions of greenhouse gases by 2050.

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[6] European Commission, REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act) https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=celex%3A52020PC0767

[7] European Commission, "Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on harmonised rules on fair access to and use of data (Data Act)." COM(2022)68 final https://eur-lex.europa.eu/legalcontent/EN/TXT/HTML/?uri=CELEX:52022PC0068&from=EN

[8] Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the reuse of public sector information (recast) (OJ L 172 26.06.2019, p. 56, ELI: http://data.europa.eu/eli/dir/2019/1024/oj)

[9] European Commission, "Commission Implementing Regulation (EU) 2023/138 of 21 December 2022 laying down a list of specific high-value datasets and the arrangements for their publication and re-use." 2023. https://eurlex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32023R0138&from=EN

[10] European Commission, "COMMUNICATION FROM THE COMMISSION The European Green Deal" COM(2019) 640 final https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0640

The European Green Deal charts a comprehensive course for action, supported by a growing number (now over 20) of legislative and regulatory actions. The Green Deal sets ambitious objectives across several priority areas of action, including restoring degraded ecosystems at land and sea across Europe with the 2030 Biodiversity Strategy[11] and reducing greenhouse gas emissions to zero by 2050 with the European Climate Law[12] and the Zero Pollution Action Plan[13]. In addition to regional action, part of the action plan is to increase the EU's "green diplomacy" and demonstrate EU leadership in multilateral fora to increase collective effort and reach the objectives of the Paris Agreement[14] and the United Nations Sustainable Development Goals (UN SDGs).

Ambitious action plans like the European Green Deal require an abundance of resources, including viable data. Data allows responsible stakeholders, including governments at multiple levels, to identify risks, tailor policy response and resource allocation, monitor progress and identify trends. However, serious data gaps remain in the global fight against climate change and environment-related risks. (According to the UNEP report Measuring Progress Towards Achieving the Environmental Dimension of the SDGs, "there is too little data to formally assess the status of 63 of the 93 environment-related SDGs indicators".) Since many consequences of climate change are irreversible, data gaps and analytics deficits need to be addressed.

The Green Deal Data Space

The Green Deal Data Space (GDDS) stands at the intersection of these two major European policy initiatives: the ESD and the European Green Deal. The GDDS will be designed and implemented to exploit the potential of data to effectively support the Green Deal priority actions, empowering policy makers, businesses, researchers and citizens, from Europe and around the world, to jointly tackle issues such as climate change, circular economy, zero pollution, biodiversity protection or deforestation, including providing assurance of compliance with policies and regulations.

Out of the many European Green Deal strategic actions, the GREAT project focuses on three priorities -Biodiversity 2030; Zero Pollution; and Climate change- to effectively capture the diversity of requirements across the full range of European Green Deal initiatives. These three actions are interlinked with other EGD strategic actions and approximate the full scope of the GDDS, as well as complementing actions that are also being addressed by other thematic data spaces (such as the "Farm to Fork Strategy", which is also addressed by the common European agricultural data space).

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[11] European Parliament, Directorate-General for Internal Policies of the Union, Nègre, F., The EU 2030 biodiversity strategy, European Parliament, 2020, https://data.europa.eu/doi/10.2861/545892

[12] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (OJ L 243 09.07.2021, p. 1, ELI: http://data.europa.eu/eli/reg/2021/1119/oj)

[13] European Commission, COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil' COM(2021)400 final https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0400&from=EN

[14] https://unfccc.int/process-and-meetings/the-paris-agreement

B. Implementation Roadmap

A roadmap is the dynamic blueprint for translating a vision into reality. It outlines the strategic actions, steps, and resource allocation required for an initiative to come to fruition, all while remaining adaptable to change and evolving circumstances.

The main objectives of the roadmap are:

1. Clarity: To provide a clear and shared understanding of the initiative's goals, milestones, and the path to success for all stakeholders.
2. Guidance: To serve as a compass, providing a structured plan that helps teams make informed decisions and prioritize tasks effectively.
3. Resource Management: To allocate resources efficiently, ensuring that time, budget, and workforce are used optimally.
4. Flexibility: To accommodate changes, unexpected challenges, and new opportunities, allowing for adaptation without losing sight of the goal.
5. Continuous Improvement: To foster a culture of continuous improvement, where lessons learned are integrated into the roadmap to enhance future endeavours.

Terminology

In this document, "vertical" and "horizontal" are terms used to describe different approaches to organizing and structuring data and related technologies.

Vertical Data Ecosystem: A vertical data ecosystem is characterized by a specialized, domain-specific approach to data management and technology. It focuses on the unique needs and requirements of a particular domain or sector. This approach involves tailoring data solutions, technologies, and standards to the specific challenges and nuances of that domain. For example, in the biodiversity domain, a vertical data ecosystem would encompass data related to species diversity, conservation efforts, and ecological research. Data sources could include records from environmental agencies, research institutions, and conservation organizations, all specific to biodiversity.

Horizontal Data Ecosystem: A horizontal data ecosystem, on the other hand, takes a more generalized and cross-domain approach. It aims to create data solutions and technologies that can be applied across various domain, sectors and industry. The focus is on interoperability, including semantic interoperability, scalability, and versatility. An example of a horizontal data ecosystem is the development of common data standards, open-source data management platforms, or general-purpose data integration tools that can be used in multiple domains, such as data analytics platforms or cloud-based data storage solutions.

In summary, the key difference lies in the scope and specialization. Vertical data ecosystems are domain-specific, tailoring solutions to the unique needs of one domain or sector, while horizontal data ecosystems are more universal and aim to provide solutions that can be applied across various domains. Both have their advantages, drawbacks and use cases, depending on the context and objectives of a data-related initiative. Both are needed.

In this document, the term ***pilot*** is used and differentiated from the term trial as follows: In a trial, activities are conducted (outside a laboratory environment) to verify the functionality of a system

or parts of it, e.g., when the correct functionality is still the primary interest. Pilot is the execution of a trial including business relationship assumptions, exemplifying a contemplated added value for the end-user of a product or service.

Trials and pilots in this document align with the Use Case Development building block described in the DSSC Blueprint, but in addition are also used to verify functionalities of the data space. Use Case Development building block aims to increase the value of the data space by stimulating its use, specifically through the development and support of so-called 'data space use cases'. Generating trials and pilots will be one of the main goals of the GDDS onboarding strategy, to be implemented by the roadmap.

Methodology

The key/important (high level) "milestones" envisioned in the roadmap are:

1. From design to proof of concept, implementation and scaling-up of the Minimum Viable GDDS
2. Expand on trials and pilots involving local, regional, national, European, and global initiatives.
3. Validate benefits of the GDDS to vertical and horizontal domains, public sectors, businesses and citizens.

In the context of the GDDS implementation, during trials and pilots, some of the key questions which should be considered by all parties include (1) What are the benefits of the GDDS? (2) How do I prove that the GDDS provides these benefits? (3) Why can't this be achieved already now? (4) What is the GDDS providing that makes this possible? And (5) How do we transition from the current situation to the GDDS? Each of the stakeholders, vertical sectors, participants, sponsors and contributors will have different objectives, expectations or KPIs and outcomes by which they will want to measure the success of the GDDS trial(s)/pilot(s). These will be driven by the user requirements and will need to be measured (quantitative or qualitative) during the trial/pilot.

Once the Green Deal Data Space has kickstarted and essential building blocks are available, trials and pilots will be conducted at local as well as Pan-European levels to accelerate the deployment of the GDDS. Validating their stability and advantages in specific vertical environments becomes a pivotal step in advancing the Green Deal Data Space implementation. The specific vertical environments are being mapped to Green Deal policies binding targets (see Annexes 1, 2 and 3), to showcase and validate the benefit of the GDDS approach in the context of major environmental objectives. This will be the main goal of the trials and pilots' cycles.

Furthermore, a secondary goal of the trials and pilots' cycles is to enhance the understanding of the novel possibilities that the Green Deal Data Space brings to vertical segments that may not have a primary focus on the objectives of the Green Deal policies, for example enabling SMEs to contribute to the data economy. This, in turn, will jump-start the adoption of the Green Deal Data Space in a broader context.

Elements of Structure

To streamline these ambitions and provide structure for developing concrete plans, three "vertical clusters" and two “horizontal clusters” have been identified. These clusters serve as illustrative examples and provide insights into potential future pilot projects:

1. **Biodiversity horizontal ecosystem cluster**
2. **Zero pollution horizontal ecosystem cluster**
3. **Climate change horizontal ecosystem cluster**
4. **Destination Earth vertical ecosystem cluster**
5. **Copernicus Services, and other EU data services, vertical ecosystem cluster**

Specific vertical environments denote that Green Deal Data Space services will be rigorously validated through pilot projects involving various vertical actors. This approach is rooted in the recognition of common interaction patterns that exist among vertical actors today and, importantly, how these patterns are envisioned to evolve in the future. Those steps are enablers for future horizontal expansion.

For example, the climate change data ecosystem in general is composed of both vertical and horizontal ecosystems, depending on the context and the specific focus.

Vertical Climate Change Ecosystem: Climate Change Mitigation in the Transportation Sector. In this vertical ecosystem, the focus is on addressing climate change within a specific sector, such as transportation. Data sources and efforts are concentrated on reducing greenhouse gas emissions, improving fuel efficiency, and implementing sustainable transportation solutions. The ecosystem includes data from vehicle manufacturers, transportation agencies, and emissions monitoring organizations, all working toward sector-specific climate goals.

Horizontal Climate Change Ecosystem: Climate Data Aggregation and Analysis. This horizontal ecosystem aims to bring together climate-related data from various sectors and domains, including meteorology, agriculture, energy, transportation, and environmental science. It focuses on providing a comprehensive view of climate change and its impacts, enabling cross-sector analysis. The ecosystem promotes data sharing, interoperability, and a holistic approach to understanding and addressing climate change.

In essence, the validation efforts aim at affirming the viability of the Green Deal Data Space vertical services and the new ecosystems that Green Deal Data Space is poised to enable, whether in provider-to-consumer or provider-to-intermediaries-to-consumer setting. From a value proposition perspective, it is prudent to conduct pilots that encompass multiple verticals. This holistic approach prevents the development and deployment of specialized platforms tailored to each vertical, which could undermine the goal of providing a versatile platform capable of accommodating and supporting diverse vertical requirements.

The success and practicality of the outcome arising from vertical trials heavily rely on the capabilities of the underlying platform. It is all about stimulating interaction between verticals and hence creating horizontal activity and enable new science, business (and better policy making). To address this, two major aspects of platform interoperability are considered:

- Verticals should benefit from common and standardized interfaces and APIs, ensuring meaningful representation of Green Deal Data Space services.
- Given that many verticals require the involvement of multiple platforms (that may come from legacy data sharing initiatives or other sectorial data spaces) to demonstrate end-to-end capabilities, interoperability between these platforms is imperative.

The scope of Green Deal Data Space vertical pilots extends beyond the identified clusters, allowing for diverse combinations, potential overlaps, and novel focus areas that may not fit within the proposed clusters. The key criterion is the involvement of multiple vertical actors in a comprehensive value proposition relationship that encompasses the entire value chain.

It's worth noting that different vertical actors exhibit varying levels of readiness for the Green Deal Data Space. Some verticals have already formed substantial alliances or consortia, such as European Marine Observation and Data Network[15] (EMODnet) in the marine sector, Integrated Carbon Observation System[16] (ICOS) for carbon observation system, or Global Biodiversity Information Facility[17] (GBIF) for biodiversity, among others. It's worth mentioning that Research Infrastructures can play a key role in shaping the GDDS (especially environmental research infrastructures, which are well organised around the ENVRI community and part of the European Strategy Forum on Research Infrastructures (ESFRI) roadmap. Following a vision for sustainable policies and funding, ESFRI updates the European Roadmap for research Infrastructures systematically. These alliances play a pivotal role in driving and shaping Green Deal Data Space adoption within their respective verticals.

Actors (across or within vertical) will have different roles. During trials and pilots, we will need to ensure a variety of actors taking on these roles, in terms of size, funding source, geographic coverage.

At the Digital Platform level, the GDDS should align with reference roles definition, with different value propositions. For example, below, such as provided by the position paper from IDSA "New Business Models for Data Spaces grounded in Data Sovereignty"[18] and reused by the DSSC Blueprint v0.5. The DSSC blueprint being updated regularly, this will be closely aligned with for consistency in the future.

1. **Data ecosystem orchestrators:** Administer the memberships, coordinate the development of rules for the data ecosystem and audit the proper functioning and adherence to common rules in the data ecosystem.
2. **Data providers**: Offer valuable data, data quality, data completion, data aggregation and special data evaluation.
3. **Data intermediary:** provides for example an interface for data provider to make their metadata available for data customers. They might offer overviews, a structure, a search engine, quality, and recommendations. They know trusted suppliers and customers. They

[15] European Marine Observation and Data Network (EMODnet) (europa.eu)
[16] ICOS - Integrated Carbon Observation System (icos-cp.eu)
[17] https://www.gbif.org/
[18] IDSA Position Paper New Business Models for Data Spaces Grounded in Data Sovereignty (internationaldataspaces.org)

could play a platform role with potential for exponential growth for all involved participants.

4. **Personal Data Intermediaries (PDIs):** trusted third parties that facilitate the exchange of personal data between organizations in a data space, ensuring data protection and privacy.
5. **Core service providers:** offer valuable services, service quality, support, service availability, service performance, a wide range of payment methods etc.
6. **Vocabulary publisher and providers:** provide ontologies, terminology, homogenous wording.
7. **Clearing House:** enables secure payment, transactional transparency.
8. **Identity authority:** delivers trust, certification, handling of identities.
9. **Software developer:** provides valuable services/apps, service quality, support, hotline, service availability, service performance, wide range of payment methods.
10. **Certification Body and Evaluation Facilities:** Offers security, proven authenticated identities, access control, interoperability.

II. Vision and Mission

The identification of the Green Deal Data Space (GDDS) relevant policy areas will be key for its deployment as they will contribute to the definition and validation of the deployment roadmap. The European Green Deal (EGD) is an ambitious plan with an integrated approach to tackle climate change and to prevent environmental degradation through a set of actions and strategies. Its success depends on the data and related services needed to quantify the many aspects of the problem, to formulate evidence-based actions, and monitor progress and impact.

To properly reflect the diversity of requirements across the full range of initiatives, the GREAT project focuses on three EGD strategic areas: (1) 2030 Biodiversity strategy, (2) Zero pollution action plan and (3) Climate Change Adaptation strategy. By being interlinked with all other strategic actions, the three selected GREAT Strategic Actions are purposely selected to represent the broad scope of topics that the Green Deal addresses and complement sectors being addressed by other thematic data spaces.

Ultimately the Green Deal Data Space must be able to support the EGD policy's objective. A good understanding of the Green Deal policies allows to assess the needs and potential gaps in data and their associated ecosystems. Binding targets set by EGD policies will allow to measure progress, identify the need for action and drive the green and digital transition as well as communicate and engage civil society, businesses, academia, administrations, EU institutions and international organisations. Targets reflect in a quantitative manner the objectives of the EU policies. With every target comes a list of specific actions to be taken. The Annexes 1, 2 and 3 describe in more detail the targets associated with every Green Deal related policy across the three GREAT Strategic Actions. They will be instrumental in shaping and inspiring the trials and pilots during the implementation phase.

The EU Biodiversity Strategy (BDS) for 2030 is a long-term plan with the objective of protecting nature and reversing the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030 and contains specific actions and commitments. It contains 16 targets to be reached by 2030 and more than one hundred actions to be taken to help reach those targets for the benefit of people, climate, and the planet. The BDS targets and actions are

organised around four main pillars: (1) establishing a coherent network of protected areas, (2) launching an EU nature restoration plan, (3) enabling transformative change, and (4) taking action to address the global biodiversity crisis, including working towards the successful adoption of an ambitious global biodiversity framework under the Convention on Biological Diversity. The EU Biodiversity Strategy Dashboard is showing progress of the EU and its member states towards the targets set for 2030. Some of the indicators are under development.

The Zero pollution vision for 2050 is for air, water and soil pollution to be reduced to levels no longer considered harmful to health and natural ecosystems, that respect the boundaries with which our planet can cope, thereby creating a toxic-free environment. This is translated into key 2030 targets to speed up reducing pollution at the source.

With the Strategy on Adaptation to Climate Change, the EU aims to shift the focus from understanding the climate change problems to developing solutions, and to move from planning to implementation.

The objectives to be achieved by a Data Space are key to its design and governance. To structure this dimension, the GREAT project has developed a taxonomy of recommended data space objectives, illustrating the potential cumulative value they create (see Table 1):

Table 1: Taxonomy of Data Space Objectives

Objective Level	Description
Level 0: **Presence of Many Parties, Relevant Parties**	A well identified Community of Practice with participants that have a good understanding of their role and commitment towards the data space is in place.
Level 1: **Level 0 + Broad Information resource**	Relevant data and services from possibly diverse sources are available with easy search, browse and access, use consistent metadata and are interoperable with each other.
Level 2: **Level 1 + Quality**	Data is labelled to specify the quality processes it has been subject to, which may include indicators such as accuracy, precision, defined procedures, mechanisms for review, errata and retraction, spatio-temporal consistency and sustainability or reliability of the data in the future and accessibility over time.
Level 3: **Level 2 + Analysis**	Various analytical tools are available, not just to transform grids, subset or visualise on individual datasets, but to bring different data across domains together to allow insights, enabling data integration and data fusion capabilities. Quality information is incorporated into the resulting product(s) so that analytical results have their own quality indicators.
Level 4:	Analysis, or even data without analysis, can be targeted to a user's needs (e.g., "give me data as well as forecasts and risk assessment

Level 3 + Actionable Insights	about my farm, about all my corporate locations, about my house"). This can include alerts if the situation changes, or new data shows a new trend.
Level 5: **Level 4 + Aggregation/ Analysis of impact**	Risks can be aggregated across sectors, jurisdictions, etc.; impact of actions taken in the past can be analysed, impact of current actions can be modelled. Overall assessments are updated as new data arrives.
Level 6: **Level 5 + Performance Monitoring**	Forecast impacts of various actions can be developed, and then new observations can be compared against the forecast.
Level 7: **Level 6 + Target Setting**	To support some use cases, particularly policy development use cases, different scenarios need to be modelled, forecasts produced, and then performance assessed against targets. As new data arrives, forecasts are updated, and target status is updated and alerted.

We are introducing here the idea that objective levels, and related policy targets, are cumulative and might be achieved through a progressive work programme embedded in the roadmap.

Each target or cluster of policy targets might be treated as a "Use Case" with a "soft" organisational boundary that allows for the "piloting" of technology, plus datasets coverage, plus governance, plus business model. Then we examine each pilot to consider its performance - were the use case objectives met? did the technology work? did the governance work? did the business model work?

Given the context described above, the GREAT project frames its consideration of mission, objectives and vision first at the level of the Green Deal Digital Ecosystem and then as a guideline for the design and governance of each Green Deal Data Space Initiatives (Use Cases, trials and pilots) established within that Ecosystem.

Table 2 presents some preliminary approaches to these questions, which will be further refined in consultation with stakeholders in Phase 2 of the GREAT project.

Table 2: Mission, Objectives and Vision

Scope	Green Deal Digital Ecosystem (GDDE)	Green Deal Data Space Initiatives (GDDSIs)
Mission: This is the near-term target – the minimum viable solution.	• Level 1 in production by 2027 • GDDE Community of Practice is clearly identified and organized, with Participants that have a good understanding of their role and commitment towards the Ecosystem.	• Data Space Use Cases are identified, aligned with EGD strategic actions, UN SDGs. • Standard governance structure developed for the GDDE has been aligned (where appropriate) to the needs of each data space initiative, and

	• A registry of Green Deal Data Space Initiatives is available, including targeted use cases, EGD strategic actions, UN SDGs. • Roadmaps/how to's for data space implementation are in place and tested (core services and providers identified, funding models, operations plan. • Level 1 Technology Frameworks are defined, with compliant technologies assessed and identified, available for interoperable implementation by service providers. • Trust framework, including trust anchors and credential providers, is in place for the full Ecosystem. • "Easy entry" tools/processes to incorporate both public and non-public data, including data preparation and annotation tools. Tools make it easy for data providers to correctly annotate data to define access and use policies. • Controlled mechanisms available for data providers to join multiple data space initiatives easily and confidently. • A Standard Governance Structure is available as a template and ready for adaptation and implementation by specific segments of the Community.	agreements, governing bodies, legal entities as needed, are in place and operational. • Operators, enablers, organizing entities, data intermediaries, etc. are in place and working using the Level 1 Technology Framework and compliant tools. • Key data holders/providers have prepared their data for participation in identified Data Spaces.

Objectives:
 	
What the Green Deal Digital Ecosystem will achieve over time
	• GD Digital Ecosystem Community will develop the transformation tools, analytics, etc. to enable increased objective levels as follows:
	  ○ Level 3 by 2028
	  ○ Level 5 by 2029
	  ○ Level 7 by 2032
		• Each Data Space Initiative will increase its objective level by adopting/developing new tools and value-added functions.
		• Each Data Space Initiative will be encouraged to achieve increased integration with other Data Space Initiatives and to

		begin to form integrated Data Spaces. • Sister data spaces will engage in cross-fertilization, harmonisation, and possible merge/consolidation.
Vision:	• GD Community is strong and self-sustaining. • GDDE and GDDSIs have synergistic business models that are self-sustaining through capture of value generated.	• Individual data spaces have consolidated into relatively few. • Links with data spaces in other sectors are in place and actively used, with data being provided and consumed in both directions.

III. Foundational elements

Achieving a Successful Green Deal Data Space: beyond resources

Creating a Green Deal Data Space entails more than just assembling the necessary resources. It involves a comprehensive understanding of the essential components that contribute to the success of this endeavour. Charting the roadmap for the development of the Data Space, it becomes imperative to identify the fundamental building blocks and solutions necessary to realize the GDDS vision. Naturally, these steps will necessitate the allocation of various resources, including financial investments and dedicated human effort.

Possible sources of funding for the Roadmap implementation (as long as they meet the funding criteria, and pursues appropriate activities) are expected to be covered in part by the EC through the Digital Europe Programme and the Horizon Europe Programme, by Member States (MSs) through specific national programmes as well as by domain specific programmes (such as the Destination Earth programme, or initiatives that relate to the Copernicus Services) and in part by sponsors (Industry, SMEs on a private basis) and contributors that will provide a multiplier effect enhancing other public funding.

However, the journey toward a successful Green Deal Data Space extends beyond resource allocation. It's paramount to emphasize the commitment of leadership and the implementation of robust change management strategies. These aspects play a pivotal role in surmounting the resistance to change that often accompanies transformative initiatives of this nature.

The mere construction of a sophisticated and technically impeccable Data Space is insufficient. The crux of the matter lies in rallying support for the proposed Data Space. The human factor must not be underestimated, as the willingness of individuals to embrace and engage with the new platform is a decisive factor in the ultimate success of the GDDS roadmap.

An effective approach to mitigate the challenges posed by introducing a new Data Space is to adopt a "people-centric perspective[19]". Consistently aligning the future-state solutions with the perspectives and preferences of the individuals who will interact with the Data Space is key. By doing so, the process of change management becomes more streamlined and adaptable. Essentially, integrating the human element into our roadmap acts as a catalyst for smoother implementation efforts, significantly enhancing the probability of achieving a successful Green Deal Data Space.

The roadmap for developing the Green Deal Data Space serves as a strategic blueprint that outlines the “how” and “when” for executing the data space vision and mission. This roadmap is a valuable tool for driving change, and perhaps equally significant, it guarantees alignment with the overarching vision, mission and strategic objectives.

A fundamental principle within the framework of the Data strategy involves the concept of keeping individual solutions concise and uncomplicated. This approach results in a multitude of solutions, each requiring successful delivery to effectively implement the strategy. The roadmap considers constraints and priorities, meticulously defining the optimal timing for the delivery of each component. A successful roadmap synchronizes all individual solutions to lay a robust foundation while maximizing the best time to attain value. Throughout the road mapping process, a primary goal is identifying "quick wins" — those smaller yet influential solutions that generate positive momentum for the data strategy.

While quick wins contribute to building momentum, the crux lies in striking a balance between solidifying the foundation and swiftly delivering value. Assembling a successful roadmap involves the art of harmonizing these elements. What we highlight in our work is the interconnectedness and synergies of adjacent use cases. We propose a multi-level structure, scalable where we define an overall framework of technology solutions, governance structure, operating models, business models, which use cases can then adopt to their own needs in pilots. Success or failure of each pilot provides feedback to the overall framework, which is revised and improved and shared with other use cases over successive piloting periods, allowing co-design and incremental improvement.

A pivotal query stemming from the assessment is, "How strong is our data foundation?" This pertains to several core aspects that are our foundational elements:

People, assessment, endorsement, onboarding:

- Maturity
- Ownership
- Change

Process, governance and business model:

- Data Management
- Data Governance
- Data Space Governance

[19] Innovating for people: the Handbook of human-centered design methods.into (2012).the Pittsburgh,overall PA:project LUMAplan. Institute, LLC.

- Value Creation

Data, high value datasets:

- Data readiness for a given purpose (quality, attributes, hierarchies)
- Metadata (domain related and IT related)
- Operational Data (quality, security)

Technology, technical blueprint:

- Data ingestion, integration, discovery, storage
- Data access/security
- Data availability/retrieval
- Data processing/analysis

Achieving a Successful Green Deal Data Space: a hierarchy of roadmaps

Let's delve into the hierarchy of roadmaps, comprised of three primary tiers and two secondary layers. Within the primary level each tier is distinguished by its specific level of detail and intended purpose. Additionally, unique perspectives can be established for each roadmap level.

This approach builds on recent trend to design roadmap in a more holistic way, following a user experience focused strategy[20], and to include non-financial goals and drive towards a more sustainable development[21].

Primary Level:

1. Strategic Roadmap for Executives and Change Management:

- High-level view
- Illustrates when and how the data strategy will realize the vision
- Allocates strategic investments
- Serves as a tool for managing organizational change
- Ensures alignment with the overall organizational vision, mission and strategy
- Presented in a visually appealing graphical format

2. Program Roadmap:

- Provides a detailed schedule of deliverables
- Emphasizes critical deliverables and factors enabling them
- Includes trial/pilot projects with alternative options
- Tracks significant program milestones and projects
- Identifies resource needs (people, tech, data)
- Specifies the time required for each solution

[20] Design Roadmapping in an Uncertain World: Implementing a Customer-Experience-Focused Strategy
Euiyoung Kim, Sara L. Beckman, and Alice AgoginoView all authors and affiliations
Volume 61, Issue 1 https://doi.org/10.1177/00081256187964

[21] Petrick, Irene J.; Echols, Ann E. (2004). "Technology roadmapping in review: A tool for making sustainable new product development decisions". *Technological Forecasting and Social Change*. **71** (1–2): 81–100. doi:10.1016/s0040-1625(03)00064-7.

- Depicts solution dependencies (predecessor and successor relationships)
- Organizes related tasks for efficient foundational work
- Recognizes achievements through quick wins
- Considers internal constraints linked to strategy (not necessarily external)
- Defines components that require investments
- Highlights essential change management efforts
- Presented in an easily digestible graphical format

3. Working Roadmap with Enhanced Detail:

- Offers an in-depth perspective, complementing the program roadmap
- Details the nuanced efforts and prerequisites for success
- Lists all deliverables (enablers) alongside their known dependencies
- Outlines resource requirements across people, processes, technology and data
- Specifies the time needed for each individual deliverable
- Provides a structured framework for managing projects for each solution
- Presented in a visually engaging format, adaptable to roadmap complexity, possibly in graphical or spreadsheet/project management tool form

Secondary Level:

1. Element-specific Roadmaps - People, Process, Technology, and Data:

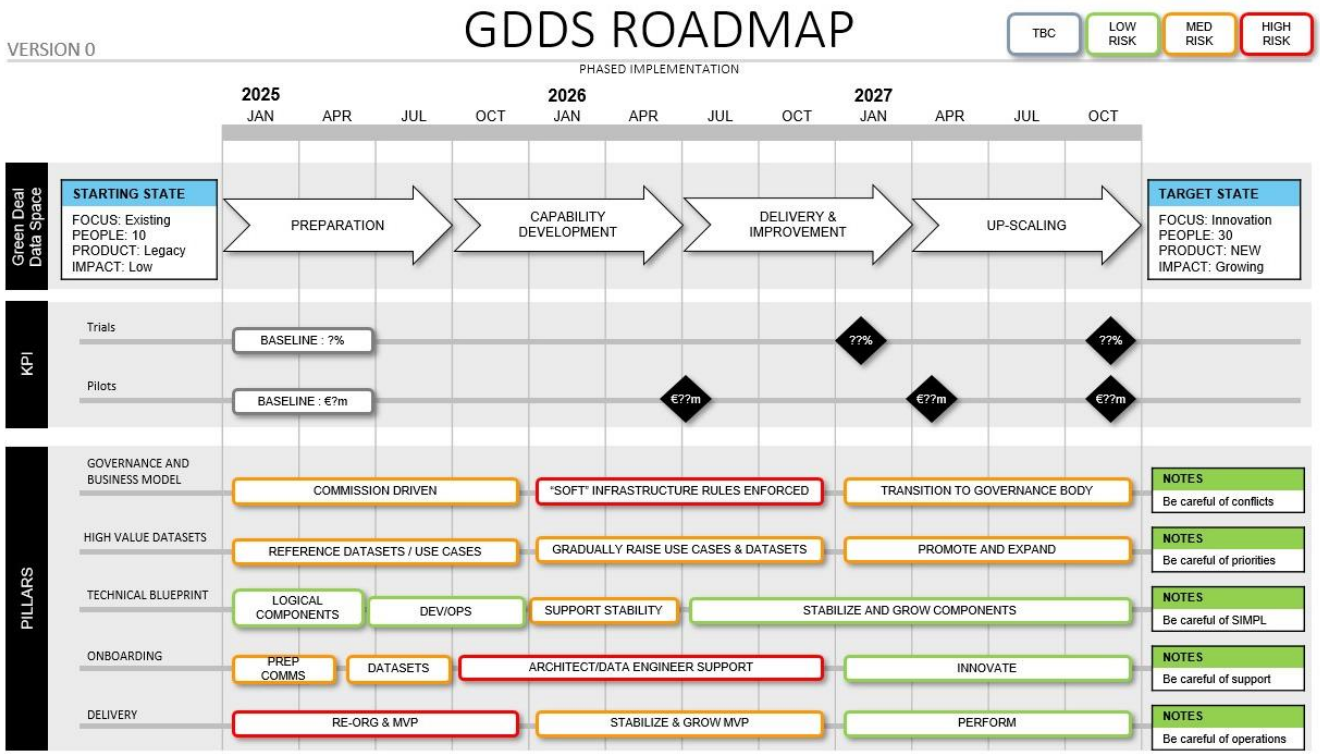
- Provides a tailored view for each core element
- Complements the working roadmap with specialized insights
- Sheds light on potential resource limitations
- Can be consolidated to the program or strategic level for effective communication and investment considerations
- Presented in a clear and visually informative graphical format

2. Roadmap for Change Management:

- Traces the evolution of impact over time, pertaining to stakeholders or business units
- Illustrates the journey of data maturity and enablement
- Monitors shifts in resource allocation
- Tracks the evolution of skill requirements
- Presented in an easily understandable graphical format

To elaborate, we begin with the strategic roadmap, which centres on investment priorities and orchestrating change (Figure 1).

Figure 1: High level roadmap



The second tier encompasses the program roadmap, focusing on pivotal deliverables, high-level resources, dependencies, constraints, groupings and change management. **The program roadmap will be delivered at the end of the GREAT project**, as an extension of this deliverable. This is to cope with the effects that feedback and other community engagement/endorsement processes will have on the program roadmap content.

Lastly, the working roadmap provides a granular perspective, meticulously outlining all deliverables, dependencies and resource requisites. Typically, **the working roadmap will be provided by the consortium or entity in charge of the implementation of the GDDS**.

Furthermore, **secondary roadmap**s can be developed for each element stream (people, process, technology and data), alongside one dedicated to change management. Some elements related to the secondary roadmap are available within their respective foundational elements section further below.

A. People and organisations

The Green Deal Data Space faces diverse challenges and opportunities due to the wide range of actors, and organisational models involved. To ensure its success, it must establish robust mechanism to connect to those, benefit from their buy in, and from their active participation in the process.

The core activities of the GREAT project are centred around building an ecosystem of potential data and service providers, users, intermediaries, and beneficiaries of the future data space – the

Green Deal Data Space Community of Practice. The GDDS and the roadmap towards its implementation could not have been developed without the input coming from the community. With their help, the consortium is defining the way forward and the outline of the future data space. Therefore, Work Package (WP) 6 has been closely collaborating with WP2 dedicated to the community engagement. Assessment unfolds as an iterative endeavour yielding decisions that shape the forthcoming state and the strategies to reach it. However, the journey commences by gauging the present situation.

Firstly – Gauging our Current State, the assessment.

This step entails an in-depth analysis of the current position. It involves understanding the existing state of our people, communities, processes, technology and data components in alignment with established objectives and capabilities. We initiated the assessment of the existing situation by utilizing our key objectives and capabilities as guiding principles.

Secondly – Envisioning our Future State, the endorsement.

Anticipate the state we aspire to achieve. Have this vision endorsed by the community. This involves envisioning how the Green Deal Data Space will look in the future based on defined goals and capabilities.

Thirdly – Navigating the Transition, the onboarding.

This stage centres on devising strategies to transition from the current state to the desired future state. It outlines the steps, initiatives and transformations required to bridge the gap between the two.

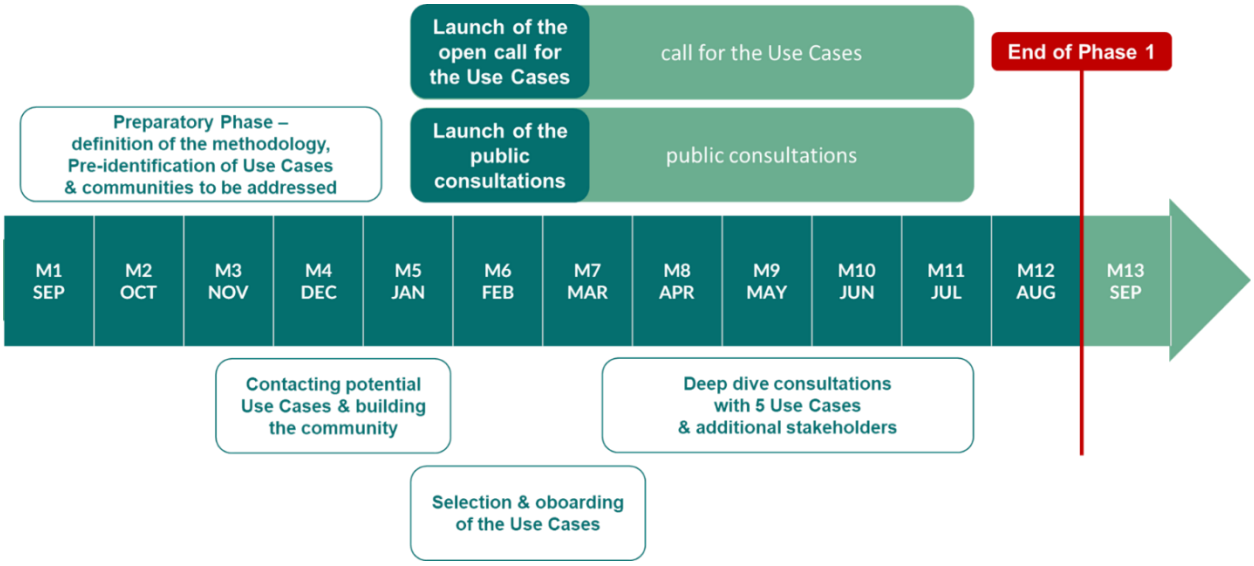
The iterative nature of this process aims to be streamlined rather than cumbersome. As we delve deeper into visualizing the future state, it invariably unveils more inquiries about our status and, just as crucially, the mechanisms for transitioning from the present to the envisioned future.

Those three phases are described below. The first two reports on activities done and planned during the GREAT project, the last phase, the onboarding, will be done after the GREAT project, during the implementation.

Assessment, GREAT project phase 1

The aim of the GREAT activities is to not only define the way forward for the GDDS, but to outline it with the *help of*, and *for*, the community which will be building and using the data space in the future. To achieve that, a methodology for consultations and feedback gathering was set up at the beginning of the project. The Figure 2 shows the timeline of the activities.

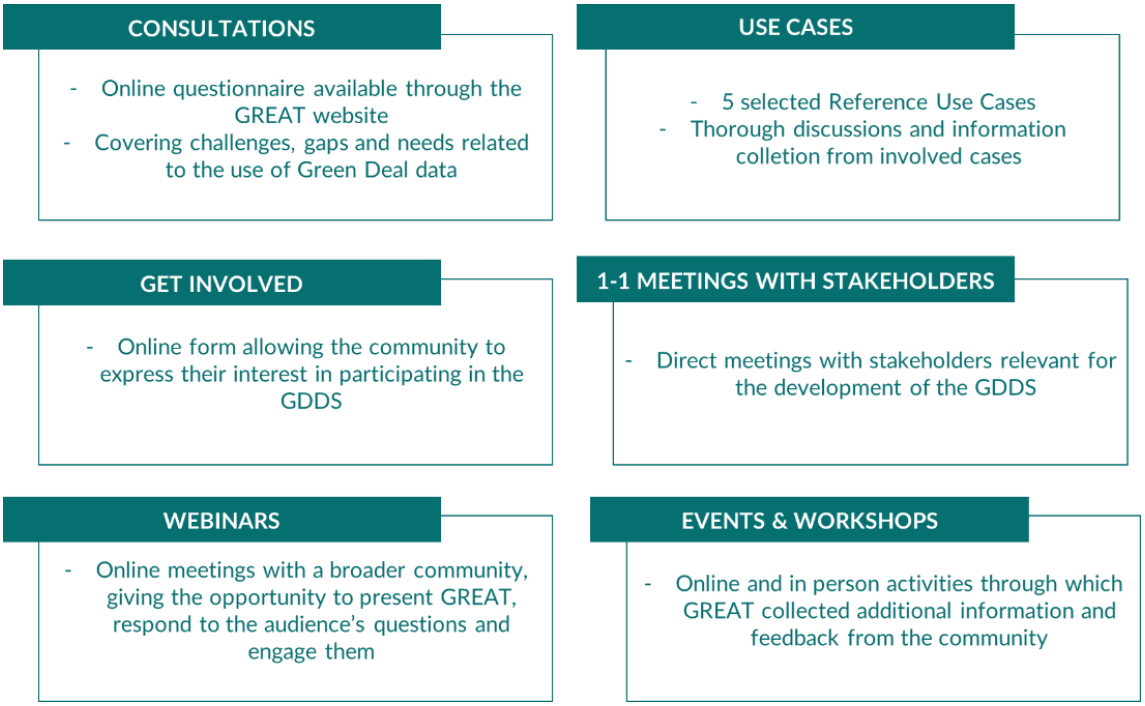
Figure 2: Assessment timeline



Throughout the first Phase of the GREAT project, the consortium was consulting and interacting with numerous stakeholders (about 450 organizations, projects and initiatives reached) to get an initial idea of what are the most common needs and requirements regarding the data space, and what challenges it should be able to address. Figure 3 is describing tools and methods used for the stakeholder engagement.

This initial Phase focused on gathering lessons learned, good practices and recommendations from experienced data sharing initiatives (like EMODNET, EPOS, GOS4M, Copernicus services and Copernicus DIAS). The overview of the involved Reference Use Cases can be found in the . Consultations were not limited to the selected Use Cases, GREAT also launched public consultations, through which all the interested stakeholders could share their needs, requirements, and faced challenges. The collected feedback served as an input for the created deliverables, especially that relevant stakeholders shared their input through an online questionnaire available on the GREAT website (Eurostat, JRC, EuroGeographics, and several more).

Figure 3: Assessment timeline



The vision of the GDDS has been shaped throughout the first months of Phase 1, based on the comments and information received from the involved stakeholders. In the final months of the Phase, GREAT was able to share some elements of the preliminary vision, therefore, some activities of initial validation and endorsement were launched. During such activities (*e.g.*, GREAT splinter meeting at EGU 2023), consortium partners presented relevant aspects of the GREAT vision, for instance, initial idea for the infrastructure or governance models, and the audience was invited to evaluate and comment upon the idea through online tools and in person discussions.

As a culmination of the research and consultations performed in Phase 1, in July 2023, the consortium organized an initial endorsement workshop where participants were the first ones to follow a thorough presentation of the GDDS covering our major outcomes. The workshop was open to GREAT Reference Use Cases, built Task Forces, and the project's Advisory Board. Attendees were invited to respond to online questions, to participate in open discussions. Such model of consultation and endorsement for a broader audience will be further used in the second Phase of the project, starting with the first Stakeholder Forum in September 2023, and followed by workshops and sessions at conferences like the INSPIRE Conference in November 2023.

Endorsement, GREAT project phase 2

As defined by the Grant Agreement, the endorsement process is composed of a validation process of the GDDS. With this vision in mind, during the first Phase, the components of the GDDS were first presented and discussed with a restricted group of community (consortium partners, Task Forces, Use Cases and proxies); in the second Phase, the overall vision and the implementation

roadmap will need to be evaluated by a broader community of already involved and external actors. Therefore, the second version of the roadmap, to be created by the end of the project, will greatly benefit from the continuation of endorsement activities launched by the consortium (foreseen several Stakeholder Fora, workshops, consultations, and meetings with relevant stakeholders). The validation of the process, its timeline, its scope, and foreseen resources needed are crucial for the successful completion of the GREAT project.

Endorsement of the GDDS vision and its implementation roadmap will remain an integral part of the project and it should remain so beyond the project lifetime. Therefore, two types and stages of the endorsement can be identified:

1. Endorsement of the initial GDDS vision – during the GREAT project lifetime, composed of a) endorsement of the GDDS components and of the b) overall GDDS vision and c) its implementation roadmap
2. Endorsement of the GDDS implementation – after the GREAT project lifetime

Not only the development of the roadmap needs to be validated and endorsed by the community, but the community should be an integral part of the GDDS deployment. The endorsement and feedback process and the ways to include the community will be adjusted, if necessary, throughout the GREAT project lifetime, and an updated version of the endorsement process will be a part of the second version of the roadmap. Building on the Community established by GREAT, further involvement of the stakeholders must be performed as an integral part of the implementation of the GDDS.

Onboarding, during the implementation

Onboarding participants from diverse background, including private and public actors at various levels (local, regional, national, international), into a new data space ecosystem is a complex yet crucial task. We also need to ensure that we can cater to a diversity in data formats and sources, highlighting the need of several migration or integration processes, calling for a diversity of tools and support for data transformation and mapping. And finally, we need to consider how the GDDS can support public and private actors to comply with relevant regulations and policies when sharing/reusing data.

By systematically integrating the onboarding and piloting processes into the implementation roadmap and using participant feedback to guide decision-making, we make sure that these processes strongly influence all aspects of the GDDS's development. This participant-driven approach will result in a more robust and user-friendly ecosystem. To ensure a successful and inclusive onboarding process, we need to employ a multi-faceted approach that encompasses several key elements. The establishment of the onboarding function must be done as early as possible during the implementation, below are the key component of a successful onboarding function.

1. Stakeholder Mapping and Engagement:

Begin by finalising and categorizing potential participants into different stakeholder groups. This could include data providers, data consumers, intermediaries, private businesses, government agencies, NGOs, local authorities, international organizations, and more. A thorough analysis of

the different stakeholder groups we aim to onboard and an understanding of their unique needs, motivations, and challenges will inform and drive the onboarding strategy.

2. Customized Communication:

Tailor the communication and outreach strategies to each stakeholder group. Highlight the unique benefits and value they can derive from the data space ecosystem. Ensure the messaging is clear, relevant, and compelling. Highlight the specific advantages and value propositions of the GDDS for them. Actively promote the value of diversity and inclusivity within the GDDS ecosystem. Share success stories and case studies that highlight the benefits of collaboration between different stakeholders. Actively promote the GDDS through various channels, including social media, industry events, scientific events and partnerships.

3. Reference Architecture and Best Practices:

Provide a comprehensive reference architecture and add best practices that showcase how participants from various backgrounds and with different roles can integrate with the data space. Highlight successful implementations. A robust reference architecture will serve as a blueprint for participants. This should outline the technical infrastructure, data standards, and integration guidelines.

4. User Support and Helpdesk:

Establish a user support system that is responsive to the diverse needs of participants. Offer multiple channels for support and ensure that support staff are trained to assist different types of inquiries. Be in line with the reference architecture and best practices.

5. Training and Capacity Building:

Develop training programs that address the specific needs and skill sets of diverse stakeholders. Offer introductory courses for beginners and advanced training for more experienced participants. Include content that explains the benefits of data sharing and collaboration within the ecosystem. Conduct training sessions covering various aspects of the data space, from technical skills to data ethics and governance. Provide access to online courses, tutorials, and documentation.

6. Hackathons and Competitions:

Organize hackathons, data challenges, or competitions that cater to different stakeholder groups. Create specific tracks or challenges that align with the interests and objectives of each group. For example, offer challenges relevant to public policy for government participants and market analysis challenges for businesses. Those events ideally would show case the unique capabilities of the GDDS. Organize events that encourage hands-on participation and problem-solving.

7. Networking and Collaboration Events:

Host networking events, workshops, and conferences that facilitate interaction and collaboration between participants. Encourage partnerships and collaborative projects that span different sectors and geographies and involve a mix of participants from various backgrounds. Highlight successful use cases and projects that showcase the benefits of the green deal data space ecosystem.

8. Diversity in Stakeholder Representation:

Ensure that the governance structure of the data space includes representation from all stakeholder groups. This will foster a sense of ownership and inclusivity. It will also promote inclusivity and ensures that diverse perspectives are considered in decision-making. We want governance to be aligned and hopefully singular/consistent, to ensure organisational interoperability.

9. Legal and Regulatory Guidance:

Offer guidance on legal and regulatory aspects, especially for actors who may have specific compliance requirements. Provide templates or resources to streamline legal agreements and data sharing arrangements.

10. Continuous improvement and sustainability:

Plan for the long-term sustainability and scalability of the ecosystem. Consider how to accommodate the growing needs and changing dynamics of the diverse participant base. Continuously monitor the onboarding process and collect feedback from participants about the overall functionality of the ecosystem. Use this feedback for continuous improvement. Do regular evaluation and adaptation in response to this. Continually assess the effectiveness of the onboarding approach and adjust based on feedback and evolving participant needs.

B. Multi-Level Governance and Business Model

GREAT's analysis of governance requirements in the Green Deal Data Space (D4.1 document) presents a comprehensive framework for the governance and related operational decisions that must be made to ensure a performant and well-governed common European data space.

It highlights the complexity of the Green Deal domain, including the diversity of objectives to be achieved, as well as the range of stakeholders that need to be involved and that may be affected by the Green Deal Data Space.

It presents a view of the Green Deal Data Space "landscape" with multiple levels of operation, in which multiple entities may exist and need to interoperate, and in which corresponding levels of governance would need to be established.

- The Green Deal Digital Ecosystem is the highest level and is conceived to encompass the many stakeholders that are involved or are affected by the Green Deal, as well as the resources and data assets that those stakeholders could potentially bring to this effort. Because it is high level and, in some sense, already exists, it is not possible to impose any requirements at this level, but instead to reach agreement on the overall vision, mission and objectives of the community, to identify values and principles that can be shared across the Ecosystem, and promote and adopt best practices that help to respect the sovereignty of community members while supporting the common objectives they share.
- The Green Deal Digital Platform is the next level. It translates the common principles, practices and procedures that have been agreed across the Digital Ecosystem, into practical implementation inside one or more digital platforms, which combine technical and operational components to deliver certain functions to participants. Multiple digital

platforms might be supported within the Digital Ecosystem. Ideally these platforms will be interoperable, allowing future applications to work seamlessly across them, but initially the focus will be comprehensive transparency, exposing the various agreements, rules, procedures, protocols, standards, etc. adopted within a digital platform to be transparently declared so that potential participants can clearly assess the suitability of the platform for their needs. Governance at the Digital Platform level is likely to be more formal, with traditional governance bodies and procedures, than at the Digital Ecosystem or Use Case levels. Data Providers and Service Providers, as well as Users and other actors, make independent decisions about their participation in each Digital Platform, and the terms and conditions of that participation, consistent with the transparently declared rules that apply.

- Each Green Deal Use Case, (referred to as a Data Space Initiative in D4.1) combines the specific actors and resources needed to meet a well-defined objective, bringing these ingredients together within a specific Digital Platform for implementation. Governance of Data Space Use Cases would be less formal, and comparable to "project" governance, rather than "legal" governance, while still having recourse to the more formal Digital Platform governance mechanisms. As with participation in Digital Platforms, actors that might be involved in a Use Case would need to make their own decisions about whether and how to participate in that Use Case. Use Cases are most likely to need "shared value" business models that allow contributors to receive value based on the outcomes of the use case and the value created for end-users.
- Data Governance, for individual items of data, is the lowest level of governance, although it must be respected from top to bottom. Here each data holder can make decisions about how its data may be accessed, for what purposes and how. Data Governance is potentially supported by two conceptual artefacts, the "data connector" and the "data intermediary". These artefacts should enable data holders to manage their conditions for data access and use, and to communicate their participation in one or more Use Cases supported by one or more Digital Platforms. Data Governance identifies the potential mismatch of a data holder's desired access and use conditions, with the capabilities and rules of participation applied by each Digital Platform and each use Case of interest.

It also distinguishes the "Formation" stage of governance, from later stages, including "Launch". In this regard, almost all of the initial implementation steps contemplated in this Roadmap are also identified as "requirements" of governance during the formation stage. They are governance requirements, since the decisions about, e.g., rules of participation for data providers should be made by governance stakeholders, along with decisions about how those rules of participation will be enforced and the consequences of non-compliance. These decisions translate into operational requirements to gather data relevant to the rules of participation, monitoring of that data to identify any problems, and formal processes for enforcement and more importantly tools and supports for remediation and improvement.

During Phase 2 of the project, the overall governance framework will be used to guide consultations with the Green Deal Community of Practice and with specific Reference Use Cases/Task Forces, as well as known data sharing initiatives in the domain. These consultations will refine the framework into a proposed governance structure, with specific roles and

responsibilities defined, along with initially agreed decision-making processes, decision-making bodies and governance entities for the Green Deal Data Space.

This governance structure will reflect best practice guidance for compliance and alignment with both horizontal legislation and regulation related to data sharing, as well as legislation and regulation specific to sectors that are relevant to the Green Deal (e.g., environment, carbon trading, sustainability claims, etc.).

The generic governance framework developed in Phase 1 identifies the requirement to define value propositions and business models at several levels.

- At the Digital Ecosystem level, where the community of practice must be established, maintained and engaged in ongoing guidance of the Ecosystem and related Platforms and Use Cases.
- At the Digital Platform level, where common services are provided and operated across each platform, for which funding will be needed, from a combination of outside sources (e.g., government), participants (providing service pro bono and/or in return for subscription or transaction fees).
- At the Use Case level, where mechanisms for the creation of shared value must be established, through which the benefits experienced by Use Case users are translated into value for Use Case contributors.
- At the individual Data Governance level, where mechanisms for data monetization provide benefits for data providers.
- Different participants will engage in these different business models in different ways. E.g., public sector bodies want to contribute their data across all levels and across multiple Use Cases, so the design of the Data Space needs to make this easy and as low or no cost as possible. Commercial data and service providers, interested in monetizing their offerings, will also want to participate in as many Use Cases as possible, both maintaining sovereignty over valuable assets and maximizing the potential for their monetization. Some private sector data holders have potentially valuable data resources but will need to build trust in the data space and data sharing idea and will need support to engage in this process.

C. High-priority Datasets

The activities within the Priority Data sets work package (WP5) during Phase 1 were focused on the identification of an initial set of high priority data sets, services and gaps (D5.1 document). This work was based on the analysis of the Phase 1 Reference Use Cases and Initiatives (Hydrology Use Cases (Large-Scale Hydrology and Seasonal Forecasting of Water Resources), Global Observation System for Mercury (GOS4M), European Marine Observation and Data Network (EMODNET), European Plate Observing System European Research Infrastructure Consortium (EPOS ERIC), BioGIS 360), the engagement with stakeholders and initiatives from the Green Deal domain, and the creation of a data inventory with the collected information. The data inventory consists of two components: the high priority data set inventory and the high priority data services inventory.

The high priority data set inventory contains a non-exhaustive list of the use case input data as well as the data products they offer. They are all considered of high priority as they are the ones

required for achieving their objectives. The requirements for the structure of the inventory were identified as follows:

- it should be capable of representing multiple data types related to the Green Deal;
- it should be easily extendable with new common metadata fields;
- it should be easily accessible and queryable via web-browsers;
- it should not represent and reproduce existing catalogues;
- it should include data sets according to their priority for the Reference Use Cases and the EGD objectives.

The dataset inventory was intentionally setup with a minimal number of mandatory metadata attributes to allow for flexibility. Conditionally mandatory metadata attributes are only necessary for certain categories (i.e., raster data), other metadata attributes are fully optional. Mandatory tags are essential for identifying, locating, and evaluating the appropriateness of any dataset for a user of the GDDS. Conditionally mandatory tags should only be completed for datasets that have a spatial or temporal component, which adds depth to the user's assessment of dataset suitability and links to documentation for further details. Optional tags offer insights into the usability, accessibility, or availability of specific inventory datasets. Lastly, the HVD categories and Essential Variables tags serve as indicators of missing data. The choice of these tags is driven by the need to represent crucial attributes like FAIR principles, data format, spatial and temporal characteristics, and associated HVD categories.

At the same, the high priority data services inventory presents a list of Green Deal relevant data services, catalogues, portals etc., which is prioritised and sorted based on selected criteria as listed in the following:

- Criterion 1: Relevance to the Reference Use Cases
- Criterion 2: Relevance to the strategic actions that GREAT focuses on (2030 Biodiversity Strategy, Zero Pollution Action Plan, Climate Change Adaptation Strategy) and their objectives
- Criterion 3: Relevance to EGD initiatives, programmes etc.
- Criterion 4: Data offering completeness (spatial and temporal coverage)
- Criterion 5: FAIRness, business models etc.

Furthermore, each service received a rating on a scale of 1 (representing the lowest score) to 5 (indicating the highest) for each of the five prioritization criteria. The score was finally weighted considering that some criteria are more important than others. Since this weighting was initially developed internally by the project in phase 2, we will validate our internal assessment with stakeholders. Moreover, the services inventory will be extended over time and therefore revaluation needs to be implemented on a regular basis.

For further elaboration of the services and dataset inventories, it is of high importance to pay attention to the following identified key points:

1. The inventories should be flexible in their setup to reflect new datasets and services as well as technological developments.

2. Only a minimum set of mandatory metadata fields should be enabled to ensure a broad representation of data.
3. Data gaps should be given close attention and targeted action.
4. For the diverse range of data types and the needed support of community-driven extensions, the search mechanisms should be flexible, scalable, and user-friendly.
5. Interoperability between data spaces should be a key goal to enable users of various data spaces with
6. High-value dataset categories should be reflected according to their relevance identified from the GREAT project.
7. Prioritisation of services and datasets in the inventories should be re-evaluated and reflected in the inventories accordingly.
8. Essential variables from the five domains relevant to Green Deal (Climate, Geodiversity, Agriculture, Biodiversity and Ocean) should be reflected in the inventory and may give indications on data gaps.
9. Both inventories should be established with robust workflows for all management actions (for instance: update, deletion, interoperability with other data spaces).

- Identification and prioritization of high-value datasets
    - Assessment of data availability and accessibility
    - Identification of potential data sources and partnerships
    - Prioritization of datasets based on their relevance to the European Green Deal objectives
- Management of high-value datasets
    - Establishment of data standards and formats
    - Creation of data workflows and pipelines
    - Development of data quality assurance and control processes
- Development of data sharing agreements and licensing frameworks: The development of agreements and frameworks for sharing data with appropriate permissions and protections.
- Establishment of data quality and validation processes: A plan for ensuring that data quality and validation processes are in place to maintain the integrity and accuracy of the data.

Supporting Open and Commercial Data

- An overview of open data standards and licensing frameworks that will be supported by the Green Deal Data Space.
- An analysis of commercial data licensing models and frameworks that will be supported by the Green Deal Data Space.
- A plan for developing processes to ensure data integration and interoperability across open and commercial data sources.

Based on the current project status the following action points for the future roadmap have been identified:

- Next to current data sets historical data as well as forecast data are essential (e.g., mean yearly streamflow predicted by a hydrological model for 2050) to investigate the past and to predict future scenarios.

- Next to current data, near-real-time data streams are essential to get insights into the actual changing state and to update and improve forecast models.
- Multiple data representations with standardised data formats like the following need to be supported:
    - static and temporal (for temporal fixed timestep and variable timestep)
    - point locations (objects)
    - area coverages (raster, vector, i.e., multiple representations and multiple dimensions, for data cubes)
- Next to the possibility of accessing multiple data formats (e.g. by near-real-time conversion), different access methods need to be supported (download, web service, APIs, etc.).
- Data search should not be limited by the actual metadata attributes, extensions towards a semantic search mechanism need to be supported in the future.
- Data search, access and processing for data distributed at multiple locations need to be supported.
- Next to the easy access of free and open data, commercial data shall be findable and usable via standardised payment methods and models.
- Data sets need to be traceable to ensure data integrity and quality.

During the second phase of the GREAT project, WP5 plans to expand the current high priority data sets and services inventory with input from additional - more inter-disciplinary - reference use cases and interactions with stakeholders from the Green Deal domain, including Destination Earth, and will ensure that data sets required to achieve the Green Deal policy objectives are sufficiently included. In addition, the currently under-represented High Value Datasets categories are going to be investigated in more detail and high priority data sets from those will be added into the inventory.

D. Technical Blueprint

- Design and architecture of the GDDS
    - Selection of appropriate technology stacks and frameworks
    - Integration with existing systems and platforms
    - Establishment of data access and retrieval mechanisms
    - Development of data storage and processing capabilities
- Support for open source and commercial data
    - Integration with open-source data management tools and platforms
    - Support for different data licenses and formats
    - Establishment of mechanisms for data sharing and collaboration

The deliverable D3.1 document described the first version of the Green Deal Data Space (GDDS) technical blueprint. Recognizing the need to design a solution which can evolve in the future responding to changes in the science/policy and technology contexts, the GDDS is based on the Digital Ecosystem (DE) paradigm. Such a paradigm fits particularly well with the vision of the Common European data spaces, and, specifically, the GDDS. In fact, this allows the GDDS to build on existing (and future) data systems, managed by organizations according to their own mandate

and governance. Besides, it allows the GDDS to evolve in support of new applications that we cannot now imagine.

Therefore, the GDDS DE is designed as a Soft Infrastructure comprised of the following two elements:

a) Agreements (including technical standards): these pertain to the governance sphere, which identifies the rules for participating in the GDDS DE.
b) Minimal set of (logical) components creating the digital environment: these components oversee the provision of the required interoperability solutions to connect the data consumers and data sources participating in the GDDS DE.

The logical components are classified in two main categories: Core and Facilitators. The former identifies the logical components which are critical for the existence of the DE; the latter category identifies the components which facilitate the use of data available in the DE. Both Core and Facilitators components expose APIs which data consumer tools can use to exploit the GDDS DE data.

Based on the initial list of logical components described in this document, we identified a possible roadmap for their development, depicted in Figure 4.

We identified three high-level phases which support increasing levels of functionality. For each phase we identified the logical components that provide the corresponding levels of functionality and a possible initial set of supported systems.

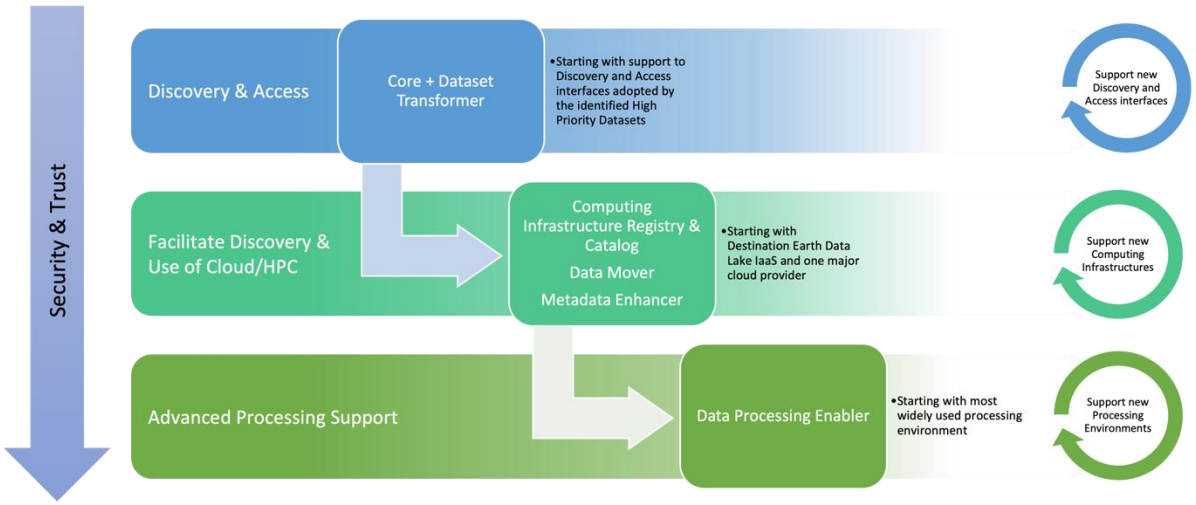


Figure 4 - Possible Development Roadmap of the GDDS DE

The initial phase will address the basic functionalities of discovery and access, implementing the Core logical components and the Dataset Transformer. Initial implementation of these components will focus on supporting the Discovery and Access interfaces utilized by Data Sources providing the identified High Priority Datasets.

The second phase will target the facilitators which enable more advanced use of available data. In this phase it will be possible to exploit Cloud/HPC platforms capabilities to cope with Big Data requirements. The Computing Infrastructure Registry, Computing Infrastructure Catalog and the Data Mover components will enable data consumers to seamlessly move discovered data to the platforms where they operate. Initial implementation should support the Destination Earth Data Lake computing infrastructure and one major cloud provider. The Metadata Enhancer will be implemented in this phase as well, allowing to enrich descriptions of available data and therefore making the discovery phase more effective.

Finally, the third phase addresses advanced support for data processing, providing the implementation of the Data Processing Enabler. This will further facilitate the use of Cloud/HPC platforms, allowing data consumers to easily submit their algorithm implementations to different Cloud/HPC platforms. To this aim, the Data Processing Enabler will initially support the most widely used processing environments for relevant computation.

E. Operational Aspects

The successful development and operation of the Green Deal Data Space (GDDS) require a comprehensive approach to address critical aspects of management, security, scalability, and adaptability. Those critical aspects are the following:

- Management and monitoring of the GDDS
  - Establishment of data governance and management processes
  - Development of data monitoring and reporting mechanisms
  - Implementation of security and access control measures
- Continuous improvement and evolution of the GDDS
  - Assessment of user feedback and needs
  - Implementation of new features and functionalities
  - Regular updates and maintenance of the GDDS infrastructure
- Key scalability technical challenges
  - Analysis of potential bottlenecks, single point of failures and scaling issues
  - Development of a scalable architecture
  - Implementation of load balancing and fault-tolerant mechanisms
  - Metrics for measuring scalability and day to day monitoring and assessment
  - Recommendations to address scalability throughout the implementation roadmap

Shortly after the procurement for the deployment of the Green Deal Data Space several fundamental operational aspects will have to be established. The objective being to set up and run the data space, building on the existing European digital service infrastructure platform and, in so far as possible, the smart cloud-to-edge middleware platform Simpl (or similar). Grants supporting Green Deal relevant initiatives and infrastructure in making use of technologies and linking up to the data space are needed (for example HORIZON-CL6-2024-GOVERNANCE-01-6: Develop innovative applications to support the European Green Deal, building on meteorological satellite data).

Simpl is the smart middleware that will enable cloud-to-edge federations and support all major data initiatives funded by the European Commission, such as common European data spaces. The GDDS will leverage as far as possible the smart cloud-to-edge middleware platform. The current estimate regarding the scope of the professional services to be procured for Simpl is:

- the development of SIMPL-Open. This will be the open-source software stack as envisaged in the above preliminary study, over which tenderers will be able to elaborate their own proposal.
- the provision and management of SIMPL-Labs, a pre-installed demonstration/playground environment where third parties (typically sectoral data spaces in their early stages of inception) can experiment with the deployment, maintenance, and support of the open-source software stack before deploying it for their own needs.
- the provision of several instances of the SIMPL-Open software stack in the form of customised production environments for three sectoral data spaces identified as part of the procurement to be initial adopters of the SIMPL capability (these are called Simpl-Live). Note that the GDDS will not initially benefit from SIMPL-Live services, which will focus on implementation of the other 3 data spaces over the period X-Y

Those professional services will be the foundation of the GDDS inception and ramp up.

Simpl is conceived as a middleware, as opposed to a "full stack". As such, it is a set of "middle" software tools that operate above the infrastructure layer, but under the data layer. Simpl doesn't pay attention to the infrastructure over which it operates. It will "abstract it" and be deployable on different types of infrastructures. Similarly, Simpl will purposely leave data-specific layer items for implementation by data space operators. In other words, the Commission-procured building blocks of Simpl will provide some basic/generic data tools (e.g., data transfers, basic visualisation tools) but Simpl will stay out of sectoral-specific data services (e.g., data ontologies, data formats, advanced algorithms) and other aspects that are specific to data spaces (e.g., data governance or user access decisions).

Ultimately operational aspects are part of the governance layers. They belong to both the soft infrastructure governance layer (organisational governance and operational level of a data space to provide essential services) and to the layer related to the data governance (the set of governance processes that focus on the rights and responsibilities concerning data, addressing facets such as data management, data quality and data security).

IV. Timeframe

The timeline for this roadmap considers both short-term and long-term objectives, considering the implications on the Green Deal Data Space of the Digital Europe Work Programme 2023-2024. The time horizon is covering an eight-year period.

The first phase of the GDDS – its initial implementation phase – lasting three years will start in January 2025 and will complete by December 2027. It will focus on configuring, deploying and piloting the initial infrastructure building blocks that will support the GDDS in its future phases. At the end of the first phase, a portfolio of trials and pilots will have been formed, they will verify functionalities and demonstrate business relationship assumptions, exemplifying a contemplated

added value for the end-user of a product or service. The standard governance structure developed for the GDDS will be aligned to the needs, and agreements. The needed governing bodies, legal entities as needed, will be in place and pre-operational.

From 2028 to 2032, these building blocks will further evolve driven by the pilot's outcome of the first phase. They will evolve to enhance capabilities (building on the taxonomy of dataspace objectives, phased building blocks inclusion and specificities of the Green Deal policies objectives), ingest the latest scientific and technological developments, and make use of the emerging digital infrastructure ecosystem supported by the European Union's Digital Europe programme.

Each objective level as described in the Taxonomy of Data Space Objectives will materialise as a milestone for the GDDS. There are 8 levels (from 0 to 7) and yearly milestones should be defined to make sure regular progress is achieved.

The high-level roadmap for the implementation of Simpl is compatible with the GDDS high-level roadmap and is as follows:

- A SIMPL Minimum Viable Platform must be released as soon as possible.
- In parallel and starting as early as possible in 2024, the open testing environment (SIMPL-Labs) will be made available for stakeholders to experiment with.
- Progressively on-board and integrate use cases, helping them to adjust SIMPL to their specific needs (without compromising its generic nature). Use cases otherwise funded under the DIGITAL Europe Work Programme will take priority.
- As an open-source project, SIMPL will conduct further developments in an open manner, listening to user needs and welcoming external contributions. The roadmap foresees major new releases every 6 months.

V. Current State Assessment and Gap Analysis

At this stage of the GREAT project, based on the assessments made in Phase 1, a preliminary gap analysis is presented below. Prominent gaps are classified into several different categories. The Green Deal Data Space is complex, so the same is true for the categories where gaps should be bridged. and the severity of each gap varies for different components and application areas for the GDDS.

- Data Availability and Sources:
    - Data availability varies across different environmental domains and sectors.
    - Gaps in data coverage and availability for specific Green Deal objectives.
- Data Quality and Standards:
    - Data quality and standards exhibit variances across various data sources and formats.
    - Inconsistencies in data standards and formats may hinder interoperability.
- Data Governance and Management:

  - The existing data governance framework and management processes require further development and strengthening.
  - Gaps exist in current data governance policies and practices, particularly regarding data security and access control.
- Interoperability and Integration:
  - Challenges are present in achieving interoperability between different data sources and systems.
  - Gaps in data integration are noticeable, particularly in connecting disparate data silos from various sectors.
- User Needs and Feedback:
  - Potential disparities between user needs and the data offerings currently available.
  - A need to gather and address feedback from users and stakeholders to better align data services with their specific requirements.
- Scalability and Performance:
  - Scalability issues in the current infrastructure may limit its capacity to handle increasing data demands.
  - Gaps exist in infrastructure capacity and performance, potentially hindering growth.
- Security and Privacy:
  - Vulnerabilities and gaps in data security measures require attention.
  - Ensuring compliance with privacy regulations and data protection laws is a concern.
- Technical Challenges:
  - Various technical challenges related to data processing, storage, and analysis need to be addressed.
  - The readiness of existing technology to meet the specific needs of the Green Deal objectives may require enhancements.
- Regulatory and Legal Compliance:
  - Compliance with environmental and data-related regulations is a priority.
  - Gaps in legal compliance with data management in the context of environmental data are potential issues.
- Stakeholder Engagement:

    - There may be gaps in effectively engaging diverse stakeholders, including private and public actors, and local to international entities.
    - Building more effective collaboration and partnerships is essential.
- Performance Metrics:
    - Identifying and implementing effective metrics and monitoring mechanisms is important to measure the success and impact of the GDDS.
    - Ensuring that key performance indicators align with Green Deal objectives is a priority.
- Training and Capacity Building:
    - Workforce readiness to manage and utilize the GDDS effectively needs to be addressed.
    - The establishment of training and capacity-building programs for users and data managers is essential to enhance their skills and capabilities.
- Funding Mechanisms:
    - The landscape of funding mechanisms for the GDDS is complex, with multiple sources and modalities contributing to its financial sustainability. This complexity may include navigating public and private funding sources, managing grants, subsidies, and public-private partnerships, all while ensuring financial transparency and accountability.
    - Understanding and optimizing this intricate funding ecosystem will be crucial to secure the necessary financial resources for the GDDS development and operation.

The mapping of these gaps will be refined during the phase 2 of the GREAT project, to inform strategies and decisions during the implementation. For example, some paths have the potential to offer “quick wins”, while others promise potentially very rewarding outcomes but would need more resources to bridge important gaps.

Addressing these identified gaps will be crucial for the successful development and operation of the Green Deal Data Space, ensuring that it aligns with the Green Deal's goals and environmental initiatives.

To illustrate how this classification could be used, find below one example for the Interoperability and Integration part, where very rewarding outcome are possible but that would require important resources.

Interoperability between vertical and horizontal data ecosystems in environmental domains, such as biodiversity, climate adaptation and zero pollution, is crucial for effective data sharing and collaboration. Here are methods and examples of interoperability in these domains:

1. Common Data Standards: Developing and adopting common data standards is fundamental. In biodiversity, the Darwin Core and the Access to Biological Collections Data (ABCD) are widely used standards for sharing data about species and collections. These standards facilitate interoperability among various institutions, researchers, and platforms.
2. APIs and Data Portals: Many environmental organizations and research institutions offer APIs that provide access to their data. These APIs allow different ecosystems to integrate data from various sources. For example, the Global Biodiversity Information Facility (GBIF) provides APIs that allow data from multiple biodiversity datasets to be accessed and integrated.
3. Metadata Standards: Standardized metadata, such as the Ecological Metadata Language (EML) in ecology, help describe and document datasets. Researchers and data providers can use these metadata standards to ensure that data are understood and can be integrated into broader systems.
4. Data Integration Platforms: Horizontal data integration platforms can accommodate specialized data structures in the environmental domain. For instance, platforms like the Integrated Assessment Modelling Framework (IAMF) enable the integration of climate and environmental data to assess the impacts of climate change.
5. Semantic Interoperability: In the environmental domain, semantic interoperability is particularly critical. Technologies like the Semantic Web (using RDF and OWL) allow data to be linked based on meaning, which is essential for integrating diverse environmental data sources.

Examples of Interoperability:

- The Copernicus Climate Change Service (C3S) offers a comprehensive dataset of climate-related information through APIs, allowing researchers to integrate climate data into their applications and studies.
- The Biodiversity Data Integration Network (BDIN) is a collaborative initiative aimed at integrating biodiversity data across various ecosystems and organizations. It enables the exchange of biodiversity data between museums, research institutions, and environmental agencies.
- The Global Biodiversity Information Facility (GBIF) is a well-known example of an organization that promotes biodiversity data interoperability. It offers tools, standards, and APIs for integrating biodiversity data from various sources globally.
- The Interoperable Geographic Information for Biodiversity Observation Network (IGIBON) project focuses on integrating geospatial data related to biodiversity. It enables the interoperable exchange of spatial data, facilitating climate adaptation and conservation efforts.

Semantic interoperability and data integration has been a long-lasting challenge and will require significant attention in the context of the Green Dea Data Space. Machine Learning (ML) and Artificial Intelligence (AI) can play a significant role in enhancing semantic interoperability within large vertical data ecosystems and across vertical ecosystems in the following ways:

Data Integration and Mapping:

- Example: ML algorithms can integrate and map data from diverse environmental monitoring stations, such as air quality sensors, to create a unified dataset for analysing air quality trends.
- Reference: "Machine Learning-Based Air Quality Prediction with Internet of Things Data" (IEEE Access, 2020)

Ontology Learning:

- Example: AI models can learn from biodiversity research publications to generate ontologies that capture relationships between species, habitats, and conservation efforts.
- Reference: "A Text Mining-based Knowledge Base for Biodiversity" (2018 IEEE International Conference on Bioinformatics and Biomedicine)

Entity Resolution:

- Example: ML is used to resolve discrepancies in ecological datasets, such as identifying and merging records for the same species collected by different research organizations.
- Reference: "Semantic Web Technologies for the Integration of Geospatial Data in Biodiversity Applications" (2016 International Semantic Web Conference)

Natural Language Processing (NLP):

- Example: NLP techniques extract environmental impact assessment (EIA) information from unstructured EIA reports to assess the environmental impact of development projects.
- Reference: "Natural Language Processing-Based Environmental Impact Assessment Classification: A New Approach" (Journal of Environmental Management, 2020)

Semantic Tagging:

- Example: ML models tag satellite imagery with geospatial metadata, making it easier for researchers to access and analyse images for climate and environmental monitoring.
- Reference: "Semantic Annotation of Earth Observation Data Using Knowledge Graphs" (2019 International Conference on Semantic Web)

Knowledge Graphs:

- Example: The Earth System Knowledge Platform (ESKP) leverages AI and knowledge graphs to provide integrated information on climate change, including data, models, and research findings.
- Reference: Earth System Knowledge Platform (ESKP)

Query Expansion and Understanding:

- Example: AI-powered environmental search engines expand queries to include synonyms and related terms, improving the discovery of climate-related research.
- Reference: "Climate Change AI: A New Data-Driven Paradigm for Climate Science" (Nature Communications, 2020)

Recommendation Systems:

- Example: AI-driven recommendation systems suggest climate-friendly behaviours and actions to individuals based on their energy consumption and environmental impact.
- Reference: "AI for Climate Action: A New Wave of Applications" (Stanford HAI White Paper, 2020)

Anomaly Detection:

- Example: ML models detect anomalies in meteorological data, such as identifying unusual weather patterns that could indicate extreme climate events.
- Reference: "Deep Learning for Anomaly Detection: A Survey" (ACM Computing Surveys, 2019)

Adaptive Ontology Matching:

- Example: AI-based ontologies in the field of hydrology adaptively match different terms and concepts used by national and international organizations to ensure consistent data integration.
- Reference: "A Linked Water Data Portal for Hydrology" (2016 IEEE/RSJ International Conference on Intelligent Robots and Systems)

Data Transformation:

- Example: ML algorithms transform unstructured environmental reports into structured datasets that can be used for climate change impact assessments.
- Reference: "Applying Machine Learning Techniques in Environmental Impact Assessment" (2020 IEEE/RSJ International Conference on Intelligent Robots and Systems)

These examples demonstrate how ML and AI technologies are applied in the environmental domain to bridge semantic interoperability gaps, support research, and address climate and biodiversity challenges.

VII. Recommendations

The GREAT project has pinpointed a series of actionable recommendations aimed at bolstering the integration of vertical and horizontal data ecosystems and establishing the groundwork for the Green Deal Data Space's operationalization. Remarkably, there are presently no initiatives of comparable scale and ambition encompassing a spectrum from zero pollution to biodiversity and climate change.

The assessment of the Green Deal Data Space (GDDS) landscape reveals several key findings and corresponding recommendations. Stakeholders are urged to take action by supporting the implementation of the GDDS, emphasizing the need for standardized data formats, interoperable APIs, cross-domain data platforms, and collaborative research projects to enhance the integration between vertical and horizontal data ecosystems. Additionally, data governance, metadata practices, and capacity building are vital elements. Continuous evaluation and improvement of the GDDS are essential to ensure its success in addressing environmental challenges. This call to action underscores the collective responsibility of stakeholders in advancing the GDDS and harnessing its potential for environmental sustainability.

1. **Standardization and Data Formats:** Encourage the adoption of common data standards and formats that facilitate interoperability between vertical and horizontal data ecosystems. Establish guidelines for data providers to adhere to these standards.
2. **Metadata and Semantic Interoperability:** Implement robust metadata practices and semantic interoperability standards to ensure that data from various ecosystems can be easily understood, shared, and integrated. Develop ontology models and data dictionaries for shared terms and concepts.
3. **Data Governance and Sharing Agreements:** Promote the development of data governance frameworks that define roles, responsibilities, and data-sharing agreements between different ecosystem stakeholders. Ensure that data access and usage are governed by clear policies.
4. **Interoperable APIs:** Design and implement interoperable Application Programming Interfaces (APIs) that enable seamless data exchange between ecosystems. API specifications should be well-documented and publicly available.
5. **Cross-Domain Data Platforms:** Create cross-domain data platforms or hubs that serve as intermediaries between vertical and horizontal ecosystems. These platforms can aggregate, harmonize, and provide access to data from various sources.
6. **Data Harmonization Tools:** Invest in tools and technologies for data harmonization and transformation. These tools can automatically align data from different ecosystems, making integration more efficient.
7. **Collaborative Research Projects:** Foster collaborative research projects that bring together experts from different environmental domains. These projects can explore ways to integrate data for comprehensive analyses and solutions
8. **Data Discovery and Catalogues:** Develop centralized data discovery platforms or catalogues that index datasets from both vertical and horizontal ecosystems, making it easier to locate relevant data.
9. **Capacity Building:** Provide training and capacity-building programs for data managers and users to enhance their skills in data integration and analysis.

10. **Public Awareness and Engagement:** Raise public awareness about the importance of integrated data ecosystems in addressing environmental challenges. Engage communities and citizens in data collection and sharing efforts.
11. **Monitoring and Assessment:** Continuously monitor the performance and impact of integrated data ecosystems. Implement metrics and frameworks to evaluate the effectiveness of integration efforts.
12. **Feedback Mechanisms:** Establish mechanisms for stakeholders to provide feedback on data integration processes. Use this feedback to refine integration strategies and improve data quality.
13. **Incentives and Recognition:** Recognize and incentivize data providers, data users, and organizations that actively contribute to data integration efforts. Awards, grants, and acknowledgments can encourage participation.
14. **Policy Alignment:** Ensure that data integration efforts align with national and international policies related to environmental conservation and climate action. Advocate for policy changes that support integration.
15. **International Collaboration:** Collaborate with international organizations and initiatives focused on environmental data integration. Leverage best practices and expertise from global partners.

These recommendations aim to facilitate the integration of vertical and horizontal data ecosystems in the environmental domain, promoting a holistic approach to addressing environmental challenges and supporting data-driven decision-making.

Given the unique scope and ambition of the GREAT project's recommendations, there is a compelling need to consolidate these proposals into a coherent strategy. Recognizing the intricacies of the funding landscape, we must judiciously pinpoint areas where investments can yield the highest value for the resources allocated.

The following axis describes how funding should be routed to maximise GDDS implementation phase efficiency:

1. Use/Leverage SIMPL as the cloud to edge middleware or identify fallback position.
2. Use/Leverage the Digital Europe technical infrastructure for Data Spaces.
3. Use/Leverage existing Horizon & Digital Europe projects (including DestinE), Copernicus.
4. Invest in developing the Green Deal Data Space data specific layer (data ontologies, semantic interoperability, data formats connectors, advanced algorithms, data governance, user access decisions, ...)
5. Invest in connecting the data specific layer to the cloud to edge middleware.
6. Invest in trials & pilots aligned with Green Deal Objectives (policies & binding targets).
7. Invest in the people-centric approach and onboarding, hackathon to boost adoption and impact.
8. Invest incentivising important actors/roles participation (data intermediaries...)

One of the key challenges in building the GDDS will be ensuring that the platform is scalable to accommodate the vast amount of environmental data and products that will be generated and made available through the GDDS.

To address scalability, it is recommended to consider the technical requirements of the platform from the outset and to build-in scalability measures throughout the development and implementation process.

VIII. Conclusion

The assessment of the Green Deal Data Space (GDDS) landscape reveals several key findings and direction for future works. Stakeholders will have to be urged to take action by supporting the implementation of the GDDS, emphasizing the need for standardized data formats, interoperable APIs, cross-domain data platforms, and collaborative research projects to enhance the integration between vertical and horizontal data ecosystems. Additionally, data governance, metadata practices, and capacity building are vital elements. Continuous evaluation and improvement of the GDDS are essential to ensure its success in addressing environmental challenges. This call to action underscores the collective responsibility that stakeholders will hold in advancing the GDDS and harnessing its potential for environmental sustainability.

As elucidated in the document, the multitude of challenges at hand demands a highly capable implementation consortium. Selecting such a consortium necessitates a meticulous assessment of their world-leading track record in areas such as the environmental domain, vertical and horizontal data ecosystems, international data governance, and policy governance, among others. The extensive and complex nature of these challenges underscores the need for an implementation partner with an impressive and proven track record.

We would like to emphasize that a substantial portion of data composing the Green Deal Data Space is public in nature, and its utilization should be channelled towards serving the public good, particularly in policymaking. This data holds the potential to expedite innovation and stimulate the data economy, thereby providing crucial support to industries, notably small and medium-sized enterprises (SMEs).

Uncertainties surrounding the middleware platform pose challenges in estimating associated costs. A proven technical middleware platform, such as SIMPL, is not yet available. Even if the GDDS roadmap is compatible with the latest available SIMPL roadmap, how much focus the GDDS would receive is not clear. Should we not wait for SIMPL (for any reasons), investment will be necessary to develop or integrate capabilities from other initiatives. This lack of platform certainty makes predicting operational costs complex.

Furthermore, existing data providers, including those in the public sector, may be inclined to offer their data 'as is, where is,' without actively enhancing interoperability. Moreover, entities like Destination Earth, Copernicus, EMODnet, and research projects funded by Horizon Europe may encounter constraints due to their scope and contractual obligations, potentially limiting their collaboration with the GDDS.

The landscape of funding mechanisms for the GDDS is complex, with multiple sources and modalities contributing to its financial sustainability. This complexity may include navigating public and private funding sources, managing grants, subsidies, and public-private partnerships, all while ensuring financial transparency and accountability. To cope with this funding fragmentation, clear lines of collaboration should be established between Horizon Europe and Digital Europe funded projects that are explicitly supposed to contribute to the Green Deal Data Space.

Understanding and optimizing this intricate funding ecosystem will be crucial to secure the necessary financial resources for the GDDS development and operation.

Semantic interoperability core challenges persist, requiring immediate resource allocation, particularly within priority use cases. While valuable lessons from pilot projects in relevant domains exist, many have lost funding, necessitating considerable effort and time to extract best practices and reusable results.

The GDDS should be designed to support open standards and implementation, to ensure that it can be easily integrated and interoperable with other data platforms and systems. This will not only support the scalability of the platform but will also increase the potential value and impact of the GDDS.

The successful implementation of the Green Deal Data Space (GDDS) requires a comprehensive and integrated approach that addresses the people, governance, data, technical, and operational aspects of the platform. By focusing on the pillars outlined in this roadmap we aim to provide a clear and actionable plan for building a robust and sustainable data infrastructure that supports the goals of the European Green Deal.

This document roadmap will be updated and refined at the end of the GREAT project, where more details will be made available to inform the different layers of the hierarchy of roadmap describes in this document. Responses to gaps identified and GREAT project phase 2 outcomes will be factored in the next version of the roadmap.

Annex 1- Policy framework for the EU Biodiversity Strategy 2030

This table details the legislative acts corresponding to each strategy under the Biodiversity Strategy. It also provides the main binding legal targets. These targets allow the EU to monitor progress towards the objectives of the policies.

Strategies and initiatives	Legislative acts and Proposals	Targets
EU forest strategy to 2030	Deforestation-free products regulation LULUCF Regulation	-Strictly protect at least a third of the EU's protected areas, including all remaining EU primary and old- growth forests; -reduce carbon emissions caused by EU consumption and production of the relevant commodities by at least 32 million metric tonnes a year; -Three billion additional trees are planted in the EU, in full respect of ecological principles; -Member states shall ensure that there is no net loss of urban green space, and of urban tree canopy cover by 2030, compared to 2021, in all cities and in towns and suburbs; -accounting of greenhouse gas emissions and removals from the LULUCF sector and checking the compliance of Member States with the commitments for the period from 2021 to 2025; -targets for net greenhouse gas removals in the LULUCF sector for Member States for the period from 2026 to 2030;
EU Nature Restoration Plan	Nature restoration Law Soil Health Law Sustainable use of pesticides Birds and Habitats Directives A new Deal for Pollinators	-Legally protect a minimum of 30% of the EU's land area and a minimum of 30% of the EU's Sea area, and integrate ecological corridors, as part of a true Trans- European Nature Network; - restoration measures that are necessary to improve to good condition areas of habitat types which are not in good condition. Such measures shall be in place on at least 30 % of the area of each group of habitat types listed in Annex I that is not in good condition, as quantified in the national restoration plan referred to in Article 12, by 2030, on at least 60 % by 2040, and on at least 90 % by 2050; - restoration measures that are necessary to improve to good condition areas of habitat types which are not in good condition. Such measures shall be in place on at least 30 % of the area of each group of habitat types that is not in good condition, as quantified in the national restoration plan referred to in Article 12, by 2030, on at least 60 % by 2040, and on at least 90 % by 2050; - Restoration of Pollinator Habitats: The EU aims to restore and improve at least 10% of the degraded habitats that are important for pollinators. -target of reaching 25% of the EU's agricultural land under organic farming or other agroecological practices, which are generally more favourable to pollinators. -Member States shall ensure that there is an increase in the total national area of urban green space in cities and in towns and suburbs of at least 3 % of the total area of cities and of towns and suburbs in 2021, by 2040, and at least 5 % by 2050; -Effectively manage all protected areas, defining clear conservation objectives and measures, and monitoring them appropriately; -Significant progress in the remediation of contaminated soil sites; -At least 25,000 km of free-flowing rivers are restored;

		-50% reduction in the number of Red List species threatened by invasive alien species; -22 conservation schemes in ten Member States with a set of measures to maintain or restore suitable habitats for farmland bird species on one of the ten agricultural systems or for one of the fifteen flagship species; -mapping Key Pollinator Areas by 2025, and targeted actions to promote capacity-building and dissemination of knowledge; -For organic soils in agricultural use constituting drained peatlands, Member States shall put in place restoration measures. Those measures shall be in place on at least: (a)30 % of such areas by 2030, of which at least a quarter shall be rewetted; (b)50 % of such areas by 2040, of which at least half shall be rewetted; (c)70 % of such areas by 2050, of which at least half shall be rewetted;
Farm to Fork Strategy	CAP Strategic Plans	-The losses of nutrients from fertilisers are reduced by 50%, resulting in the reduction of the use of fertilisers by at least 20%; -targeted actions to conserve or restore biodiversity including high-nature-value farming practices will cover close to 31% of the EU's agricultural area. -reducing the risk and use of chemical pesticides by 50% (compared to 2015-2017); -reducing nutrient losses from agriculture by 50%, while ensuring that there is no deterioration in soil fertility (compared to 2012-2014/2015); -achieving a coverage of organic farming of at least 25% of total agricultural area (compared to 2018); -bringing at least 10% of agricultural area under high-diversity landscape features (compared to 2015/2018); -reducing by 50% the sale of antimicrobials (compared to 2018); - ensuring 100% access to fast broadband internet in rural areas.

Annex 2- Policy framework for the EU Zero Pollution Action Plan

This table details the legislative acts corresponding to each strategy under the EU Zero Pollution Action Plan. It also provides the main binding legal targets. These targets allow the EU to monitor progress towards the objectives of the policies.

Strategies and initiatives	Legislative acts and proposals	Targets
Air quality	Revision of the Ambient Air Quality Directives Ozone Regulation	-improving air quality to reduce premature deaths caused by air pollution by 55%; -reducing the share of people chronically disturbed by transport noise by 30%; -limit $PM_{2.5}$ and NO_2 to 10 µg/m^3 and 20 µg/m^3 respectively -Specific targets set by the Air Quality Directive: **Particulate Matter (PM10):** The directive sets a limit value for PM10 concentrations, which must not be exceeded on more than 35 days per calendar year. Additionally, there is an annual mean limit value that should not be exceeded. **Nitrogen Dioxide (NO2):** The directive establishes an hourly mean limit value for NO2 concentrations, which should not be exceeded more than 18 times per calendar year. There is also an annual mean limit value. **Ozone (O3):** The directive sets an information threshold, a warning threshold, and an alert threshold for ozone concentrations. Member states are required to take specific actions when these thresholds are exceeded. **Sulfur Dioxide (SO2):** The directive establishes an hourly mean limit value for SO2 concentrations, which should not be exceeded more than 24 times per calendar year. There is also a daily mean limit value. **Lead (Pb):** The directive sets an annual mean limit value for lead concentrations. **Benzene (C6H6):** The directive establishes an annual mean limit value for benzene concentrations. **Carbon Monoxide (CO):** The directive sets an 8-hour mean limit value for carbon monoxide concentrations.
Water quality	Review of the lists of pollutants affecting	-improving water quality by reducing waste, plastic rubbish at sea (by 50%) and microplastics released in the environment (by 30%)

	Surface waters and groundwaters Industrial emissions portal Revision of the Urban Wasterwater Treatment Directive Drinking Water Directive Bathing Water Directive Nitrates Directive EU Floods Directive	-Member States shall take the measures necessary to ensure that water intended for human consumption is wholesome and clean: water is free from any micro-organisms and parasites and from any substances which, in numbers or concentrations, constitute a potential danger to human health; water meets the minimum requirements set out in Parts A, B and D of Annex I (Drinking Water Directive). Specific targets set by the Nitrates Directive: **Nitrate Vulnerable Zones (NVZs):** Member States are required to designate specific areas as Nitrate Vulnerable Zones where water pollution from nitrates is a significant concern. NVZs are areas where the nitrate concentration in waters exceeds or is at risk of exceeding the EU's drinking water standard of 50 milligrams per litre. **Action Programs:** Member States with designated NVZs must develop and implement action programs that include specific measures to reduce nitrate pollution from agricultural sources. These measures may include, but are not limited to, limiting fertilizer application, adopting specific agricultural practices, and establishing buffer strips along water bodies. **Farm Management Practices:** The directive requires member states to promote good agricultural practices that reduce the risk of nitrate leaching, such as optimizing the timing and rate of fertilizer application, using nitrogen-fixing crops, and implementing soil conservation practices. **Record-Keeping Requirements:** Farmers in NVZs are required to keep records of fertilization practices and certain farming activities to ensure compliance with the action programs. **Training and Advisory Services:** Member States are encouraged to provide training and advisory services to farmers to help them implement the required measures effectively. **Monitoring and Reporting:** Regular monitoring of nitrate levels in surface and groundwaters is essential to assess the effectiveness of the action programs. Member States are required to report on the results of monitoring and the progress made in reducing nitrate pollution.
Soil quality	EU Soil Health Law Proposal on carbon removals certification Industrial Emissions Directive- Revision Environmental Liability Directive- evaluation	-improving soil quality by reducing nutrient losses and chemical pesticides' use by 50%; -reducing by 25% the EU ecosystems where air pollution threatens biodiversity; -reducing by 50% residual municipal waste and significantly reducing waste generation - The objective of the certification of carbon removals is to set out a Union net removal target of 310 Mt CO2 eq by 2030, and to allocate respective targets to each Member State (Proposal on certification of carbon removals) -Member States shall assess the soil health in all their soil districts based on the data collected in the context of the monitoring referred to in Articles 6, 7 and 8 for each of the soil descriptors referred to in Parts A and B of Annex I (Soil Health Law) -A soil is considered healthy in accordance with this Directive where the following cumulative conditions are fulfilled: (a) the values for all soil

		descriptors listed in part A of Annex I meet the criteria laid down therein and, where applicable, adapted in accordance with Article 7; (b) the values for all soil descriptors listed in part B of Annex I meet the criteria set in accordance with Article 7 ('healthy soil'). (Soil Health Law) - Member States shall take at least the following measures, taking into account the type, use and condition of soil: (a) defining sustainable soil management practices respecting the sustainable soil management principles listed in Annex III to be gradually implemented on all managed soils and, on the basis of the outcome of the soil assessments carried out in accordance with Article 9, regeneration practices to be gradually implemented on the unhealthy soils in the Member States; (b) defining soil management practices and other practices affecting negatively the soil health to be avoided by soil managers. (Soil Health Law) -Member States shall manage the risks for human health and the environment of potentially contaminated sites and contaminated sites, and keep them to acceptable levels, taking account of the environmental, social and economic impacts of the soil contamination and of the risk reduction measures taken pursuant to Article 15 paragraph 4. (Soil Health Law)

Annex 3- Policy framework for the Strategy on Climate change adaptation

This table details the legislative acts corresponding to each strategy for Climate change adaptation. It also provides the main binding legal targets. These targets allow the EU to monitor progress towards the objectives of the policies.

Strategies and initiatives	Legislative acts and proposals	Targets
EU Strategy on Climate change Adaptation	Climate Law	-In order to reach the climate-neutrality objective set out in Article 2(1), the binding Union 2030 climate target shall be a domestic reduction of net greenhouse gas emissions (emissions after deduction of removals) by at least 55 % compared to 1990 levels by 2030. -In order to ensure that sufficient mitigation efforts are deployed up to 2030, (...) the contribution of net removals to the Union 2030 climate target shall be limited to 225 million tonnes of CO_2 equivalent. To enhance the Union's carbon sink in line with the objective of achieving climate neutrality by 2050, the Union shall aim to achieve a higher volume of its net carbon sink in 2030. -process for setting a 2040 climate target, considering an indicative greenhouse gas budget for 2030-2050 -to be published by the Commission-
Fit to 55 Package	EU Emissions Trading System	- The EU ETS sets an annual emissions cap on the total amount of greenhouse gas emissions that installations (companies) covered by the system can release. This cap declines each year to reduce the overall emissions allowed over time. - The EU ETS includes a linear Cap Reduction Factor, which determines the rate at which the emissions cap decreases each year. The reduction factor is intended to ensure a gradual decline in emissions and contribute to the EU's climate goals. -The EU ETS is designed to help the European Union achieve its climate targets. The system contributes to the EU's overall goal of reducing greenhouse gas emissions by at least 40% by 2030 compared to 1990 levels. -The Market Stability Reserve (MSR), introduced in 2019, is an important quantitative target within the EU ETS. The MSR adjusts the number of allowances in circulation to address any significant imbalances between supply and demand, helping to stabilize the carbon market and support the price of allowances. -Linear Reduction Factor Post-2020: From 2021 onwards, the EU ETS introduced an increased linear reduction factor of 2.2% per year. This factor applies to the emissions cap to accelerate the pace of emissions reductions compared to the previous period. -binding national targets for each EU member state to collectively reduce greenhouse gas emissions by 10% below 2005 levels by the year 2020. (effort sharing)
	Carbon border adjustment mechanism	
	Effort sharing	
	CO2 emissions for cars and vans	
	Reducing methane emissions in	

	the energy sector	-for the period from 2021 to 2030, established individual national targets for each member state to collectively reduce emissions by 30% below 2005 levels by 2030. (effort sharing) -Reduction of the average CO2 emissions from new light commercial vehicles (vans). The target for 2021 was to achieve an average emissions reduction of 30% compared to 2007 levels -Reduction of the average CO2 emissions from new passenger cars sold within the EU. The target set for 2021 was to achieve an average emissions reduction of 40% compared to 2007 levels. -EU should reduce its methane emissions from energy by 58% by 2030, in comparison to 2020 levels. -ban on venting and flaring of methane by 2025 from drainage stations and by 2027 from ventilation shafts -Fuel suppliers must ensure that 2% of fuel made available at EU airports is SAF in 2025, rising to 6% in 2030, 20% in 2035 and gradually to 70% in 2050. -Annual average carbon intensity has to decrease by 2% in 2023 and by 6% in 2030 and then further by 5-year periods till 2050, when carbon intensity should be 75% compared to the 2020 base year. (sustainable maritime fuels) - for each registered battery-electric car in a given Member State, a power output of 1.3 kW must be provided by publicly accessible recharging infrastructure. In addition, every 60 km along the trans-European transport (TEN-T) network, fast recharging stations of at least 150 kW need to be installed from 2025 onwards. - Recharging stations dedicated to heavy-duty vehicles with a minimum output of 350 kW need to be deployed every 60 km along the TEN-T core network, and every 100 km on the larger TEN-T comprehensive network from 2025 onwards, with complete network coverage to be achieved by 2030. -Hydrogen refuelling infrastructure that can serve both cars and lorries must be deployed from 2030 onwards in all urban nodes and every 200 km along the TEN-T core network, ensuring a sufficiently dense network to allow hydrogen vehicles to travel across the EU - Maritime ports that see at least 50 port calls by large passenger vessels, or 100 port calls by container vessels, must provide shore-side electricity for such vessels by 2030 - Airports must provide electricity to stationary aircraft at all contact stands (gates) by 2025, and at all remote stands (outfield positions) by 2030 - target to source 42.5% of energy at EU level from renewable sources like wind and solar, with a potential top-up to 45%. -EU energy efficiency target for 2030 of at least 32.5% (compared to projections of the expected energy use in 2030), with a clause for a possible upwards revision by 2023. The 32.5% target translates into a final energy consumption of 956 Mtoe and/or primary energy consumption of 1 273 Mtoe in the EU by 2030
	Sustainable aviation fuels	
	Greener fuels in shipping	
	Alternative fuels infrastructures	
	Renewable energy	
	Energy efficiency	
	Energy performance of buildings	
	Hydrogen and decarbonized gas market package	
	Energy Taxation	

		-increase to the binding EU energy efficiency target from 9% to 13% compared to the 2020 Reference Scenario (750 Mtoe in final and 980 Mtoe in primary energy consumption, respectively)- REPower EU - public buildings will have to achieve at least energy performance class E by 2027, and D by 2030. In addition, all new buildings occupied, operated or owned by public authorities should be zero-emission from 2026.

Annex 4- Legal and Ethical Assessment Methodology

The Legal and Ethical Assessment Methodology provided by the Ethics Advisor of the GREAT project, serves as a comprehensive framework designed to systematically identify, evaluate, and address legal and ethical risks associated with a project's deliverables. Following a "by design" approach, this methodology is seamlessly integrated into the project's technical workflow, ensuring the consideration of legal and ethical aspects throughout the project's lifecycle. Its primary objectives encompass optimizing technical and business goals, ensuring compliance with relevant legal standards and ethical principles, and fostering ongoing competence-building within the research community involved.

Implemented in three key steps, the methodology begins with a preliminary meeting involving Work Package (WP) leaders, where the foundational literature and guiding legal and ethical principles are presented. The checklist analysis phase follows, employing a proactive "learning-by-doing" approach to identify potential gaps and risks across domains such as Data Privacy, Ownership, Licenses, Competition, Artificial Intelligence, and Social Media. Feedback from the Ethics Advisor on identified gaps and risks is integrated into the final deliverable, concurrently nurturing the skills necessary for crafting resilient legal and ethical solutions. These solutions address a breadth of domains and prioritize the overall impact of the deliverable while aligning with research and business goals, fostering a comprehensive legal and ethical framework.