WP 5	Deliverable No. 5.2

MARBEFES Project

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Abbreviation list

Abbreviation	Full name
BBT	Broad Belt Transect
CSS	Cascading Style Sheets
CSV	Comma-Separated Values
DEMO	Demonstration
EIA	Environmental Impact Assessment
EU	European Union
GA	General Assembly
HG	Horrendogram
IECS	Institute of Estuarine and Coastal Studies
JSON	JavaScript Object Notation
LW ERIC	LifeWatch ERIC
MARBEFES	Marine Biodiversity and Ecosystem Functioning leading to Ecosystem Services
MS	Member States
MSP	Marine Spatial Planning
NLP	Natural Language Processing
OG	Organigram
SEA	Strategic Environmental Assessment
UN	United Nations
UN-SDG	United Nations Sustainable Development Goals
URL	Uniform Resource Locator
VRE	Virtual Research Environment
WP	Work Package

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Summary

The MARBEFES project, funded by the EU's Horizon Europe programme, aims to establish links between biodiversity, ecological structure, and the functioning of coastal and marine ecosystems, as well as the ecosystem services and societal goods and benefits they provide.

This deliverable 5.2, *"Online demonstration of the effectiveness of different governance and management schemes across and between BBTs and regions on the VRE"* (A), serves as a mid-term report within Work Package 5: "Integration and Scenarios". It outlines the methodology developed by the consortium to assist stakeholders in identifying and comparing governance and management schemes across and between Broad Belt Transects (BBTs) and regions.

This report describes the process of selecting and developing a tool that enables stakeholders to conduct inquiries and navigate data seamlessly. The ObsidianTM software was chosen for its dynamic visualization capabilities and its efficient management of large, interconnected datasets using a local-first approach. This software facilitates the organization and exploration of interlinked, markdown-based notes, enhancing data accessibility and achieving better stakeholder engagement.

Additionally, the report presents outcomes derived from the implementation of the tool, which will be subsequently integrated into the MARBEFES Toolbox. It also includes details of demonstrations conducted for project partners, highlighting preliminary results from simulations and online analyses and demonstrating how the tool works.

The project will then continue to refine the tool and methodologies to improve accessibility and functionality. Ongoing collaboration with project partners and feedback from stakeholders will be key to ensuring the tool remains aligned with current and evolving policy frameworks.

This mid-term report marks a significant milestone for the MARBEFES project, laying the groundwork for future research, development, and implementation.

This deliverable focuses on Part A of Task 5.2 and demonstrates how Organigrams (OGs) and Horrendograms (HGs) can be digitally interrogated to compare governance and management schemes across BBTs and regions. ItThis deliverable presents a digital approach for interrogating and comparing complex governance and management schemes across Broad Belt Transects (BBTs) and regions. The results presented here provide an operational foundation that will be further consolidated and extended in Part B at the end of the project.

The integration of Organigrams and Horrendograms into an interactive environment enables stakeholders to efficiently identify relevant legislation, governance bodies and institutional responsibilities for specific sectors.

The tool enhances transparency, accessibility and usability of governance information, moving beyond static diagrams towards dynamic, queryable visualizations.

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A practical demonstration, including a sector-based example (offshore wind), illustrates the operational value of the approach for policy-relevant and stakeholder-oriented use.

The work provides a solid foundation for further development and integration into the MARBEFES Toolbox, supporting long-term use, scalability and alignment with evolving policy frameworks.

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1. Introduction

Marine management encompasses the regulatory framework consisting of the legislation and agreements at the local, national, regional and global levels, and those statutory bodies required to implement that legislation (Cormier et al 2022; Elliott et al., 2025). The administrative bodies then require to be horizontally integrated across sectors (fishing, navigation etc) and the legal instruments and agreements need to be vertically integrated from the local to the global (Cormier et al., 2022). These aspects constitute part of the governance of the marine system which is then supplemented by other public and private governance (Elliott et al., 2025).

The MARBEFES project includes 12 Broad Belt Transects (BBTs) across various regional seas, each governed by distinct management frameworks. This variety is also associated with multiple, key institutional and administrative bodies, their responsibilities under relevant legislation, and the specific legal instruments associated with different sectors and challenges. In order for the above diversity to be captured by the tool, each BBT has created both an Organigram (OG) and a Horrendogram (HG) for their area.

Organigrams (OGs) are visual representations of the institutional landscape in each BBT, showing how relevant organizations are structured and interrelated in the context of marine and coastal governance. They help identify key actors, administrative levels, and their respective roles and responsibilities. Horrendograms (HGs), on the other hand, map the regulatory and legislative frameworks that apply to marine management. These documents present the links between international, EU, and national laws and policies, providing a comprehensive overview of the governance mechanisms affecting each area. Both OGs and HGs are categorized by sectors, which act as the common reference to interlink institutional structures with legal instruments, thus offering an integrated and cross-referenced understanding of how governance and legislation are articulated across regions.

To address this complexity, the consortium has developed two complementary tools for each BBT: OG and HG. These are based on Boyes and Elliott (2015, 2014) and updated by Elliott et al. (2022), respectively. OGs visually map the institutional structure of marine management agencies, illustrating their roles, hierarchical relationships, and sectoral responsibilities. HGs, in contrast, clarify the legislative and policy context of each BBT, providing a broader overview of the legislative and regulatory landscape, linking international, regional, and national commitments that influence marine governance. These tools help stakeholders navigate the intricate network of policies, laws, agreements and regulations that shape environmental decision-making.

However, the high volume of information and the complexity of these frameworks can make them difficult to interpret and apply effectively. Stakeholders may struggle to interrogate the frameworks and extract relevant insights quickly, limiting their practical utility.

This report outlines the consortium's efforts to enhance their usability by integrating these tools into a digital platform within the MARBEFES Toolbox. It describes the demonstration process carried out with project partners and highlights the next steps for further development, focused on improving accessibility and functionality to better align with stakeholder needs.

This deliverable is developed within WP 5 (Integration and Scenarios) and contributes to the integration of governance, institutional and legislative information across BBTs and regions. It builds on the OGs and HGs produced by the BBTs (WP2), providing the technical and conceptual basis for

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their digital interrogation and comparison.

By enabling structured queries and interactive exploration of governance frameworks, the deliverable supports cross-BBT and cross-sectoral analyses that are relevant for integrated assessments and scenario development. The outcomes also contribute to other MARBEFES WPs by offering a shared governance and institutional reference that can be used to contextualise ecological, biodiversity and socio-economic results (WP3 & WP4).

In addition, the work feeds into the MARBEFES Toolbox (WP5 & 6), where the approach will be further consolidated and extended in later project stages, supporting stakeholder-oriented use (WP1) and ensuring coherence between scientific outputs, governance analysis and policy-relevant applications across the project.

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2. Methodology

2.1 The means of interrogation - why a software is needed and what is required

In order to create usable tools targeted to the statutory governance of an area, the project requires a specialized software solution to streamline user interaction with complex datasets and interrelated information. This solution is designed to simplify data complexity, providing faster and more intuitive access to relevant information. By improving user's experience through a structured interface and efficient navigation, the tool fosters stakeholder engagement and supports informed decision-making. In particular, the software is needed to allow the user to interrogate the HGs and OGs when confronted by a specific challenge, for example the occupation of marine space by an industry.

The information and database are structured around two key components: HG (Figure 1) and OG (Figure 2). From the centre moving outwards, the HGs map the vertical governance levels from the **International Law/Conventions** (e.g. United Nations), **International Regulatory Bodies, and European Law** (e.g. EU) and national laws (e.g. country specific implementation) related to marine management which encompasses all activities required to be factored into coastal management (Cormier et al., 2022). Each has been linked to relevant web based sources for easy access. OGs outline institutional frameworks, mapping **Umbrella/Parent Organizations, Ministries, and Non-Departmental Public Bodies/Executive Agencies** to illustrate governance structures. Both components have been categorized by sector to provide targeted insights.

2.1.1 Sectors Covered:

- Multi-sectoral
- Physical restructuring of rivers, coastline, or seabed (water management)
- Security/Defence
- Transport
- Extraction of non-living resources
- Production of energy
- Urban and industrial uses
- Tourism/Leisure
- Cultivation of living resources

2.1.2 Additional Sector Protection:

- Nature conservation/protection
- Flood risk management
- Fisheries
- Water quality
- Marine Spatial Planning (MSP)
- Climate change
- Strategic Environmental Assessment (SEA)

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- Environmental Impact Assessment (EIA)

- Historical protectionThis structured categorization ensures that stakeholders can efficiently navigate and analyse governance frameworks, sectoral interactions, and regulatory influences within the MARBEFES project and have access to all relevant information available. The HG consists of concentric sets of legislation from the central international and regional bodies, through the intermediate levels of European legislation and to the outer level of national and local instruments and their means of implementation (Figure 1). In contrast, the OG for each area shows the cascade and hierarchy from the national government departments and ministries down to the agencies and other government bodies (Figure 2).

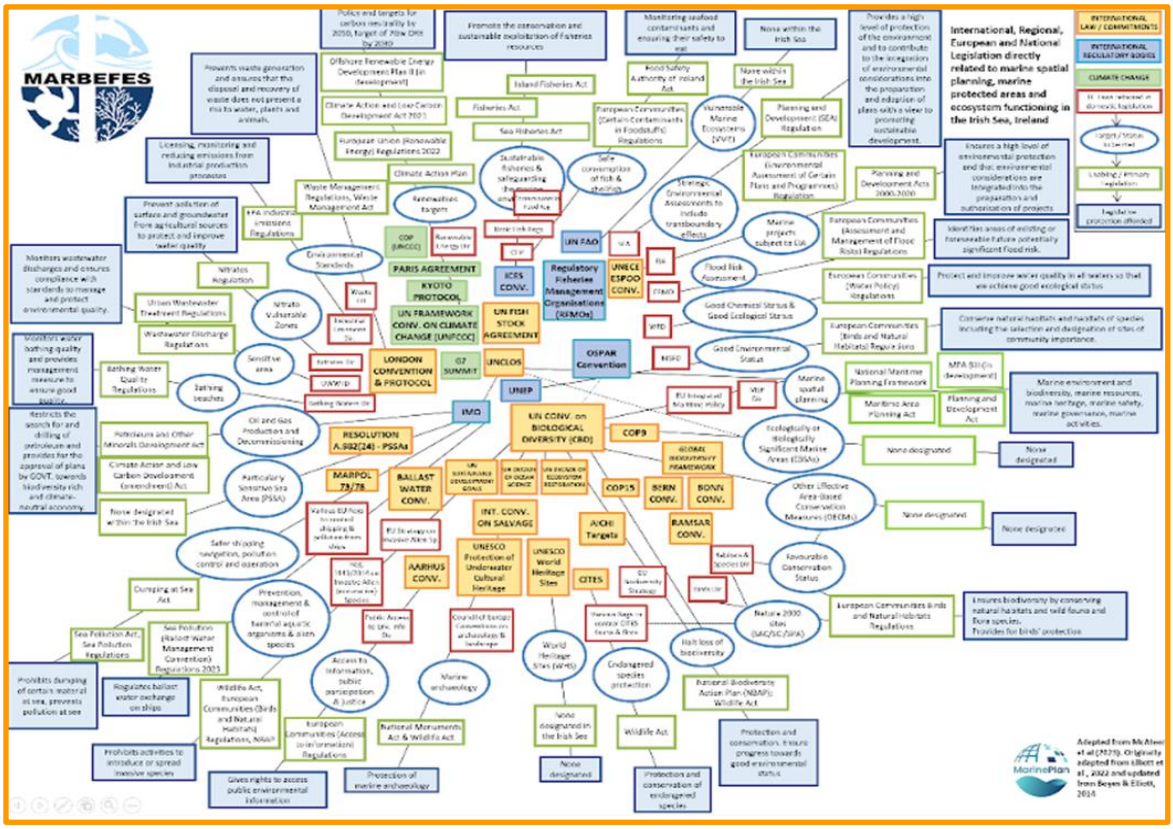

Figure 1. Visual complexity of Horrendogram (HG) (from Boyes and Elliott (2015, 2014)).

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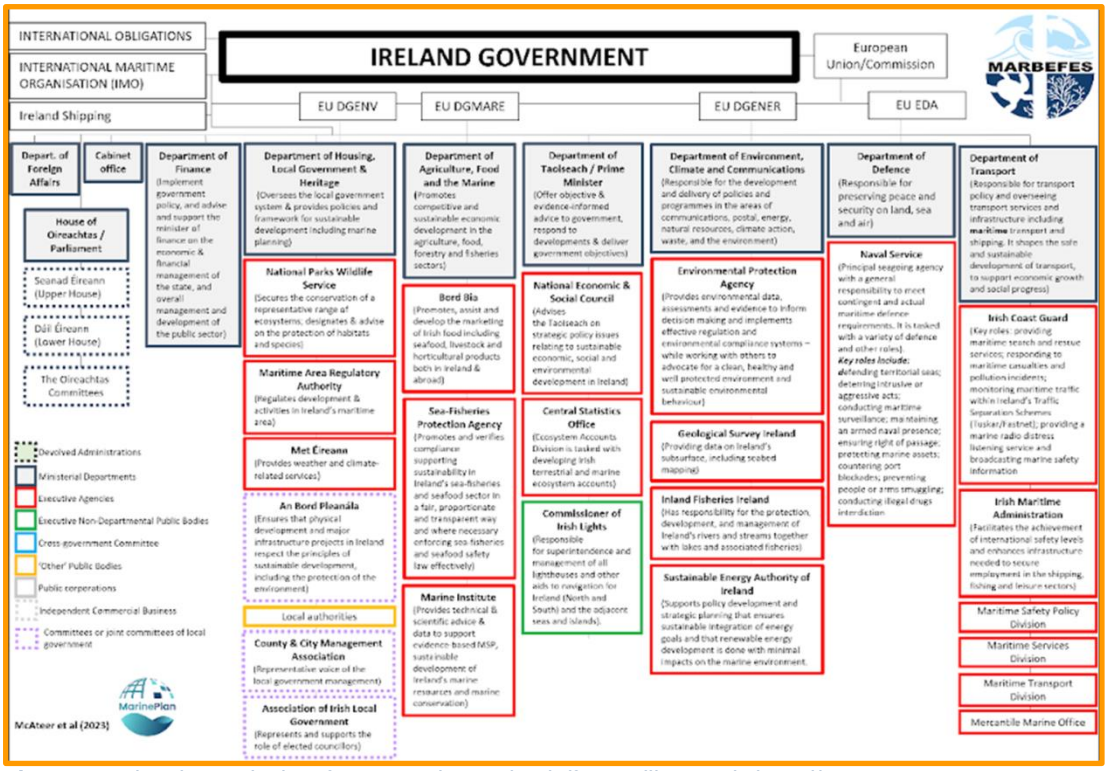

Figure 2. *Visual complexity of an Organigram (OG) (from Elliott et al. (2022))*

2.2 Software selection

Selection Criteria

The selection of ObsidianTM as the software solution to allow interrogation of the OG and HG was driven by key criteria including **security, flexibility, scalability, ease of integration, and robust data management capabilities**.

Additionally, the Obsidian **markdown-based architecture** enables the structuring of large, interconnected datasets with ease. This approach allows for **efficient organization, retrieval, and navigation of complex information networks**, making it particularly suitable for handling governance structures, regulatory frameworks, and institutional relationships (See Figure 3).

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Figure 3. *Example of an Organigram represented as Markdown files in Obsidian. Each organisational entity is stored as a plain-text Markdown note containing structured metadata (e.g. organisation name, sectoral relevance, and web links). Internal links between notes create explicit relationships between institutions, enabling dynamic navigation and graph-based visualisation of governance structures.*

The software **flexibility and extensibility**, supported by a rich ecosystem of plugins and customization options, further enhance its adaptability to evolving project requirements.

By meeting these and the afore-mentioned criteria, Obsidian provides a **secure, scalable, and intuitive** platform for managing and analysing intricate datasets, ensuring that stakeholders can effectively engage with the information while maintaining control over their data.

Comparison of Alternatives

Several tools were assessed for their ability to manage and visualize hierarchical structures, including **Lucidchart, Microsoft Visio, Notion, and Excel**. While each offers valuable features, they fall short in providing the **flexibility and dynamic interconnectivity** required for efficiently managing complex data relationships. The Obsidian **markdown-based system** and **graph-based visualization** ultimately positioned it as the most suitable choice.

Lucidchart and Microsoft Visio excel in diagramming but lack the **real-time adaptability** needed for managing evolving, interconnected datasets. Their reliance on static representations necessitates **substantial manual updates**, limiting scalability in dynamic environments.

Notion and MS Excel offer structured data management in **tabular and database formats**, but they do not inherently support **real-time linking** nor provide the **graphical clarity** needed to quickly interpret intricate relationships between entities.Obsidian overcomes these limitations by **seamlessly**

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integrating structured markdown-based note-taking with a dynamic graph visualization, enabling **instant updates, bidirectional linking, and intuitive exploration of interconnected data** (see Figure 4).

Tool	Primary purpose	Strengths	Limitations	Suitability for HG/OG
Obsidian	Knowledge management and graph-based visualization	Dynamic linking, bidirectional relationships, local-first data control, customizable graph view	Learning curve for non-technical users, no native real-time collaboration	**Highly suitable**: supports complex hierarchical and sector-based governance structures
Lucidchart	Diagramming and flowcharts	Clear visual diagrams, easy to use	Static representations, limited scalability for complex updates	Low: diagrams require manual updates
Microsoft Visio	Professional diagramming	Structured layouts, widely used in administration	Static files, limited interoperability	Low: not designed for dynamic interrogation
Notion	Collaborative documentation	Cloud-based, collaborative editing	Weak graph visualization, limited hierarchical querying	Medium–low: good for text, weak for governance graphs
Microsoft Excel	Tabular data management	Structured data, widely available	No native visualization of relationships	Low: requires external tools for interpretation

Table 1. This table summarises the comparison of software tools considered for supporting the interrogation of Organigrams and Horrendograms. While several tools provide useful features for documentation or diagramming, Obsidian was selected due to its ability to dynamically represent complex, interlinked governance structures and support sector-based queries across BBTs

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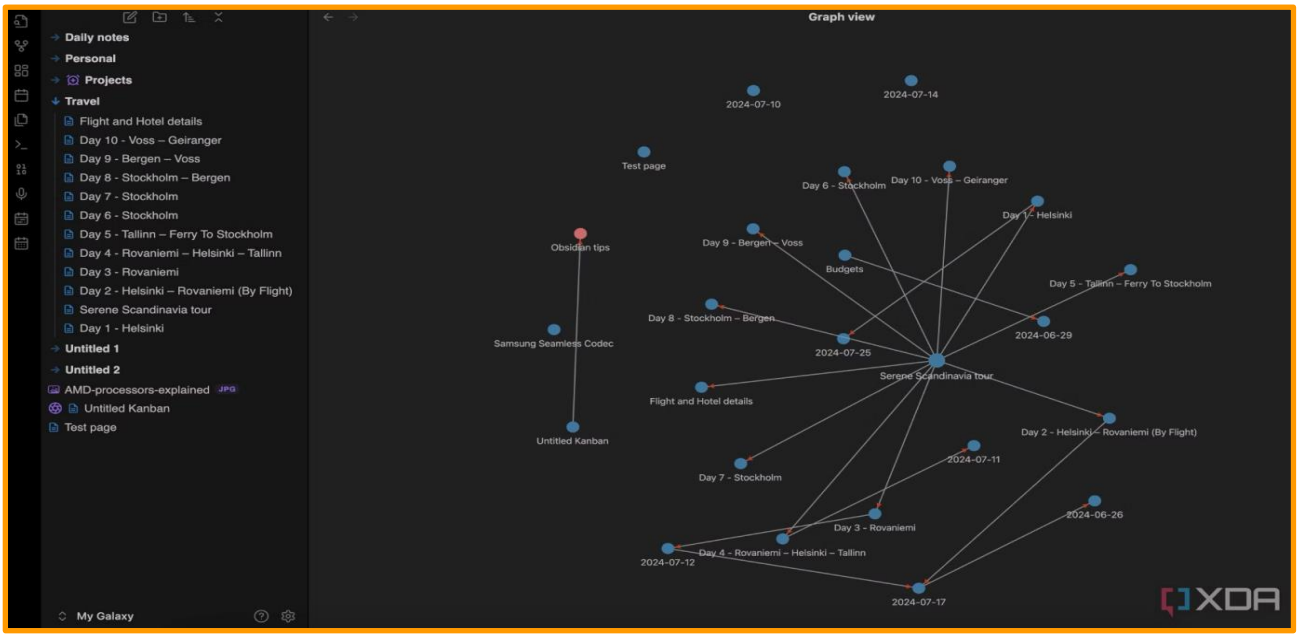

Figure 4. Standard Obsidian interface showing the integration of structured nodes and graph-based visualisation. The central panel displays the network graph generated from linked Markdown files, where nodes represent organisations or legal instruments and arrows represent their relationships. This interactive view allows users to explore governance structures dynamically, filtering by sector or relevance.

Reason for Selection

Obsidian was chosen for its unique combination of markdown simplicity and advanced visualization capabilities. Its modular architecture allows for extensive customization through community-developed plugins and themes, enabling additional functionalities such as task management, advanced linking, customizable interfaces, and software integrations. This adaptability makes Obsidian particularly well-suited for the project's diverse requirements, facilitating efficient data management, storage, and retrieval while ensuring scalability (See https://publish.obsidian.md/lifewatch).

A key advantage of Obsidian is its Graph View, which provides an intuitive and dynamic way to visualize hierachical structures and relationships. The interactive nature of the graph, coupled with the ability to refine visualizations, ensures that Obsidian remains flexible and adaptable to complex research environments.

Limitations

Despite its many advantages, the Obsidian markdown-based system and local-first approach may introduce a learning curve for users unfamiliar with regular text editors. Additionally, while highly scalable for individual and team-based data management, the lack of native cloud-based real-time collaboration may present some constraints compared to fully cloud-integrated alternatives. In practice, this means Obsidian lacks features like live editing or automatic syncing across users, which are standard in fully cloud-based tools like Google Docs or Notion.

2.3 The use of sectors as a common thread

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In this project, as listed above, sectors represent the main categories of marine users and are depicted as distinct thematic or operational areas that are crucial for organizing the very large amount of data and relationships managed within the HGs and OGs. The integration of these sectors into our data visualization strategy serves as a common thread that ties different elements (the administration and the legislation) of the project together, ensuring coherence and alignment.

By using sectors as a shared reference point, we establish a structured approach to connect institutional interactions with their corresponding organizational frameworks. This allows for a coherent representation of how different institutions and governance structures interact within specific thematic or regulatory domains, ensuring a more comprehensive and interconnected analysis of the system.

Both HGs and OGs in the MARBEFES project involve a similar process of transforming structured data from Excel into interactive Markdown files for visualization in Obsidian, leveraging Python language programming for data manipulation. Excel files were derived from graphical representations (in PowerPoint) of the HGs and Organigrams created by the BBTs in MARBEFES. However, there are notable differences in how each type of diagram is constructed and used, reflecting their distinct purposes and the specific nature of the data they represent.

2.4 Organigrams

The creation of **an OG** starts with Excel files that map out the marine regulatory framework, relevant to a BBT (Figure 5). These files are processed using Python to transform hierarchical relationships and attributes into Markdown format. The script treats each row as a component of the broader legal framework, converting it into a Markdown file. The table below indicates that each row has the following components (by columns):

- **Column A → NODE:** Contains a unique identifier for each entry, used to categorize and organize data within Obsidian.
- **Column B → colour**: Set to "Green" for all records, used to indicate a common classification or status in the knowledge graph visualization.
- **Column C → BBT**: Specifies that all records belong to a BBT, establishing the geographical context of the dataset.
- **Column D → TAG**: Defines the filename for the note generated in Obsidian and is also included within the note as `"TAG:CC"`, serving as a key label for searching and organizing within the note system.
- **Column E → Name**: Provides the descriptive name of each element, improving identification and contextualization of each node within the knowledge graph.
- **Column F → URL**: Contains a reference link included in the Obsidian note as `"URL:CC"`, allowing easy access to additional information or external sources.
- **Columns G to CF → Sectors**:
    - If a cell within these columns contains `"YES"`, a Markdown field is created as `[[name]]`, where *name* is the text in **row 2** of the same column.
    - Each column represents a **category, criterion, or relationship**, which is activated when `"YES"` is present, enabling interconnections between related notes in Obsidian.

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	A1	A2	A3	A4	A5	A6	A7	A8	A9	Additional sector protection									
URL (containing more information about the element)	Physical restructuring of rivers, coastline or seabed (water management)	Extraction of non-living resources	Production of energy	Extraction of Living Resources	Cultivation of living resources	Transport	Urban and Industrial uses	Tourism / Leisure	Security / Defence	Nature conservation / protection	Flood risk	Fisheries	Water quality	MSP	Climate change	SEA	EIA	Shipping	Historical protection
Department for Environment, Food	1	1	0	1	1	0	1	0	0	1	1	1	1	1	0	1	1	0	0
Natural England - GOV.UK	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	1	0	0
Marine Management Organisation	1	1	0	1	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0
Environment Agency - GOV.UK	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	0
Home | Seafish	0	0	0	1	0	0	1	0	0	1	0	1	1	0	0	0	0	0	0
Flood Forecasting Centre - GOV.UK	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
JNCC - Adviser to Government on N	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
Home - Cefas (Centre for Environm	0	0	0	1	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0
Animal and Plant Health Agency - G	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Fish Health Inspectorate - GOV.UK	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Advisory Committee on Releases to	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Flood and Coastal Erosion Risk Ma	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Home - Office for National Statistic	0	0	0	1	1	0	0	0	0	1	0	1	0	0	1	1	1	0	0
Natural Resources Wales	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
About DAERA | Department of Agric	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0
Isle of Man Government - Environm	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0

Figure 5. Excel file generated from an Organigram to feed Obsidian software.

This method emphasizes the handling of complex legislative data and focuses on visual customization, such as applying CSS (Cascading Style Sheets) for clarity and emphasis in the Obsidian interactive graph.

Organigrams focus on organizational structure. The Excel files here describe the hierarchy within or between organizations responsible for the environmental management in a BBT. The Python script translates these relationships into Markdown, but with a stronger focus on accurately mapping parent-child connections integral to organizational charts. Columns in Excel designated to define these relationships are dynamically identified for each BBT, ensuring that organizational links are accurately represented in Obsidian's graph view.

The process involves:

- The use of Python (programming language) and pandas (python library) to read and manipulate Excel data.
- The conversion of these data into Markdown files for use in Obsidian, taking advantage of the Obsidian graph view to visualize complex relationships.
- The application of Markdown link syntax to create dynamic, interactive visualizations that users can explore by clicking on nodes.

2.4.1 Operational use of Organigrams (OGs)

Organigrams are used to identify which institutions are responsible for marine management and governance within a specific sector and BBT. By structuring institutional hierarchies digitally, OGs allow users to quickly determine competent authorities, administrative levels, and sectoral responsibilities. When combined with HGs, OGs support cross-BBT comparisons by linking legal obligations to the institutions responsible for their implementation.

2.5 How Obsidian works and how it is used in MARBEFES

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Obsidian performs best at storing, linking, and visually representing the connections between plain-text documents. Operating primarily as a client-side application, Obsidian interacts directly with the local file system, removing the need for proprietary formats or centralized databases. This design choice ensures that all data remain portable and accessible, fully independent of the tool, and capitalizes on the universal adaptability of Markdown (See Figure 6).

The fundamental mechanism through which Obsidian establishes relationships between data points is through its internal linking feature. Links are formulated using Markdown syntax, which links directly to other Markdown files within the same digital repository, or vault. When such a file exists, Obsidian automatically generates a bidirectional link, making the relationship visible and navigable from both linked nodes. These connections are then dynamically illustrated in the Obsidian Graph View as a network of nodes and arrows, depicting the intricate web of interrelations (Figure 7).

Each Markdown document is treated as a node within this graphical representation, with links connecting the nodes in the visible graph. This graph is dynamic, updating in real time with any modifications to the files or their links. The Graph View offers extensive customization options, allowing users to filter and display nodes and edges based on specific attributes, styling preferences, or custom metadata embedded within the documents. Furthermore, CSS is employed to enhance the visual distinction of nodes, such as highlighting particular categories (e.g. legislation or organisations related to a particular sector) or adjusting their size for better visibility.

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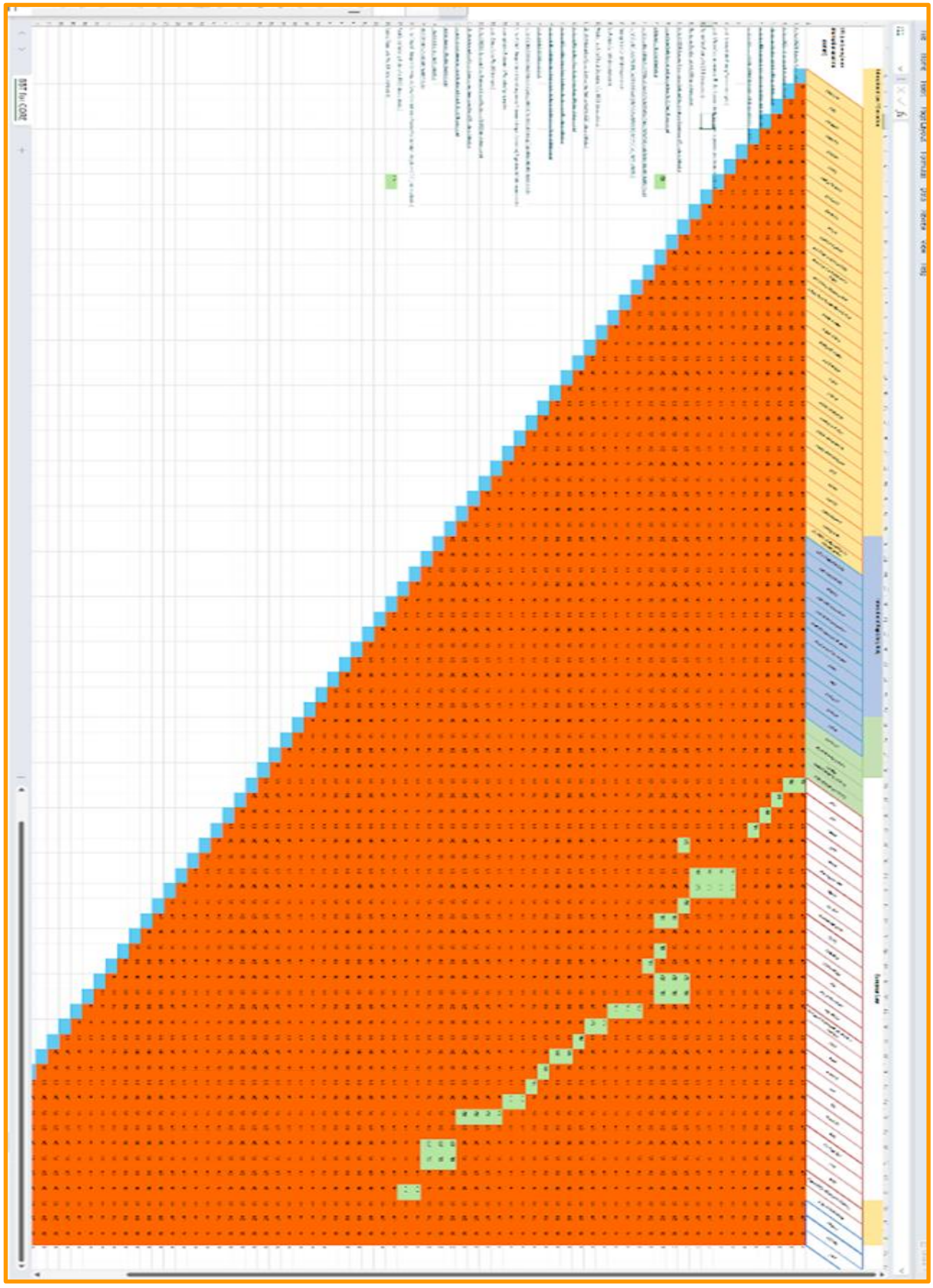

Figure 6. Excel file generated from an Horrendogram to feed Obsidian software.

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Figure 7. Obsidian graph view representing an Organigram for a BBT. Brown nodes represent main institutional bodies, while linked nodes show subordinate agencies and sector-specific responsibilities. The highlighted connection illustrates the institutional pathway relevant for the selected sector.

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Figure 8. Relation between nodes. Obsidian graph view representing an Organigram for a BBT. The orange node represents the main law, while the linked node shows subordinate agencies. The highlighted connection illustrates the relevant institutional pathway.

Obsidian has been instrumental in visualizing the hierarchical and organizational structures derived from Excel data.

Additionally, the Obsidian capability to integrate custom CSS styles into the Markdown files or apply them globally across the vault enhances the utility of the tool. This feature is used to visually distinguish central organizational elements, such as those denoted in the C column related to BBT, which are styled to appear larger and coloured green, thereby creating an intuitive visual hierarchy that simplifies navigation and analysis.

In Obsidian, each node of information, includes also relevant weblinks to organisations and individual pieces of legislation to assist the user.

This sophisticated application of Obsidian within the MARBEFES project showcases how powerful data processing tools can effectively bridge the gap between static data management and dynamic, interactive data visualization, enhancing the comprehensibility and accessibility of complex information structures.

2.6 Horrendograms

Horrendograms (HGs) are designed to support the interrogation of complex multi-level legislative frameworks by allowing users to identify which legal instruments apply to specific sectors and governance levels within each BBT.

The creation of HGs follows a structured approach that begins with Excel files containing extensive legislative and regulatory data relevant to a BBT (Figure 9). These files are processed using Python scripts, which transform hierarchical relationships and legislative frameworks into Markdown format, making them accessible within Obsidian. Each row in the dataset represents a specific law,

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or international agreement, and is converted into an individual Markdown file, ensuring structured data visualization and easy navigation.

Each row in the dataset consists of multiple components, represented in columns, which structure the information systematically within Obsidian:

2.6.1 Structure of Columns in the HG Dataset

- **Column A → NODE**: Contains a unique identifier for each legislative or regulatory entry, essential for categorizing and organizing governance data.
- **Column B → HG Category / Box Colour**: Specifies the classification of the governance element within the HG. Includes colour-coded categories to distinguish different regulatory levels or legal instrument types.
- **Column C → Type**: Defines the type of legislative framework, such as **International Law/Convention**, **European Law**, or **National Regulation**.
- **Column D → Column ID**: Serves as an additional categorization or internal identifier for the specific governance document.
- **Column E → Law Name / International Organisation Name**: Provides the **full official name** of the legislative document, international convention.
- **Column F → URL**: Contains **reference links** for direct access to the official legislation, agreements, or regulatory bodies (Figure 9).

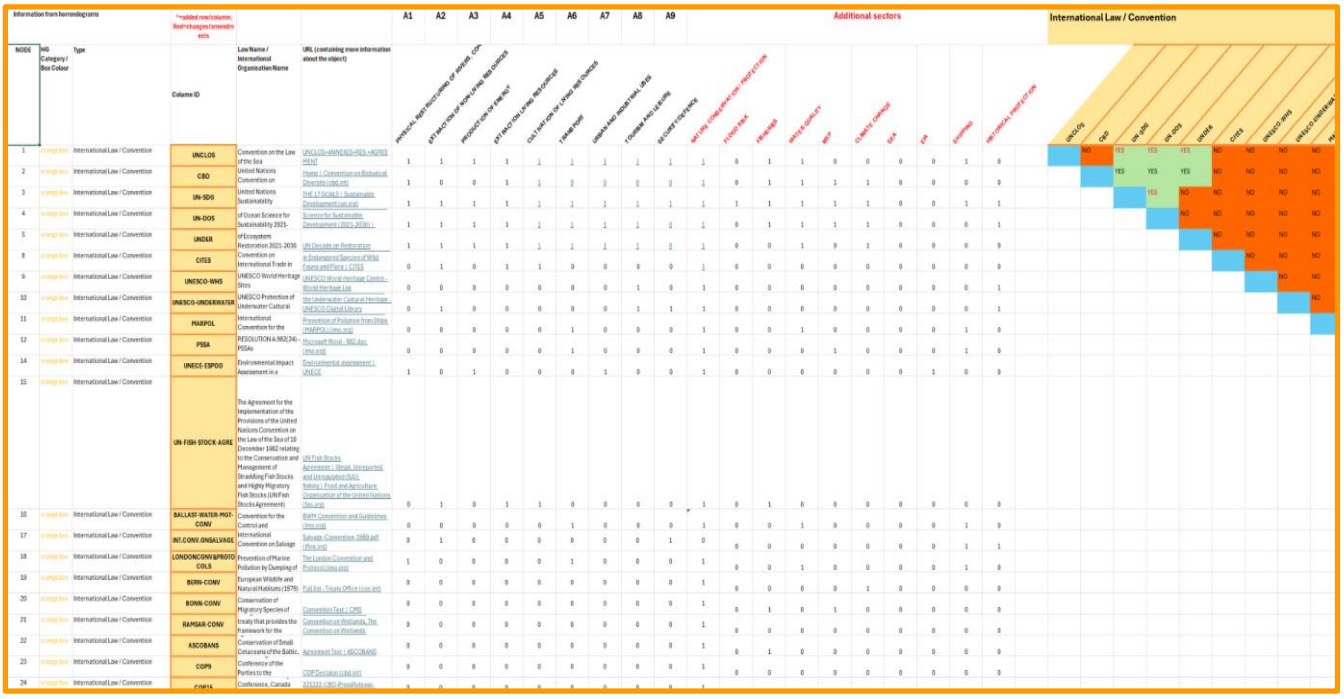

Figure 9. Excel file used for the Horrendogram classification.

Legislative Classification and Sectoral Applications (Columns G-CF)

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The dataset categorizes governance elements based on **policy domains, institutional levels, and sectoral applications**.

- **Columns G-Y → Policy Domains and Governance Categories**:
    - These columns specify whether a **law, directive, or regulation** falls under **international, regional, or national governance levels**.
    - If a cell contains `"1"`, it means the corresponding law applies to the **category** described in **row 2** of that column.
    - Examples of governance categories:
        - **International Law/Conventions**
        - **European Directives**
        - **National Marine Policies**
        - **Sector-Specific Legislation** (e.g., fisheries, spatial planning, climate change)
    - `"1"` values generate a **Markdown link (`[[Category]]`)** in Obsidian, allowing users to navigate related policies.
- **Columns AA-CF → Sectoral Relevance and Applications**:
    - These columns define how **specific legal frameworks relate to various marine governance sectors**.
    - `"YES"` values indicate that a regulation applies to a **specific sector**, identified by the label in **row 2** of that column.
    - Typical sectoral categories include:
        - **Marine Protection & Conservation**
        - **Fisheries Management**
        - **Climate Change Adaptation**
        - **Water Quality Regulations**
        - **Strategic Environmental Assessment (SEA) & Environmental Impact Assessment (EIA)**
    - `"YES"` values generate `[[Sector]]` references in **Obsidian**, enabling dynamic exploration of sectoral policies.

2.6.2 Integration into Obsidian and Visualization Enhancements

This structured approach allows **interactive exploration of complex legislative networks** using **Obsidian Graph View (Figure 10)**. The **Python script** automates the conversion of structured data into Markdown, leveraging **bidirectional linking** to interconnect laws, instruments, and sectoral frameworks.

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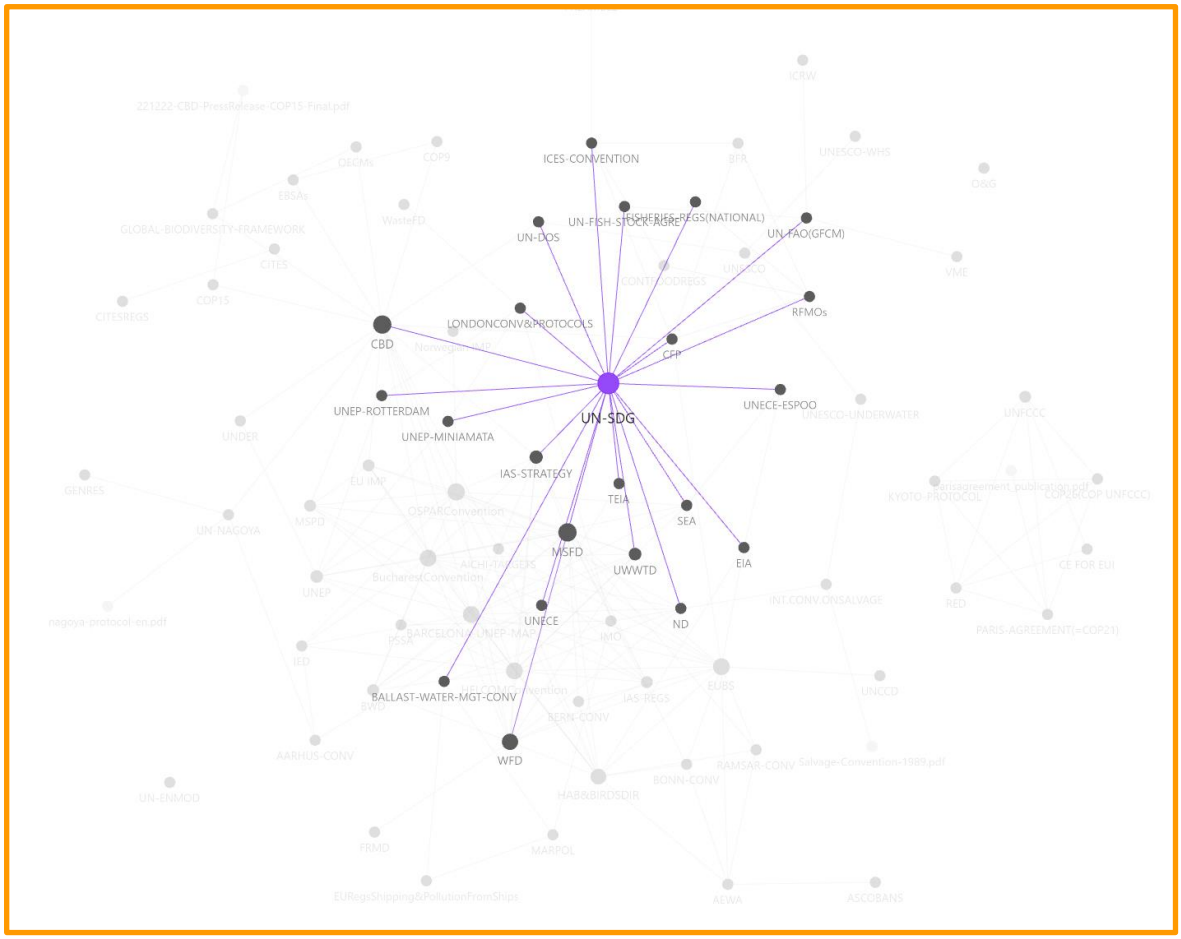

Figure 10. Obsidian graph view representing a Horrendogram for a BBT (UN-SDG). Nodes represent international, European, and national legal instruments, while links indicate sectoral applicability. This view enables users to identify the relevant governance framework for a specific sector across governance levels.

Key **functionalities in Obsidian** applied to HGs include:

- **Automated linking** between related policies, ensuring contextual navigation.
- **Graph View customization**, allowing users to filter and visualize governance structures by legal category or sector.
- **CSS-based styling**, highlighting major governance entities and legal instruments for better readability.

Unlike **Organjgrams (OGs)**, which focus on **institutional hierarchies**, **HGs emphasize legislative complexity**, requiring a more structured **classification system and interactive visualization**. The integration into **Obsidian** ensures that stakeholders can efficiently access, interpret, and explore **multi-level governance frameworks**, making complex legal data **more accessible and actionable**.

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3. Results and Demonstration

3.1 Capabilities and Examples

One of the key capabilities of Obsidian is its ability to manage and visualize hierarchical structures, which is particularly beneficial when dealing with **OGs**. Users can trace institutional linkages, explore how different governance bodies interact, and analyse organizational dependencies across the BBTs. Through bi-directional linking, OGs can be expanded to include sub-agencies, regulatory bodies, and decision-making entities, providing a clear view of authority distribution and sectoral responsibilities.

For **HGs**, Obsidian enhances the way legislation is structured and accessed. The tool allows users to categorize legal frameworks, group related policies, and quickly retrieve relevant information through linked references and embedded queries. Stakeholders can cross-reference multiple regulatory frameworks, ensuring that each governance structure is contextualized within its international, regional, and national legislative landscape. By filtering sectoral interactions, users can focus on specific legal domains, such as maritime spatial planning, climate change policies, or biodiversity conservation, streamlining decision-making processes.

The Obsidian graph view further strengthens analytical capabilities by providing an interactive representation of how institutions, regulations, and policies interconnect. This feature allows users to toggle visibility layers, focusing on specific sectors or relationships, and dynamically adjust perspectives to highlight critical governance intersections. The ability to customize visual outputs using CSS and plugins ensures that stakeholders can adapt the tool to varied research and policy needs (See Figures 11, 12 and 13).

By integrating HGs and OGs into a structured, queryable system within Obsidian, stakeholders gain a powerful decision-support tool that enhances their ability to navigate governance complexities, understand institutional hierarchies, and assess policy interactions. The combination of rich metadata linking, interactive visualization, and structured markdown documentation ensures that the tool remains scalable, adaptable, and future-proof.

3.1.1 Practical example: Offshore wind governance in a BBT

For example, when querying the offshore wind sector in a selected BBT, the Horrendogram allows users to identify the applicable international conventions, EU directives, and national legislation. The corresponding Organigram then highlights the competent ministries and agencies responsible for implementation. This combined view supports stakeholders in understanding regulatory obligations and institutional responsibilities associated with offshore wind development.

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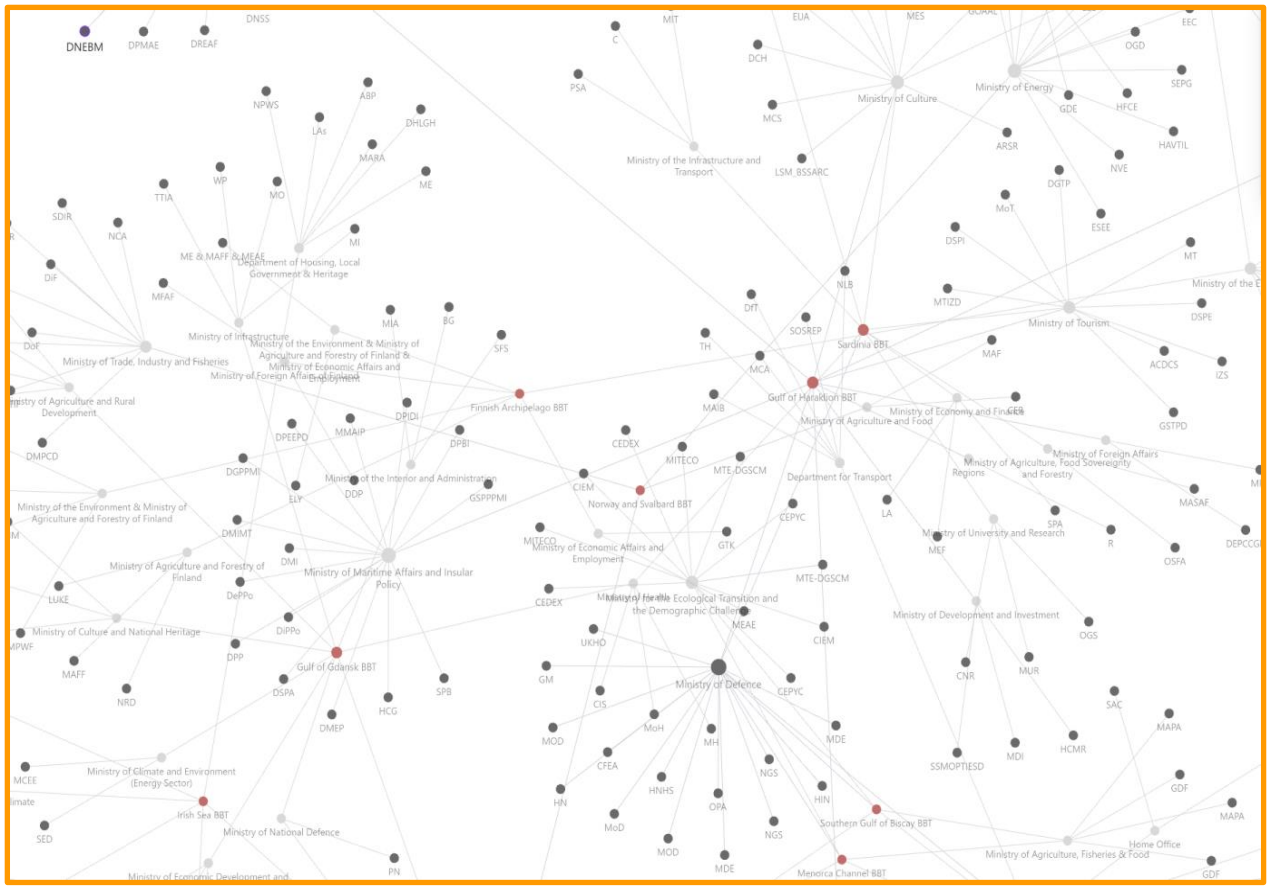

Figure 11. *Graph view in Obsidian showing BBTs (red), legal instruments (black), and thematic or intermediary links (grey). This visual highlights how each BBT connects to relevant governance elements, assisting the stakeholder understand the institutional relationships.*

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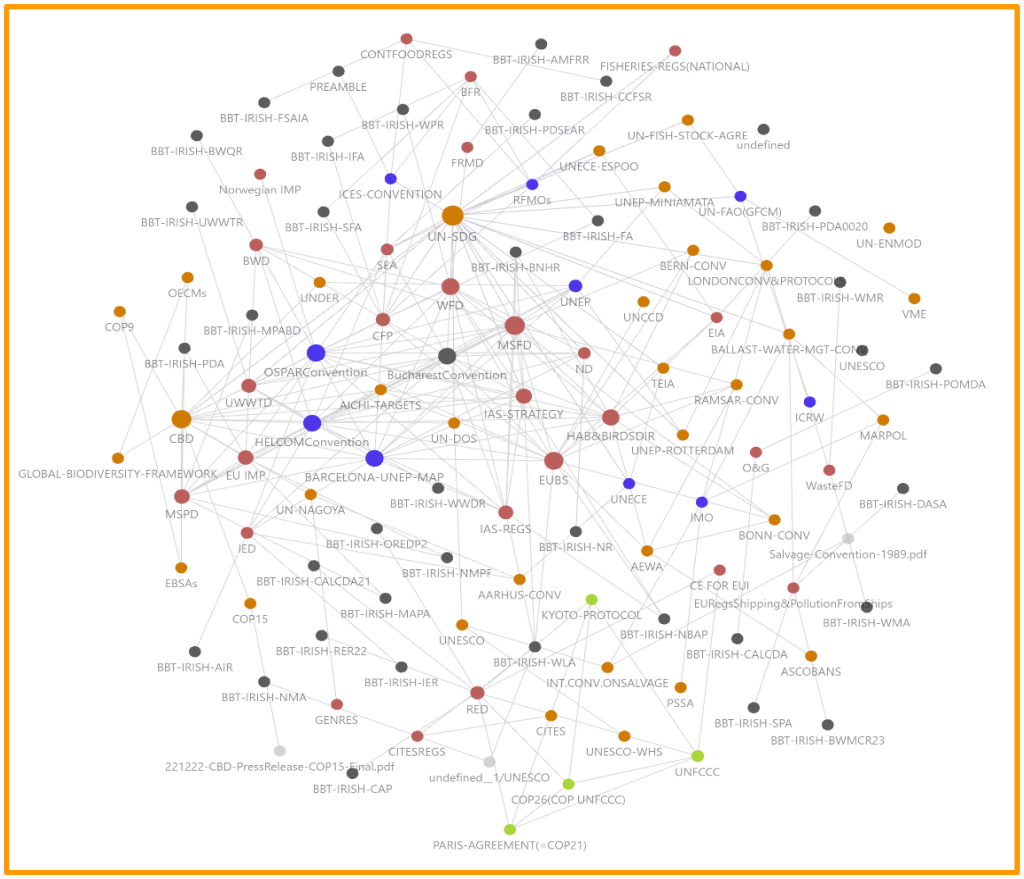

Figure 12. *Graph view illustrating the applicable governance and legislative landscape for the offshore wind energy sector within a BBT, including international conventions (red nodes), EU directives and strategies (blue nodes), and sector-specific national legislation (grey nodes). Cross-sectoral policy frameworks and global initiatives are shown as (orange nodes), while environmental and climate-related agreements are highlighted as (green nodes). Links represent sectoral applicability and legal or governance relationships between instruments.*

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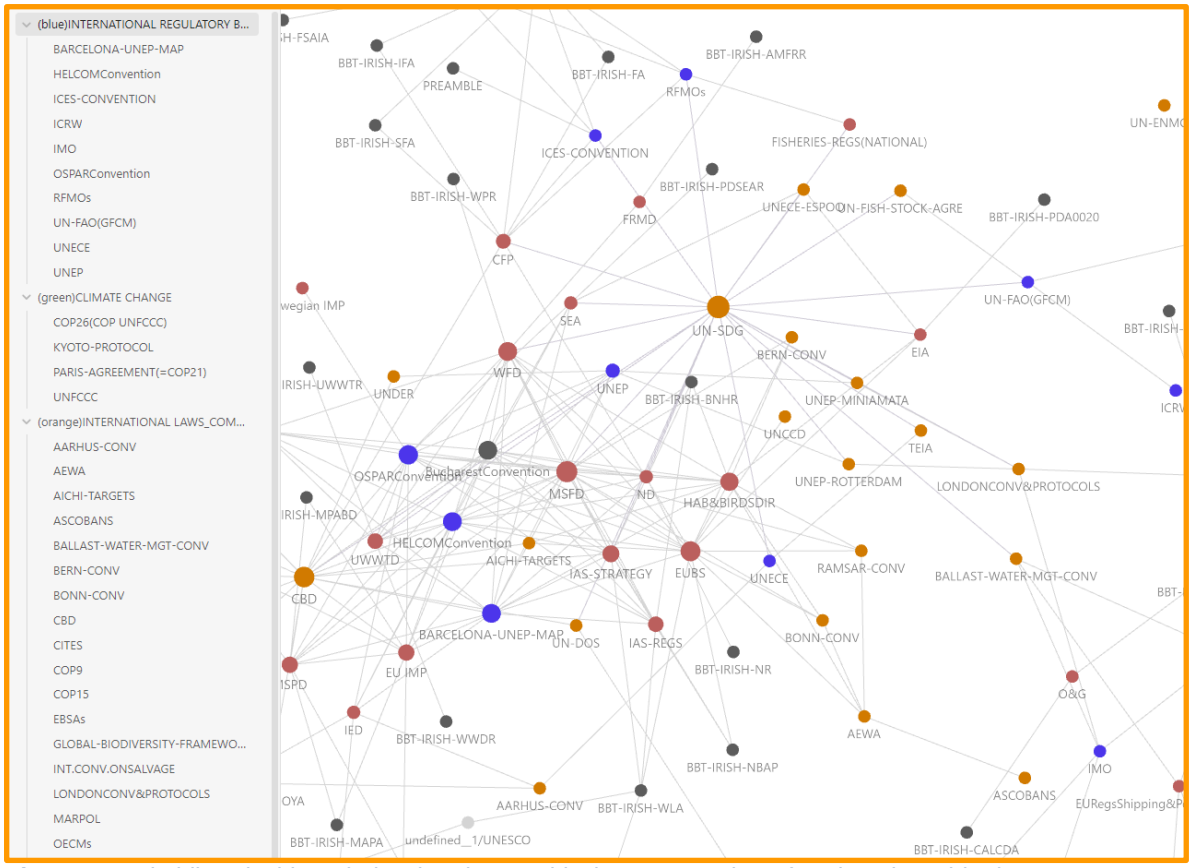

Figure 13. *Obsidian dashboard showing the graphical representation of nodes alongside the tree structure of related markup files.*

The graph results from a sample query (e.g. offshore wind), where international regulatory bodies and conventions are displayed as (blue nodes), climate change–related agreements as (green nodes), international environmental and cross-sectoral frameworks as (orange nodes), and national legislation and country-specific instruments as (grey nodes). This visualisation helps stakeholders explore connections between BBTs and legislative entities in an intuitive and exploratory visual format, while the tree view provides structured access to the underlying markup files.

3.2 Demonstration for project partners

A software demonstration using a role-play approach was conducted during MARBEFES General Assembly 2024, held in Dublin, to effectively showcase the capabilities of the Obsidian tool, currently under development within the MARBEFES project (record of the functionalities used in https://zenodo.org/records/15012953).

In this creative enactment, one of the partners portrayed the director of a consultancy firm, overwhelmed with enquiries from government entities and journalists about environmental impacts associated with offshore wind projects. Another participant assumed the role of a consultant at the firm, who introduced a novel solution employing the Obsidian software. This tool demonstrated its capability to efficiently access and organize legislation relevant to the offshore energy sector.

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The demonstration was delivered with subtle humour to captivate the audience, while specificallyhighlighting the software practical benefits and the critical need to integrate it with organizational charts to bolster operational efficiencies in environmental consultancy practices.

This professional presentation not only underscored the technical functionalities of the Obsidian tool but also illuminated its practical applications to the project's stakeholders. This innovative approach provided a compelling preview of the potential benefits of the tool to stakeholders once completed.

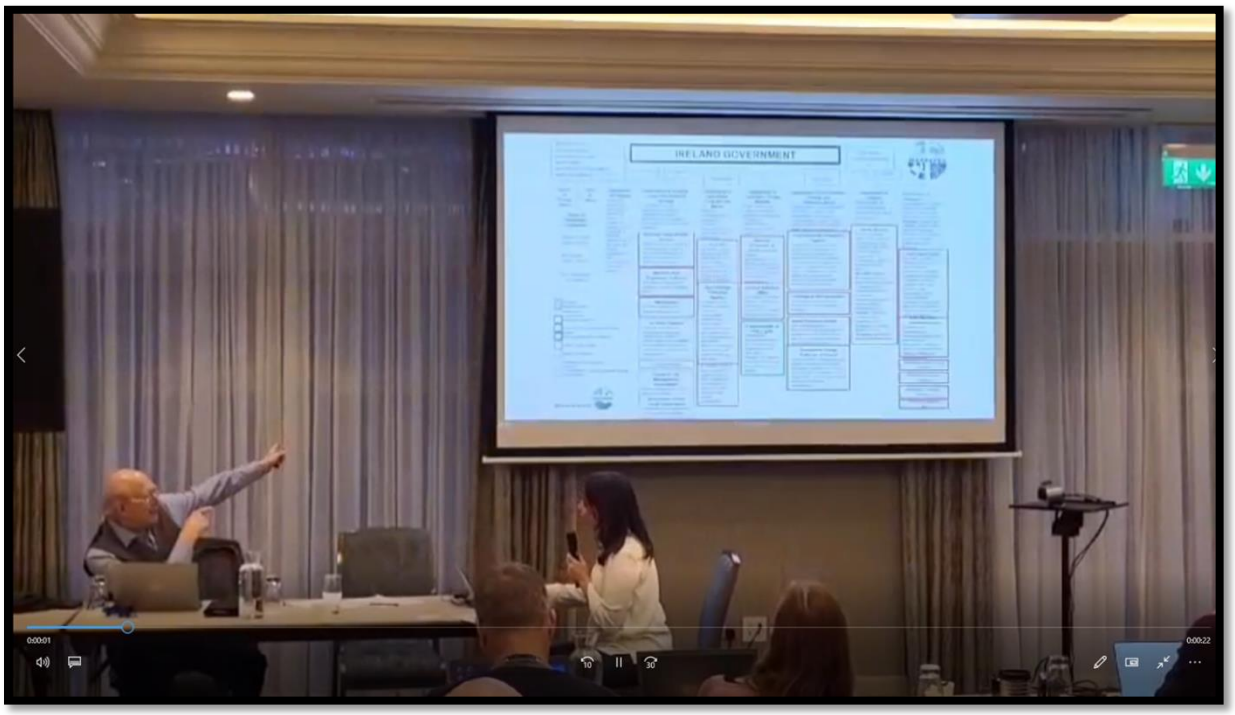

Figure 14. Screenshot of the video made during the DEMO performed by IECS and LW ERIC at the GA of MARBEFES (Dublin, October 2024).

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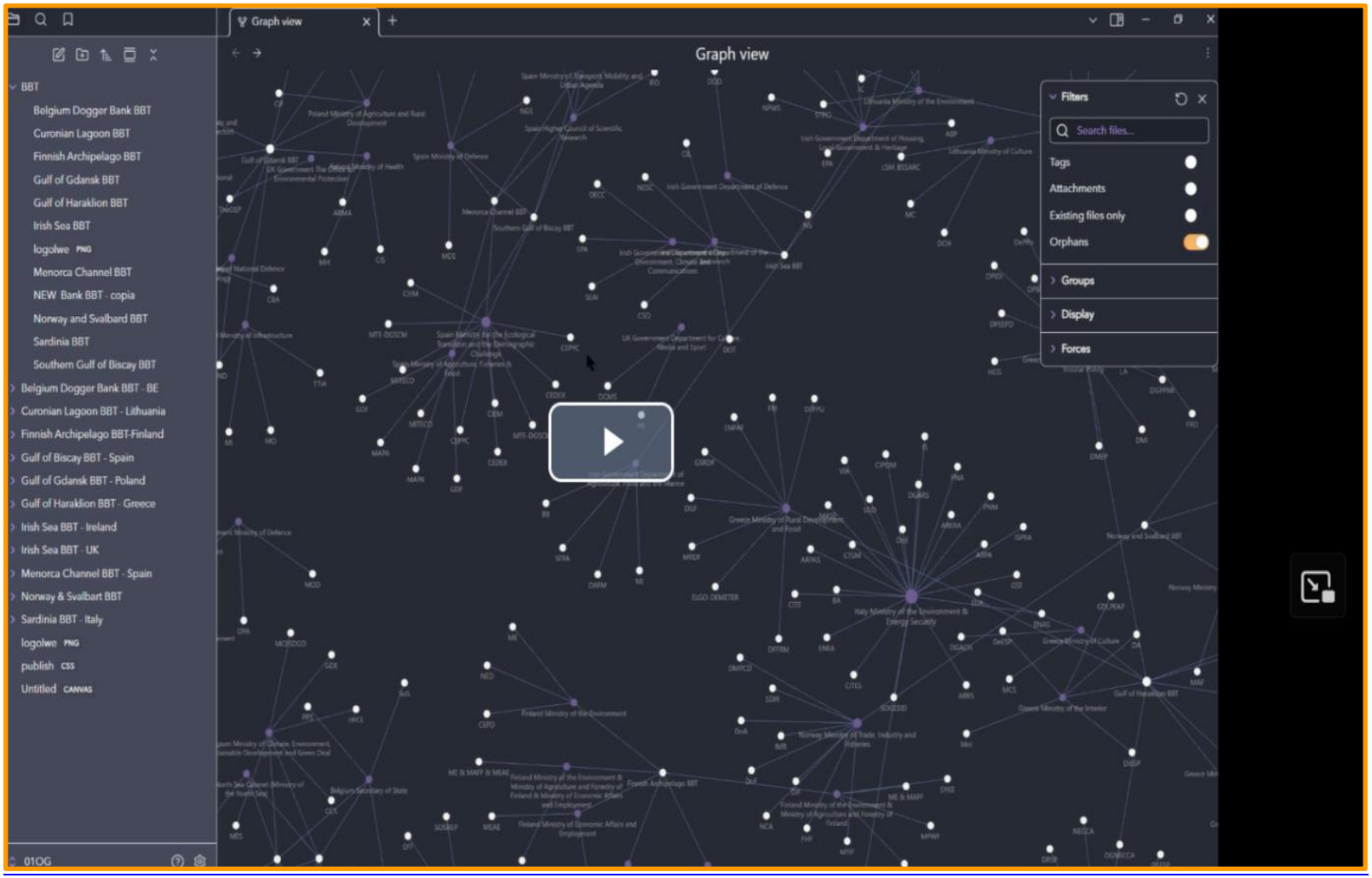

Figure 15. Record of the Zenodo video used for demonstration. (Dublin, October 24)

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4. Discussion and way forward

The Obsidian software has proven to significantly improve the ability of project stakeholders to navigate the complex system of legislation, institutions, and agencies involved in marine management. It has proven far more effective than previous tools such as static graphical maps of OGs and HGs in simplifying access to critical information, and in its visualization.

This tool introduces a new approach that removes the barriers of complexity involved in identifying relevant legislation, institutions, and agencies from 2D diagrams. Previously, the OG and HG showed the users the complexity of the system by presenting all the available information. The Obsidian-based software then enables the user to only see the elements in which they are interested.

However, it has limitations in the amount of information that can be uploaded for each piece of legislation, and in keeping it current with updates to governmental departments and key personnel (the base information has to be adjusted each time the organisations and/or administrative bodies change) Dedicated human resources are necessary to manage these aspects of the tool in the long run. This need for continuous updates is particularly relevant for Horrendograms, which must reflect evolving legislative frameworks, and for Organigrams, which must be regularly updated to account for changes in institutional structures, mandates, and responsibilities.

The subsequent development phases for both the HG and OG are focussing on transitioning from a local, Obsidian-based implementation to a fully web-enabled platform. This transition aims to enhance accessibility, functionality, interactivity, and utility, making these tools more robust and user-friendly for distributed teams and organizations.

Both tools are planned to move to web platforms that facilitate online access and collaborative features. Technologies such as D3.js, Cytoscape.js, or vis.js will be used to enhance graph visualization capabilities, offering dynamic, interactive graphs that can be accessed from anywhere. This will support more effective data sharing and visualization, and reduce barriers associated with local setups.

With regard to Front-End and Back-End Development, the web platforms will be developed using modern web technologies such as React or Vue.js for the front end, ensuring responsiveness and user-friendliness. The back end may use frameworks such as Node.js or Django to handle functionalities including user authentication, data storage, and real-time data processing. Cloud-based databases such as Firebase or MongoDB will ensure scalability and robust data management.

Key features will include real-time collaboration, allowing multiple users to simultaneously work on datasets, adding or modifying nodes and relationships with immediate updates visible in the graph view. This feature will be supported by real-time communication technologies such as WebSockets and robust version control systems similar to Git.

Both platforms will incorporate plugins or extensions to increase functionality and interactivity. These might include tools for uploading data in formats such as Excel, CSV, or JSON, collaborative editing, and advanced analytics features powered by graph databases like Neo4j. Users will also be able to annotate nodes or relationships directly within the graph, attaching notes, images, or additional metadata.

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Integration with third-party tools such as Slack, Microsoft Teams, or HR management software could ensure that the platforms can be embedded seamlessly into existing workflows. Custom styling and theming options will allow users to tailor visual representations to fit specific organizational needs, enhancing the visual appeal and making the platforms indispensable tools for visualizing and managing complex hierarchies.

By implementing these advancements, the HG and OG platforms will evolve into comprehensive, sophisticated web-based tools that offer a seamless and engaging experience for managing hierarchical data. There is also a proposal to merge the OG and HG products into a system linked by marine sectors. These enhancements will maintain the technical robustness seen in the Obsidian implementation while expanding their use cases and improving their integration into diverse operational environments.

The end-product will be a combined system between HG and OG.

5. Conclusions

The consortium has developed a tool to visualise the complex relations between legislation and institutions and agencies in charge of its implementation. The Obsidian unique combination of dynamic linking, visualization, customization, scalability, and open architecture makes it the most suitable choice for this project. Its ability to adapt to evolving requirements and integrate seamlessly with other workflows ensures that it will remain a reliable and efficient solution for managing and interrogating diagrams (HG and OG) of any complexity.

This application serves as a useful tool for rapidly exploring and understanding the complex web of governance, roles, and responsibilities in maritime management and conservation efforts. It is particularly valuable for stakeholders needing to navigate, interrogate and interact with these institutions effectively. Once the tool is finalized and HG and OG are integrated, it will be ready for dissemination.

Final note: Any mention of proprietary products in the report is not an official endorsement of those products; other similar products may be available

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