European Commission

JRC TECHNICAL REPORT

Mapping interlinkages between EU-funded research projects and EU policy priorities

Application of the TIM open access tool to case studies in the context of the EU Biodiversity Strategy for 2030

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2022

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EU Science Hub
https://ec.europa.eu/jrc

JRC127579

EUR 31106 EN

PDF ISBN 978-92-76-53299-6 ISSN 1831-9424 doi:10.2760/37559

Luxembourg: Publications Office of the European Union, 2022

How to cite this report: Parracciani, C., Ganisheva, K., Ventocilla Jaramillo, J.L., and Estreguil, C., Mapping interlinkages between EU-funded research projects and EU policy priorities. Application of the TIM open access tool to case studies in the context of the EU Biodiversity Strategy for 2030, EUR 31106 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53299-6, doi:10.2760/37559, JRC127579

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Acknowledgements

The authors wish to thank the colleagues from the Competence Centre on Text Mining and Analysis at the Joint Research Centre, notably Sotirios Fragkiskos and Olivier Eulaerts for their guidance on text mining, the use of TIM software during this study and the development of the TIM dashboard.

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Abstract

This initiative from the European Commission (EC) Knowledge Centre for Biodiversity[1] (KCBD) was conducted in support of the EC Directorate-General for Research and Innovation. The aim was to explore EU-funded research projects over the last fifteen years (i.e., Framework Programmes FP7 and Horizon 2020) and to map their linkages first, with the policy priorities of the EU Biodiversity Strategy for 2030 and its four pillars, and second, with the cross-sectoral policy domain of Biodiversity and Health.

The methodological workflow, easily replicable and accessible to non-expert users, alternates automated and manual processes. The research projects are described by their metadata as archived in the EC CORDIS database, they are analysed with the *Tools for Innovation Monitoring* (TIM)[2] Open Access software developed by the Joint Research Centre of the European Commission. First, a conditional search string consisting of keywords and logical operators is defined by the user to best qualify the topic and/or policy of interest. Second, a dataset was automatically created based on the projects extracted using the search string in TIM. Third, the dataset is finalised using expert judgement, particularly to exclude irrelevant projects. Then, the dataset is explored through three main lenses in TIM: general information with interactive list of projects and spatial and temporal trends, partnerships and collaboration axis, and thematic foci keywords that are automatically extracted by text mining and natural language processing algorithms.

Main findings when linking to the Biodiversity Strategy were as follows:

- Decrease in the number of projects related to the establishment and effective management of protected areas, pillar 1 of the Strategy;
- Emphasis on marine and forest ecosystems and marginal research for other ecosystems and habitat types;
- Agriculture sustainable management partially covered and only under the biodiversity restoration context (pillar 2);
- No clear thematic foci for EU-funded research projects relevant to pillar 3 on transformative change;
- Missing links biodiversity to human health except in the case of the zoonosis cluster and more focus on animal health and environmental health.

Crucial methodological aspects were related to (1) the potential bias introduced by expert judgement in the formulation of the conditional search string and in the manual quality check, (2) unprecise policy relevance within the metadata of the projects. To minimize human intervention in the workflow and improve the performance of the automated extraction process (in this exercise about 15% of projects were discarded), it is of foremost importance to improve the metadata of research projects archived in the EC CORDIS database. Writing guidelines could be prepared, e.g., for the upcoming projects funded under the Horizon Europe (2021-2027) Framework Programme.

The methodological workflow could be further tested for other cross-sectoral topics (e.g., Biodiversity and Trade) and to specific biodiversity policy actions and commitments such as the restoration of free-flowing rivers or the reduction of 50% of chemical pesticides.

The results of this study can be viewed on an interactive TIM based dashboard on the *EU research project – policy link explorer* page of the Knowledge Centre for Biodiversity website: https://knowledge4policy.ec.europa.eu/biodiversity/topic/eu-research-project-policy-link-explorer_en.

[1] https://knowledge4policy.ec.europa.eu/biodiversity_en
[2] EU, Joint Research Centre, TIM Analytics, http://www.timanalytics.eu/

1 Introduction

In May 2020, the European Commission adopted the new EU Biodiversity Strategy for 2030 "Bringing nature back into our lives" (European Commission, 2020), henceforth referred to as the Strategy. It includes a comprehensive, ambitious and long-term Action Plan for protecting nature and reversing the degradation of ecosystems. The Strategy aims to put Europe's biodiversity on a path to recovery by 2030 for the benefit of people, the planet, the climate and economy, in line with the 2030 Agenda for Sustainable Development (UN General Assembly, 2015) and with the objectives of the Paris Agreement on Climate Change[3]. The Strategy contains specific actions and commitments to be delivered by 2030, and is divided into 4 main pillars[4]:

1. *"Protect Nature"* - All considerations and actions regarding the establishment of a larger EU-wide network of protected areas on land and at sea;
2. *"Restore Ecosystems"* - Launching an EU nature restoration plan to restore degraded ecosystems by 2030 and manage them sustainably, addressing the key drivers of biodiversity loss;
3. *"Transformative Change"* - The strategy highlights unlocking funding for biodiversity, and setting in motion a new, strengthened governance framework to ensure better implementation and track progress, improve knowledge, financing and investments, and better respecting nature in public and business decision-making;
4. *"EU for an ambitious global biodiversity agenda"* - Introducing measures to tackle the global biodiversity challenge. These measures will demonstrate that the EU is ready to lead and address the global biodiversity crisis. In particular, working towards the successful adoption of an ambitious global biodiversity framework under the Convention on Biological Diversity.

Moreover, an action within the Action Plan of the Strategy is the establishment of the new Knowledge Centre for Biodiversity[5] (KCBD) that was put in place in close cooperation with the European Environment Agency and steered by the European Commission's Directorate-General for Environment[6] (DG ENV). The KCBD is responsible for: (i) tracking and assessing progress by the EU and its partners including in relation to implementation of biodiversity related international instruments; (ii) fostering cooperation and partnership, including between climate and biodiversity scientists; and (iii) supporting policy development (European Commission, 2020). The KCBD supports policymaking for biodiversity and related fields by (1) identifying, filtering, organizing relevant information and making it accessible, (2) fostering a cross-sectorial dialogue by analysing available evidence, and bringing together researchers, policy makers, NGOs, industry and citizens, (3) communicating available evidence in a transparent, tailored and concise manner.

The work presented in this report originates as an initiative of the KCBD, contributing to knowledge management at the science-policy interface. This work is conducted in support of the European Commission's Directorate-General for Research and Innovation (DG RTD)[7], with the aim to explore current and past research projects funded by the European Commission and map their links with the new Biodiversity Strategy for 2030, notably its four pillars with its target and various goals. This work also investigates cross-disciplinary domains such as biodiversity and health. The research mapping outcomes are displayed on the basis of a TIM dashboard (with 6 different datasets) that is developed specifically for the work described in this report to show the thematic research landscape including budget, geographic distribution and partnerships in Europe and world-wide. By highlighting the link between research and the Biodiversity Strategy, such dashboard also enables identifying key policy priorities that are lacking research efforts and weak collaboration axis. Furthermore, policy makers from all domains could easily gain updated and historical knowledge by retrieving such structured information and available scientific evidence according to their policy needs.

[3] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement
[4] https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en
[5] https://knowledge4policy.ec.europa.eu/biodiversity_en
[6] https://ec.europa.eu/info/departments/environment_en
[7] https://ec.europa.eu/info/departments/research-and-innovation_en

Building on successful past experiences (Borchardt, S. and Estreguil, C., 2020), text mining and analysis tools – TIM, *Tools for Innovation Monitoring*[8] Open Access – developed by the Joint Research Centre (JRC), has been used and customized for the purposes of this work.

The entire analysis process is divided into five main steps:

– The selection of keywords to qualify policies and search for projects;

– The retrieval of projects and the creation of the database with TIM;

– The manual quality check of the retrieved projects to assess their relevance to the topics at stake, notably the EU Biodiversity Strategy 2030;

– The analysis of the retrieved projects including their spatial and temporal trends, the partnerships and collaboration axis, and their thematic foci;

– The development of a TIM based dashboard to make public the results obtained from this analysis, and the subsequent creation of the *EU research project – policy link explorer* page on the KCBD website to make the dashboard accessible to users.

The work is conducted within the KCBD core team; it also involved meeting (virtually) with DG RTD to understand policy needs, collaborating with the Competence Centre on Text Mining and Analysis (JRC Unit I.3. Text and Data Mining) to customize the use of TIM in our context and develop the TIM dashboard, and finally interacting with the KCBD website developer to publish the results.

[8] EU, Joint Research Centre, TIM Analytics, http://www.timanalytics.eu/

2 Exploring EU-funded research and its relevance to policies with bibliometric analysis

2.1 Short introduction to the Tools for Innovation Monitoring (TIM)

The quantity of generated and stored data is massive nowadays, i.e., from the internet and from specific databases. Text data is usually provided as unstructured information, making it desirable to apply text mining techniques in order to first, extract information from the text (information retrieval according to selected criteria) and second, to make sense of it (text summarization based on keywords). Available fit-for-purpose methods and algorithms cover various topics ranging from data mining, natural language processing and information retrieval (Borchardt, S. and Estreguil, C., 2020).

In this work, among other bibliometric tools available, we selected the *Tools for Innovation Monitoring* (TIM) developed at the JRC's Competence Centre on Text Mining and Analysis (JRC Unit I.3. Text and Data Mining). The TIM Open Access is a web application for bibliometric data analysis. The text mining capacity of this tool has already been tested to provide a better understanding of scientific evidence and trends, and help support policy-making in the European Institutions in the field of research, innovation and technological development (Moro et al., 2018; Borchardt, S. and Estreguil, C., 2020). TIM enables the user to (1) process and analyse scientific documents such as publications, patents or EU-funded research projects, (2) design search queries and extract knowledge from large and complex datasets in various scientific domains and relevant policy fields, identify research networks and monitor them over time, (3) extract trends in research and development, identify key players in specific research fields, and detect gaps in scientific knowledge that can then be addressed as potential new areas to allocate funding (Borchardt, S. and Estreguil, C., 2020).

TIM Tools for Research and Innovation Monitoring have two versions, one internal to the Commission and one with free open access; we used the Open Access version. TIM Open Access considers data from three different sources: scientific articles from the Semantic Scholar database, European patent data from the European Patent Office's PATSTAT data base, and information about EU-funded research projects from the CORDIS data base covering the EU's Framework Programmes (in TIM only from FP5 to Horizon 2020). The archive consists of more than 200 million documents (EU-funded projects <1%).

From an operational point of view, TIM utilizes the method of information retrieval and access the metadata of each record in the database, according to a structured and conditional search string that retrieves the matched documents (projects in our case) from the database. The search query consists of a SOIR query syntax that is composed of terms (such as thematic fields selected by the user) combined by Boolean operators ("AND", "OR") and is searched for in metadata, notably the title, abstract and keywords. With logical operators, elaborated search queries can be defined to narrow the search using combinations of keywords, specific time range and country, and search only specific categories of documents.

In addition, the method of extractive text summarization is performed in TIM as an automated meaningful text mining. Natural language processing algorithms generate a list of automatic relevant keywords. This is applied to extract information units (i.e., relevant keywords) from any text available, i.e., the abstract of publications, that summarise best the original text itself and/or a collection of documents. TIM outcomes, such as clusters of these thematic keywords based on the frequency of terms and their connections within a collection of documents, are particularly useful.

Besides text mining, TIM provides temporal and geographical filters as well as network visualisations and analyses. For example, TIM enables exploring a collection of documents over time – temporal trends of number of documents – and spatially – country profiles and maps based on data frequency. It also provides network graphs such as the network of collaborations between institutions or countries. All TIM outputs, from datasets to results, can be exported as Excel tables, HTML, JSON or with other formats for graphs (e.g., GEXF) (Borchardt, S. and Estreguil, C., 2020).

This work is primarily focused to extract, analyse, and synthesise information from EU-funded research projects and address their interlinkages to the EU Biodiversity Strategy. It aims at exploring the use of TIM as a single open source analytical tool to complement information already retrieved within CORDIS[9]. The intention is to provide the user a tool directly accessible from the public KCBD website, reason why this work primarily explores TIM capacities from its open access version.

For more operational details on how TIM works, see TIM Open Access software documentation[10].

2.2 Data source

Since this work focuses on analysing EU-funded research efforts over time and how they relate to the EU's new Biodiversity Strategy, the TIM based search was restricted to EU-funded projects as available from the CORDIS database.

CORDIS is the European Commission's publicly available source of results from the projects funded by the EU's Framework Programmes for research and innovation (FP1 to FP7, and "Horizon 2020"). The funding programmes began in 1984 with FP1, and continue to the present day with the current ninth Framework Programme (FP9) - "Horizon Europe", running from 2021 to 2027, with a budget of €95.5 billion. CORDIS is managed by the Publications Office of the European Union on behalf of the European Commission's Research and Innovation Directorate-General. CORDIS is a rich and structured public repository with all project information such as project factsheets, participant countries, reference, starting date, reports, deliverables and links to open-access publications.

The metadata linked to the CORDIS database on EU-funded research projects is accessible and can be explored and analysed through TIM.

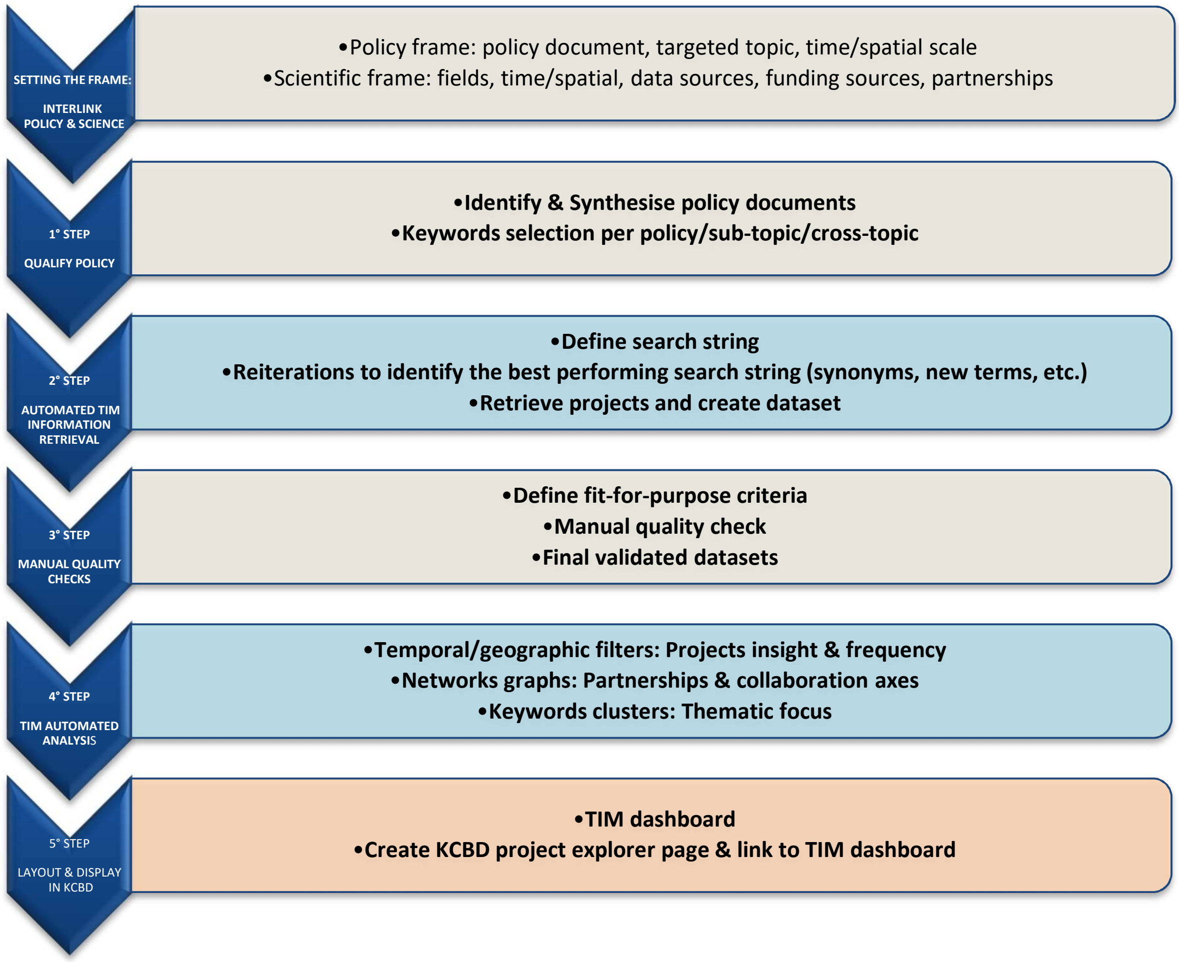
A search query within the CORDIS platform allows retrieving records based on metadata including keywords defined by the project owner or operator. Only search queries with very simple syntax, i.e., no combinations of multiple keywords can be conducted. This limited capacity may result insufficient to address interlinkages with policy domains. Furthermore, the platform does not allow an automatic mapping of networks based on the frequency of data and their connections.

2.3 Methods

This section provides the workflow and operational details (Figure 1) to conduct the TIM analysis of the EU-funded research projects in relation to the new Biodiversity Strategy 2030.

[9] EU, Community Research and Development Information Service, https://cordis.europa.eu/
[10]https://knowledge4policy.ec.europa.eu/text-mining/tim_oa_en

Figure 1. Workflow diagram to map interlinkages between EU-funded research and policies with TIM.



Source: JRC, 2021.

2.3.1 Keywords selection

The construction of the search string is a crucial step, it determines how many and which projects are extracted and therefore the content of the dataset to be analysed. It first requires a good understanding of the policy document at stake, in our case the Biodiversity Strategy for 2030 (European Commission, 2020). Thus, keyword selection and use of logical operators must be accurate to properly capture all or targeted elements of the Strategy.

The selection of keywords starts with carefully reading the text of the Strategy in order to extract major concepts, actions and targets to finally select the most representative terms and their best combination into various search strings depending on the sub-topic or part of the Strategy of interest. We decided to first conduct the selection of keywords at a higher level of granularity, i.e., for each of the four pillars of the Strategy (see Table 1), and then combine all keywords to represent the whole Biodiversity Strategy for 2030. Second, we decided to also address the selection of keywords for a cross-sectoral policy domain of interest, namely Biodiversity and Health to understand if biodiversity is mainstreamed into commonly separated domains in science and in policy. We anticipate that from an initial list of chosen keywords, several reiterations will be needed to define the best performing terminology and search string.

The Biodiversity Strategy is complex and multi-faceted, encompassing four pillars, each vehiculating various topics and degrees of complexity such as the heterogeneous pillar 3 on transformative change in comparison to the simpler thematic focus of pillar 1. The search strings will certainly reflect this heterogeneity.

2.3.2 Projects retrieval

Once the keywords search string is defined, the retrieval of projects is made automatically through the TIM search function by selecting the document type “EU projects”. Besides the keywords, the conditional search function includes other criteria that are articulated through logical operators. The conditional search string in our case was composed of three elements: the list of keywords, the EU Framework Programme (as a time range) and the document type. TIM retrieves a list of projects according to the conditional search by scanning the projects’ title, abstract, and author keywords (if any).

This work is focused on extracting EU-funded research projects covering the time frame related to the last two European Union’s Framework Programmes: FP7 (years 2007-2013) and Horizon 2020 (years 2014-2020). This decision was dictated by the fact that an analysis of the relatively most recent projects would certainly provide a representative view of the state of biodiversity research in recent decades and best interlink to the goals towards 2030 of the current Strategy. Another consideration to be made is that terminology, especially in the scientific field, could change a lot over time. Continuously new terms replace more obsolete ones as scientific research progresses, progressively enriching the terminology used in science. The vocabulary used within the current Strategy has evolved over time and encompass recent scientific concepts and societal challenges (for example the “transformative change” to replace “transition”), making projects belonging to older Framework Programs more difficult to extract effectively.

At the end of extraction, TIM output provides a dataset containing all the matched projects, exported as an Excel table. The fields of the table used for subsequent analysis contain for each project, information on project ID, acronym, title, description, participant countries, organisations names and their countries of affiliation, starting and ending date, projects’ budget, programmes, and CORDIS links to access abstracts, factsheets and some results as deliverables and publications, if available.

2.3.3 Quality check

The quality check is conducted manually by checking all the extracted projects. It consists in assessing for each project its relevance versus the conditional search, for example for each pillar of the Strategy. It also includes assigning projects to another relevant pillar when appropriate.

The quality check exercise primarily considers the title, abstract and factsheet of each project. The following information has been assigned to each project:

Relevance of the project to the Strategy (Yes/No);

Relevance to which pillar (1/2/3/4; with the possibility of including more than one pillar);

How is biodiversity addressed (Direct (1)/Indirect (2));

The geographic scope of the project (European (E)/Global (G)).

Below some indications on the assignment of the value for the different fields:

Pillar(s) assignment criteria such as the pillar’ focus (below) and a list of topics (see Annex 1) by which it is represented, were used to assign each project to one or more pillars. It is possible for a project to be relevant to more than one pillar, in this case the project was included in the resulting lists for each assigned pillar.

Pillar 1 Focus - All the projects that concern, even if only in part, the delineation, management and effectiveness of protected areas and their inclusion as part of ecological networks, were considered relevant and included in the final list.

Pillar 2 Focus - All the projects that concern, even if only in part, the monitoring and restoration of ecosystems and their natural functions (in particular forest, soil, freshwater and marine ecosystems), the reduction of pressures and threats to biodiversity and to ecosystems in general (including e.g., pollution, unsustainable practices and invasive alien species) as well as urban ecosystem targeted actions such as greening plans, were considered relevant and included in the final list.

Pillar 3 Focus - All the projects that concern the radical change of our way of thinking and behaving, as individuals or collectively through organizations, to make our society more sustainable and to achieve transformative change at the level of Europe as a whole, were considered relevant and included in the final list.

Pillar 4 Focus - All the projects that concern, even if only in part, biodiversity and environmental protection from a global perspective, with Europe as an active participant in achieving global objectives, were considered relevant and included in the final list. All projects considered as Global were also included in the final list (see *Geographical scope of actions Europe (E) – Global (G)*).

Biodiversity and Health Focus - All the projects that concern, even if only in part or indirectly, biodiversity (understood by its species, genetic and ecosystem component) and health, whether in relation of that of humans, animals and/or ecosystems, were considered relevant and included in the final list.

Biodiversity addressed directly (1) - indirectly (2)

1 - Explicitly related to biodiversity; or explicitly aligned with one of the topics, actions or targets of the BD Strategy 2030.

2 - Biodiversity not explicitly included in the objectives/targets of the project; more indirect actions and indirect relevance.

Geographical scope of actions Europe (E) – Global (G): Evaluation of the location of project actions, or if the location of the actions is not explicitly stated, we refer to participant`s location.

E - The project takes place entirely in a European[11]/pan-European[12] country or the project explicitly refers to a European dimension within its goals; or all participating countries are European.

G - The project takes place partially/entirely in a non-European country or the project explicitly refers to a global dimension within its goals; or at least one of the participating countries is non-European.

2.3.4 TIM Exploratory analysis

Data can be analysed in different ways in TIM[13]. We customised our analysis towards serving our goal of managing research knowledge, help understanding efforts and progress, in support of DG RTD. TIM enables exploring and visualising the created dataset according to three main lenses:

Project information. The first insight covers general information of the dataset and includes a list of all relevant projects, their time trend, the budget provided by the EU, and the geographical distribution. TIM provides an overview of the data showing frequency, i.e., the number of documents (projects) sorted by type and source, and their trend over time. In addition, it is possible to map their geographical distribution at global level, European level, or organised the information by city or country, based on the location of organisations. Further information on each project can be obtained by clicking on active links.

Collaborative networks and partnerships. The second insight includes all information about collaborative partnerships across countries and organizations, and makes it possible to determine who the main actors of research and progress are and where the most productive collaborations are. Graphs of collaborative networks can be displayed showing relative importance and connections between organisations, cities or countries. Network visualisations contain nodes and edges that can be adapted depending on the visualisation that is selected. The size of the nodes corresponds to the number of records (projects in our case) retrieved for each node. The edges correspond to projects in common between two nodes. Regarding

[11] https://www.nationsonline.org/oneworld/europe_map.htm
[12] https://www.nationsonline.org/oneworld/map/European-Russia-map.htm
[13] https://knowledge4policy.ec.europa.eu/text-mining/TIM_documentation_en

geographical distribution, the nodes represent organisations, cities or countries, and the links represent co-publishing, co-patenting or co-granting of EU projects, the thickness of which is a function of the number of projects in common, hence the intensity of collaboration. The colours highlight collaborative networks (i.e., organizations/countries that tend to collaborate). Based on the country profile, further insights can be derived with graphs and tables showing the collaboration data for each country.

Thematic focus. The third insight concerns themes and automatic keywords, and allows detecting the presence of known themes, or new emerging themes, or particular focuses within the dataset. The TIM "topic" section provides all the charts relating to the topics or themes of the underlying documents (projects). In particular, it is possible to obtain graphs relating to the major themes and keywords found in the projects that compose the dataset. Keywords can be provided directly by the projects or by TIM using automated text processing and text mining algorithms. Network graphs obtained for the automatic keyword visualization display a node for each keyword, which size is proportional to the frequency of the word; the thickness of the link between two nodes (i.e., keywords) is given by the frequency with which they appear together in the projects. Keywords are also ordered in a table according to a score that measures the number of projects retrieved per keyword in the dataset.

This analysis is conducted on the dataset after the quality check process (i.e., with the relevant and validated list of projects).

3 Exploring interlinkages between EU-funded research and the EU Biodiversity Strategy 2030: case studies

3.1 Results of the case studies

3.1.1 Keywords, project retrieval and quality checks

We defined a first set of keywords for each pillar of the Strategy and for the cross-policy topic Biodiversity and Health. We tested each of them as a query in TIM. Several iterations and semantic adjustments in the translation of policy concepts (e.g., synonyms) were necessary to identify the best set of terms leading to a satisfactory selection of projects (Table 1). These adjustments most certainly reflect inaccuracies or imprecision in language in the writing of project metadata files archived in CORDIS. For example, instead of using the term “environmental footprint”, we used “environmental impact” and “environmental effect” in the final search string, as “environmental footprint” narrowed by the topic “biodiversity” did not extract any project in TIM.

In the case of the cross-sectoral topic Biodiversity and Health, the terms that were finally selected convey the different dimensions at the cross-road between the two disciplines.

Table 1. List of best performing keywords.

<u>Biodiversity Strategy for 2030</u> *Protect Nature (Pillar 1)*: “natura 2000”, “natura2000”, "protected area", "ecological corridor", "ecological network"
Restore Ecosystems (Pillar 2): "agro biodiversity", “agroecology”, “agrobiodiversity”, "aquatic ecosystem", "biodiversity conservation", "biodiversity loss", "biodiversity management", "biodiversity monitoring", "biological invasion", “biomass”, "coastal ecosystem", "coastal marine", "conservation of biodiversity", "ecosystem restoration", "ecosystem services", "endangered species", “fertiliser”, “fertilizer”, "floodplain ecosystem", "forest conservation", "forest ecosystem", "freshwater biodiversity", "freshwater ecosystem", "habitat conservation", "invasive alien species", "invasive species", "loss of biodiversity", "marine biodiversity", "marine ecosystem", "marine litter", "management of biodiversity", "monitoring biodiversity", "nature based solutions", "nature-based solution", “NBS”, "old growth forest", "organic farming", "pest management", “pesticides”, “pollinators”, "protected species", "riparian ecosystem", "river biodiversity", "river ecosystem", "soil biodiversity", "soil ecosystem", "species conservation", "species extinction", "sustainable agriculture", "sustainable fisheries", "terrestrial biodiversity", "terrestrial ecosystem", "threatened species", "urban greening"
Transformative Change (Pillar 3): "biodiversity governance", “business”, "ecological effect", "ecological footprint", "ecological impact", “education”, "environmental compliance", "environmental effect", "environmental impact", "environmental law", “financing”, "food chain", “labelling”, "sustainable consumption", "sustainable food", "sustainable production", "value chain"
EU for an ambitious global biodiversity agenda (Pillar 4): “ocean governance”, “biodiversity governance”, “deforestation”, “ecological effect, “ecological footprint”, “ecological impact”, “environmental effect”, “environmental impact”, “forest degradation”, “global biodiversity”, “indigenous communities”, “indigenous people”, “local communities”, “local people”, “protected area”, “sustainable consumption”, “sustainable production”, “wildlife trade”
<u>Biodiversity and Health cross-policy topic</u>: “health”, “animal health”, “animal welfare”, “zoonotic”

Our final list of keywords consisted of 85 unique terms. Some keywords are not exclusive to a specific pillar and are found across different pillars e.g., “biodiversity governance” in pillar 3 and 4; they are relevant for different macro-areas with different perspectives. Also, a different number of keywords were identified for each pillar. This is due to the structure of the Strategy into pillars covering either one single focus or multiple topics.

For example, pillar 2 is very broad in scope and includes various topics, and consequently is represented by a greater number of keywords than pillar 1, which focuses on nature protection and in particular on the establishment of protected areas and ecological networks. This fact could constitute a bias in the number of projects retrieved per pillar.

Once the terms have been identified, we conducted the search in TIM by combining all the keywords into a single string (Table 2). Each string was composed of three elements: keywords, Framework Programme and document class. We limited the Framework Programmes to “FP7” and “H2020” (known as “emm_programme” in TIM), while the document class was strictly "EU projects". Initially, the output provided a large number of projects, many of which were out of our context, due in particular to the presence of few keywords with a wide meaning (e.g., “biomass” or “business”). Consequently, the search was narrowed by completing the list of keywords with one or two topics, such as "biodiversity" or "ecosystem services". Therefore, TIM selected a project if one of the keywords and "biodiversity" or “ecosystems services” were both present in the project documents. For Biodiversity and Health, the topic “biodiversity” was sufficient to keep the query with the right focus.

Table 2. Search strings used in TIM to extract FP7 and H2020 projects for the Strategy and the cross-policy topic.

Biodiversity Strategy for 2030 **topic:** ("natura 2000" OR "natura2000" OR "protected area" OR "ecological corridor" OR "ecological network" OR "agro biodiversity" OR agroecology OR agrobiodiversity OR "aquatic ecosystem" OR "biodiversity conservation" OR "biodiversity loss" OR "biodiversity management" OR "biodiversity monitoring" OR "biological invasion" OR biomass OR "coastal ecosystem" OR "coastal marine" OR "conservation of biodiversity" OR "ecosystem restoration" OR "ecosystem services" OR "endangered species" OR fertiliser OR fertilizer OR "floodplain ecosystem" OR "forest conservation" OR "forest ecosystem" OR "freshwater biodiversity" OR "freshwater ecosystem" OR "habitat conservation" OR "invasive alien species" OR "invasive species" OR "loss of biodiversity" OR "marine biodiversity" OR "marine ecosystem" OR "marine litter" OR "management of biodiversity" OR "monitoring biodiversity" OR "nature based solutions" OR "nature-based solution" OR NBS OR "old growth forest" OR "organic farming" OR "pest management" OR pesticides OR pollinators OR "protected species" OR "riparian ecosystem" OR "river biodiversity" OR "river ecosystem" OR "soil biodiversity" OR "soil ecosystem" OR "species conservation" OR "species extinction" OR "sustainable agriculture" OR "sustainable fisheries" OR "terrestrial biodiversity" OR "terrestrial ecosystem" OR "threatened species" OR "urban greening" OR "biodiversity governance" OR business OR "ecological effect" OR "ecological footprint" OR "ecological impact" OR education OR "environmental compliance" OR "environmental effect" OR "environmental impact" OR "environmental law" OR financing OR "food chain" OR labelling OR "sustainable consumption" OR "sustainable food" OR "sustainable production" OR "value chain" OR "ocean governance" OR deforestation OR "forest degradation" OR "global biodiversity" OR "indigenous communities" OR "indigenous people" OR "local communities" OR "local people" OR "wildlife trade") AND **topic:** (“biodiversity” OR "bio diversity" OR "ecosystem services") AND **emm_programme:** (fp7 to h2020) AND **class:** euproject
Biodiversity and Health **topic:** (“health” OR “animal health” OR “animal welfare” OR “zoonotic”) AND **topic:** (“biodiversity” OR "bio diversity") AND **emm_programme:** (fp7 to h2020) AND **class:** euproject

The Biodiversity Strategy related dataset consisted of 720 projects that were manually checked and also allocated to one or more pillars. For Biodiversity and Health, the automatically retrieved dataset consisted of 143 projects (Table 3). The metadata of each automatically retrieved project was checked as described in section 2.3.3. Worth noting, the underperforming of search strings leading to unlisted but relevant projects was not tracked (false negatives). In contrast, false positives were tracked and their presence highlighted the fact that (some) projects were not reporting their policy relevance precisely enough and with appropriate terms (or were over-selling) in their abstract. Although a time-consuming task, the quality checks are fundamental to understand the performance and reliability of the automated search. The results of the TIM based queries shown in Table 3 underlined the need of manual filtering (about 15% of the projects were found irrelevant to the topic) that is most likely due to inaccuracies and imprecisions in the language used in the project’ metadata files archived in the CORDIS database.

Next, we carried out the exploratory analysis of the quality filtered set of projects with TIM according to three main lenses as mentioned in section 2.3.4.

Table 3. TIM outcome, impact of manual filtering and final number of projects to be analysed.

TIM	EC Biodiversity Strategy for 2030					Cross-policy topic
	BDS 2030	BDS 2030 distribution by pillar				Biodiversity & Health
		1	2	3	4	
Automatically retrieved projects	**720**	/	/	/	/	**143**
Projects excluded after quality check	134	/	/	/	/	20
Projects after quality check	**586**	**30**	**431**	**170**	**258**	**123**
% of total number	81%	4%	60%	24%	36%	86%

Source: JRC, 2021.

3.1.2 Case studies of interlinkages

3.1.2.1 Interlinkages with the EC Biodiversity Strategy for 2030

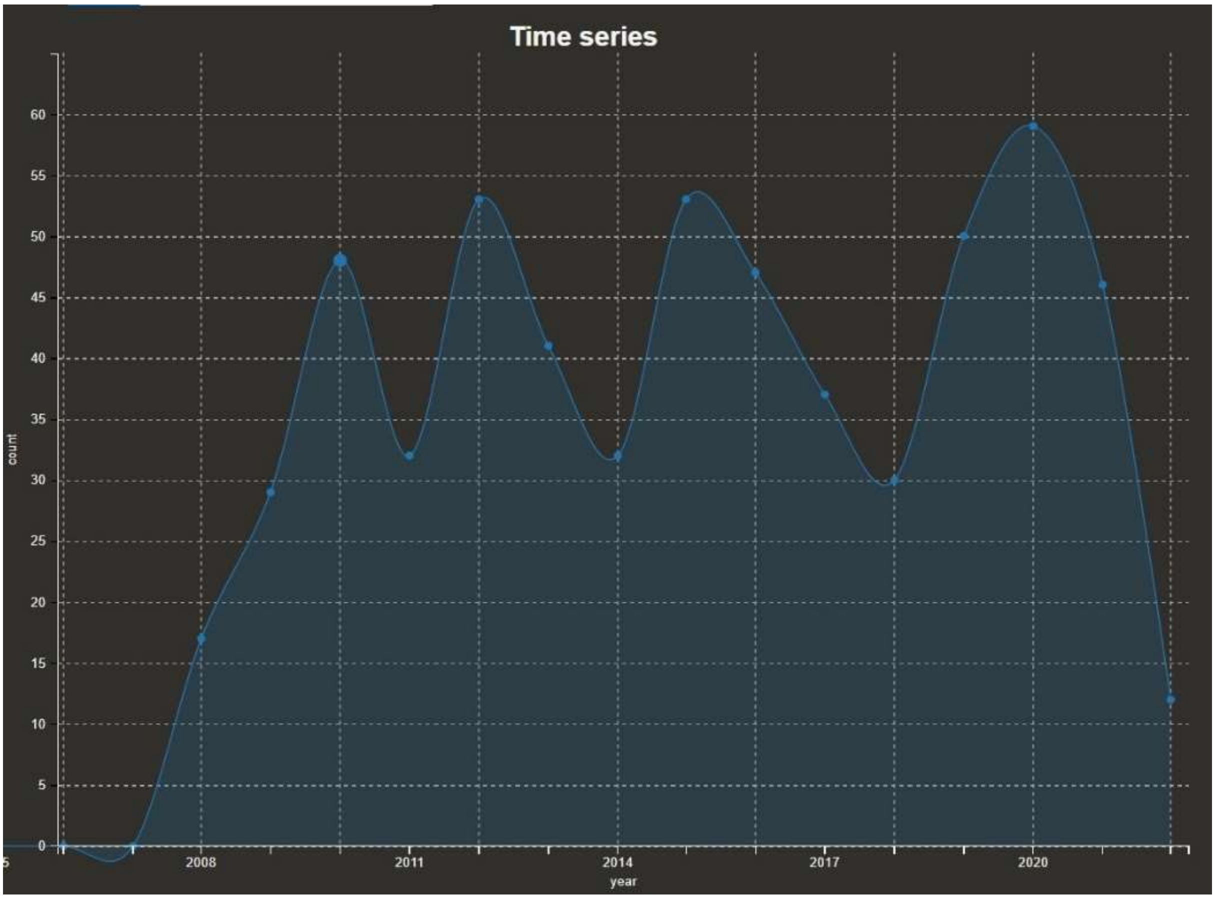
From the entire dataset of 720 projects, 586 projects (i.e., 81%) were considered relevant to the Strategy and were allocated to one or more pillars depending on their focus. Only 4% of the projects were considered relevant to the first pillar, followed by 24% for the third, 36% for the fourth, and finally, the largest pillar was the second, including 60% of all projects.

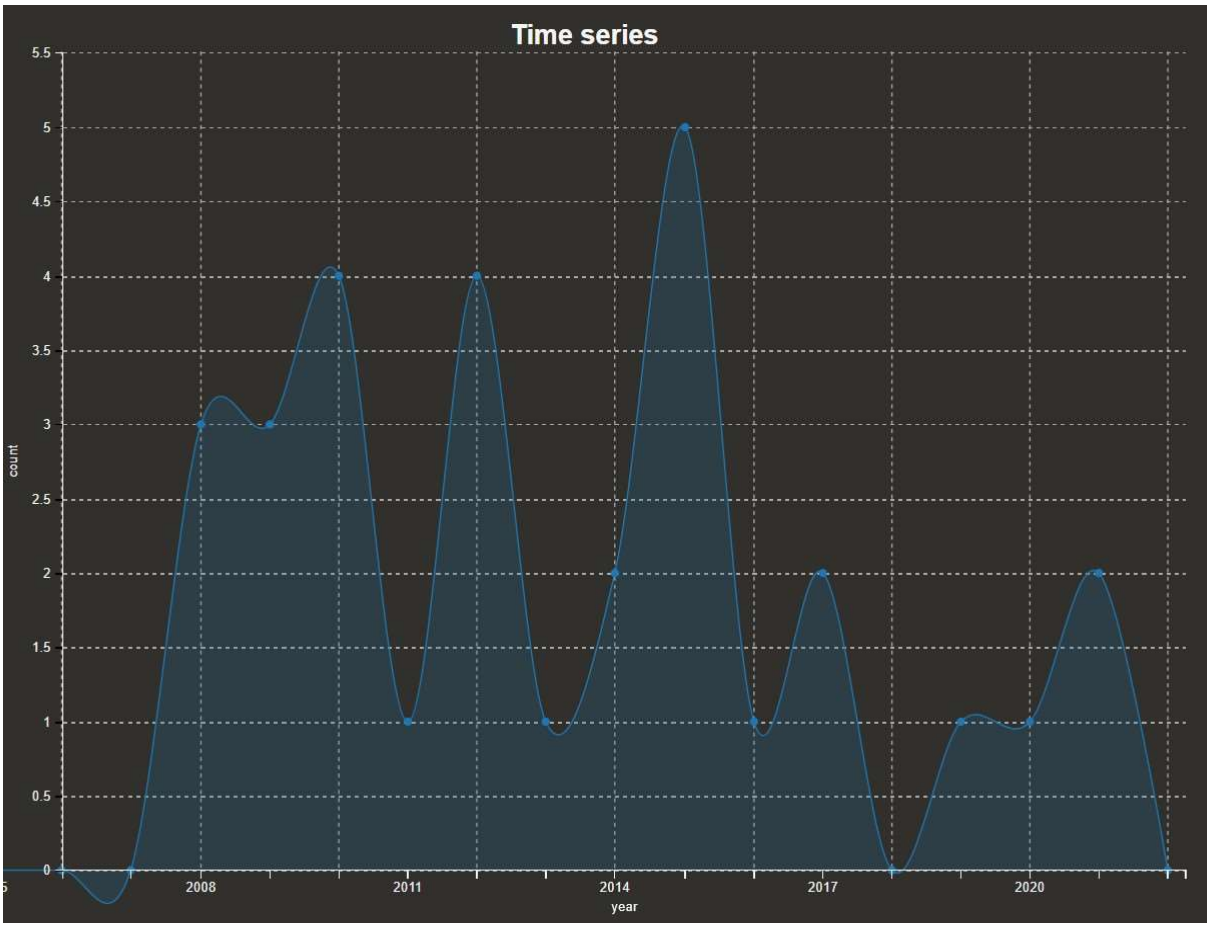
Project information

The first relevant information to get an overview of the status of EU-funded research is the trend over time. For the Strategy as a whole, the trend in the number of projects over time is stable, showing a slight increase in more recent years (Figure 2 top). Indeed, the FP7 programme counts 255 relevant EU-funded research projects, while the more recent H2020 has a total of 331.

When analysing the annual distribution for each pillar, the first pillar is the only one showing a decrease in the number of projects over time (Figure 2 at bottom). Out of 30 projects, 20 are under FP7 and 10 under H2020. Why is there a decrease in projects focusing on the design and management of protected areas and an increase in the other pillars? Despite the small number of projects, we assume that this decrease is caused by a greater cross-cutting approach of newer biodiversity-related projects. Projects in more recent programmes may be characterised by a particular interdisciplinary value that encompasses all the most sensitive and relatively new topics in biodiversity-related science, such as the emerging and increasingly important "restoration" or "transformative change".

Figure 2. Annual distribution of the 586 EU-funded projects relevant to the Strategy (top) and of the 30 EU-funded projects relevant to the first pillar of the Strategy (bottom). The x-axis represents the years (2007 to 2022). The y-axis represents the number of EU-funded projects.

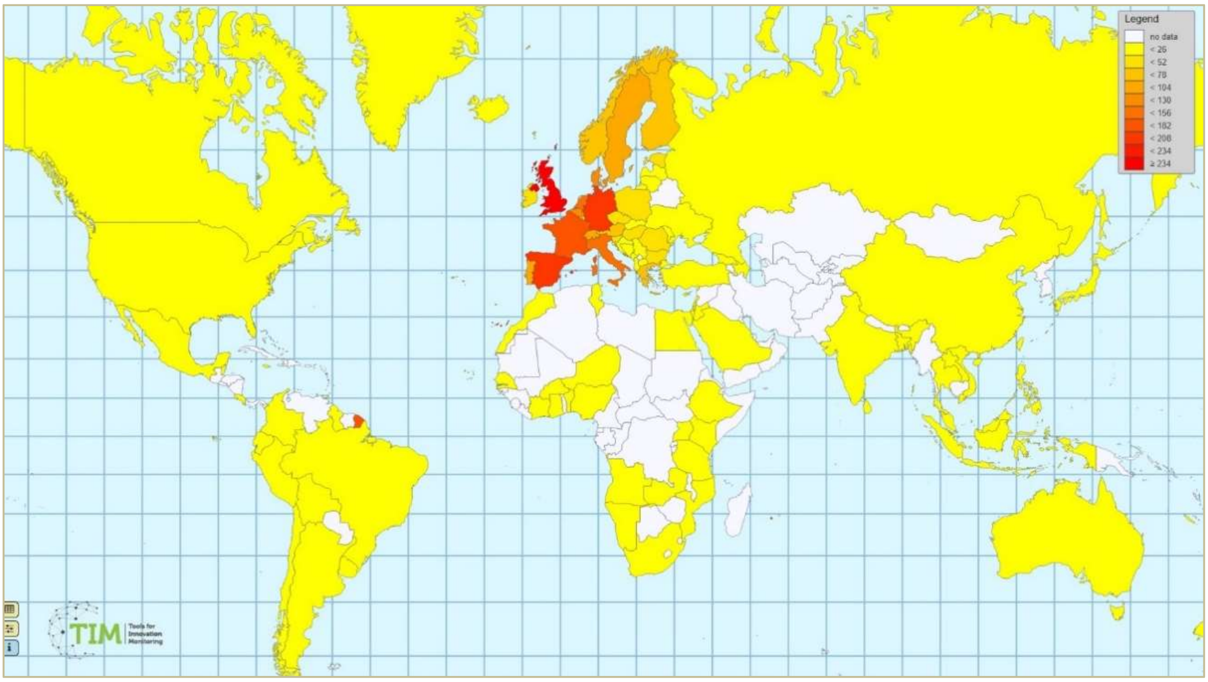




Source: JRC, 2021.

When mapping the global distribution of projects at country level, there is as expected a higher concentration of projects in Europe, meaning those projects are coordinated by European organisations. There are slightly less projects coordinated by countries of the Boreal zone. The geographical distribution is based on the location of the coordinating organisation and not on the location of the project's actions and objectives. Part of the Middle East and Central Asia as well as part of the African continent, with notably no project partners in most of the Maghreb, Sahara and Congo regions seems to be the least represented at global level (Figure 3).

Figure 3. Global geographic distribution of the 586 EU-funded projects obtained for the Biodiversity Strategy for 2030.



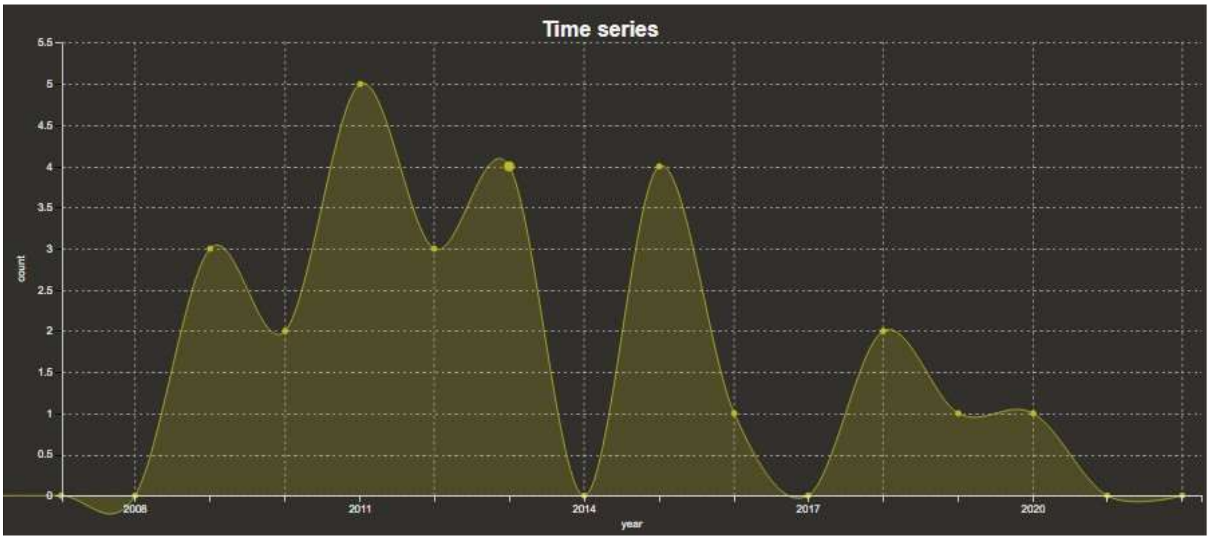
Source: JRC, 2021.

Collaborative networks and partnerships

The study identified the main actors at country level in biodiversity research and the main axes of collaboration between countries. In general, the results for the Strategy shows that the top 10 countries are in Europe, with the UK contributing to the largest number of projects, participating in 42% of all EU-funded research projects relevant to the 2030 Strategy. The majority of projects including the UK acknowledges an international partnership (68.53% International Collaboration), only 28% of projects are conducted exclusively within this country (see Annex 2). In the other countries the percentage of projects with international collaboration is also very high, always >70% for the top 10 countries (see Annex 2). At pillar level and for all the four pillars, the UK leads by number of projects, followed by Spain, Germany, France and Italy, with variable ranking. TIM enables the user to explore further the patterns of collaborations for any country of interest and identify the number of common projects. Regarding networking, the two main axes of collaboration in FP7 were UK-Germany, and Spain-Italy. In H2020, the two main axes of collaboration were UK-Germany, and Spain-France, while Italy expanded its network of collaborations and particularly with the Netherlands.

The distribution of EU-funded research projects was also analysed at institutional level. For the Strategy, the top 10 institutions are all from the EU, and the most represented countries are France, Netherlands and Denmark with two institutions each (Table 4). Although most projects are led from the UK at country level, at institutional level it is the *Agencia Estatal Consejo Superior de Investigaciones Cientificas* (CSIC), located in Spain, which has the largest number of projects. Further, TIM provides the temporal pattern of the research of each organisation. The top three organisations saw their number of projects decreasing over the last 15 years, while others less productive in the past such as the University of Copenhagen, Aarhus University and "*Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement"* have seen a clear increase. This may indicate that the distribution of projects is becoming more balanced across institutions. The JRC is also listed among the top organisations ranked at the tenth position with 26 projects, although the trend in the number of projects seems to be declining in recent years (Figure 4).

Figure 4. Temporal trend of the number of projects with JRC participation. The x-axis represents the years (2007 to 2022). The y-axis represents the number of EU-funded projects.



Source: JRC, 2021.

Indeed, the JRC dropped from the 6th position in FP7, with 17 projects, to the 18th in H2020, with 9 projects. Also at pillar level, the JRC is always among the top 10 organizations, except in the first pillar and cross-policy topic Biodiversity and Health. Except for the first pillar showing some variability, we found the same 10 most important organisations in biodiversity research across pillars with a few exceptions.

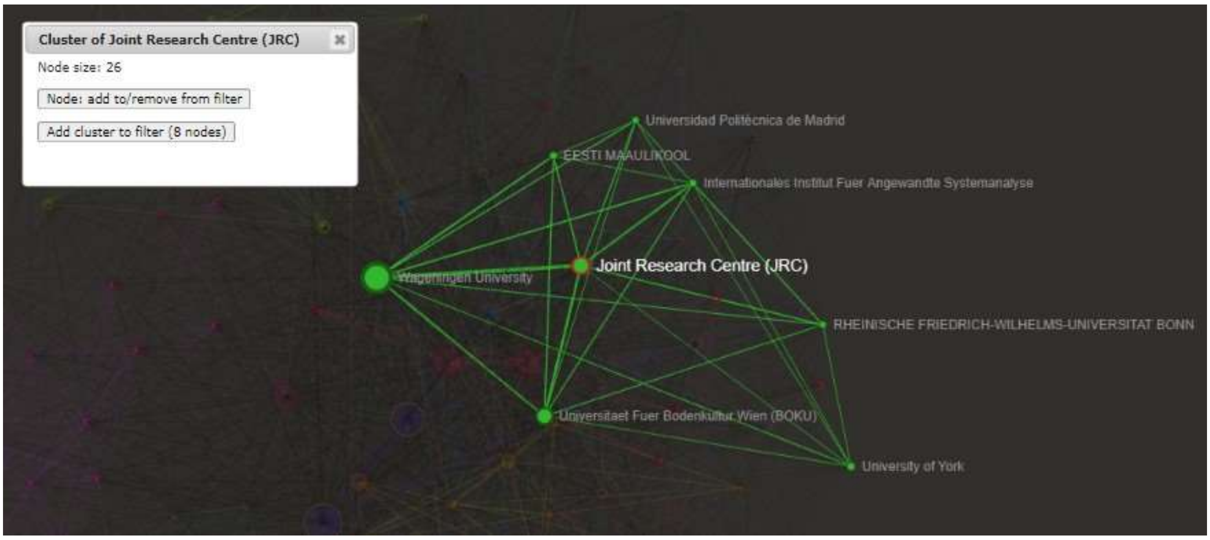
Table 4. The top 10 organisations with the largest number of projects relevant to the Strategy with year of first and last project and the corresponding total number of EU-funded projects.

Organization	First	Last	Total	Country
Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC)	2008	2021	61	Spain
Centre National De La Recherche Scientifique (CNRS)	2009	2022	53	France
Wageningen University	2008	2020	45	Netherlands
University Of Copenhagen (UCPH)	2008	2020	43	Denmark
Stichting Wageningen Research	2008	2020	43	Netherlands
Aarhus University	2008	2021	41	Denmark
Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (INRAE)	2009	2021	41	France
Sveriges Lantbruksuniversitet	2008	2021	33	Sweden
Consiglio Nazionale delle Ricerche (CNR)	2009	2021	29	Italy
Joint Research Centre (JRC)	2009	2020	26	Belgium

Source: JRC, 2021.

Regarding collaborative partnerships between institutions, for example, the JRC collaborates with several organisations, i.e., 76 direct collaborators including 8 more prominent (Figure 5) within 26 projects.

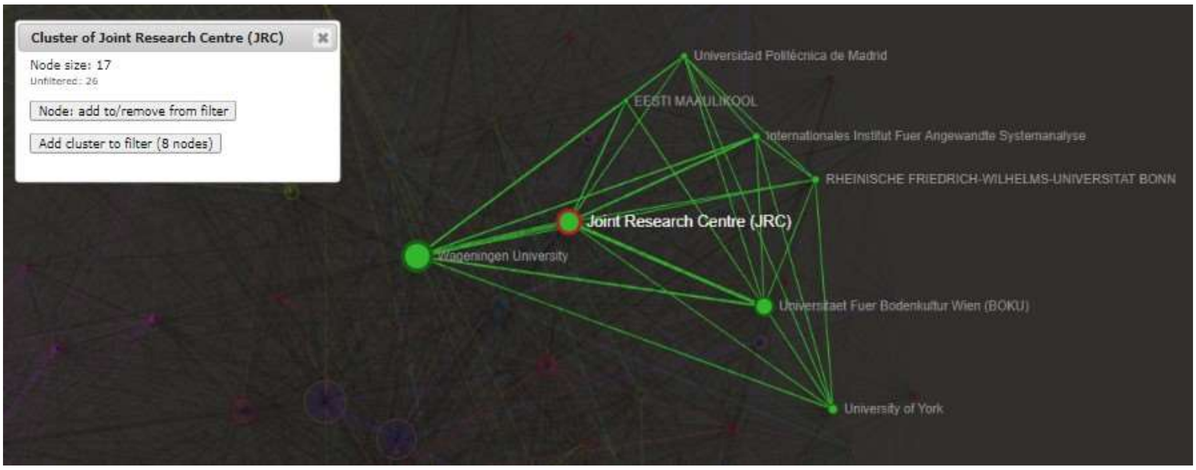
Figure 5. JRC collaboration network.



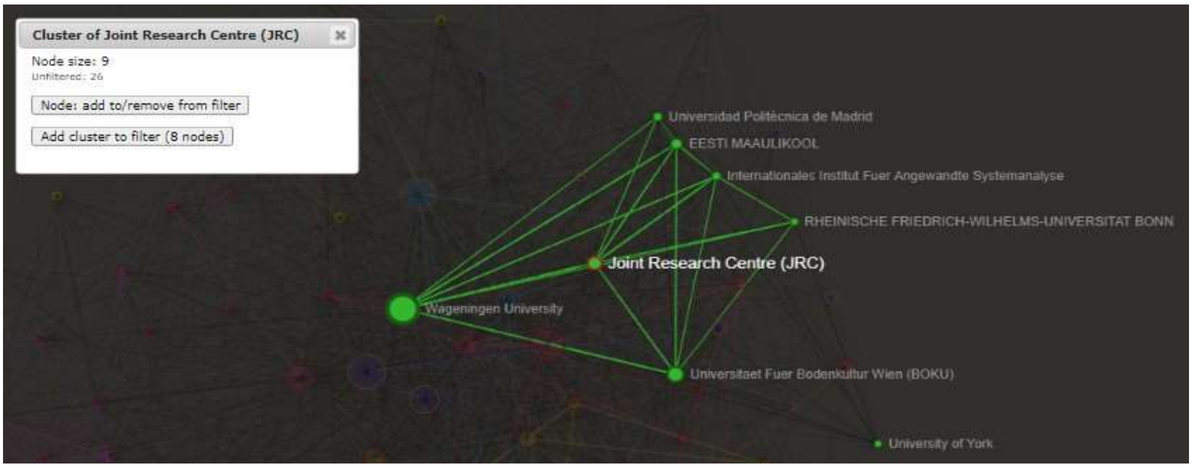
Source: JRC, 2021.

The JRC collaboration network remains fairly stable between FP7 (Figure 6a) and H2020 (Figure 6b), with the Wageningen University as a key partner.

Figure 6. JRC collaboration network for FP7 (a) and H2020 (b).



(a)

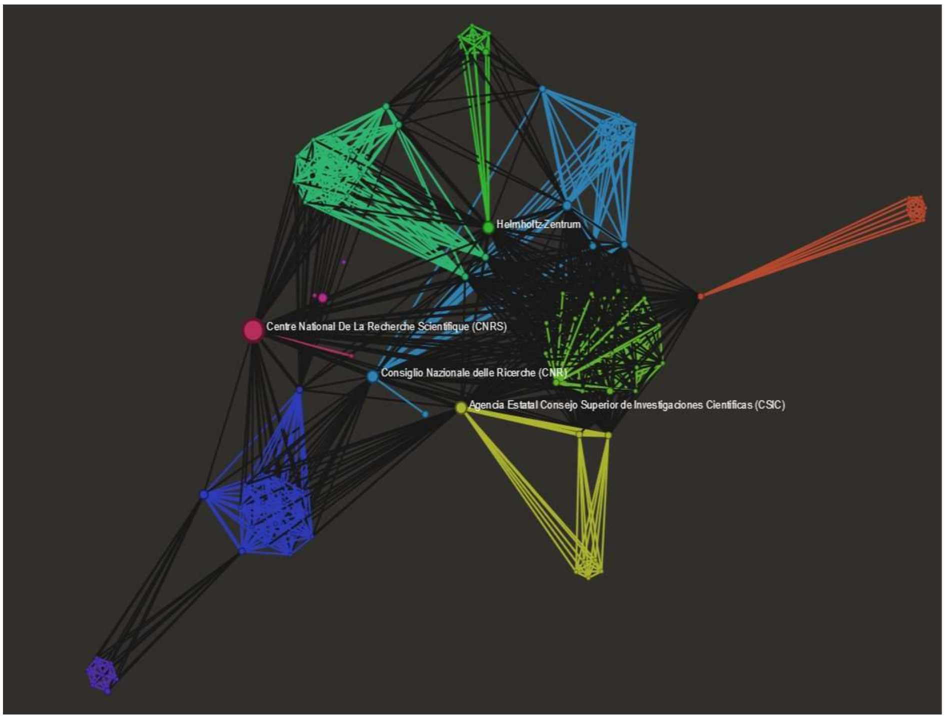


(b)

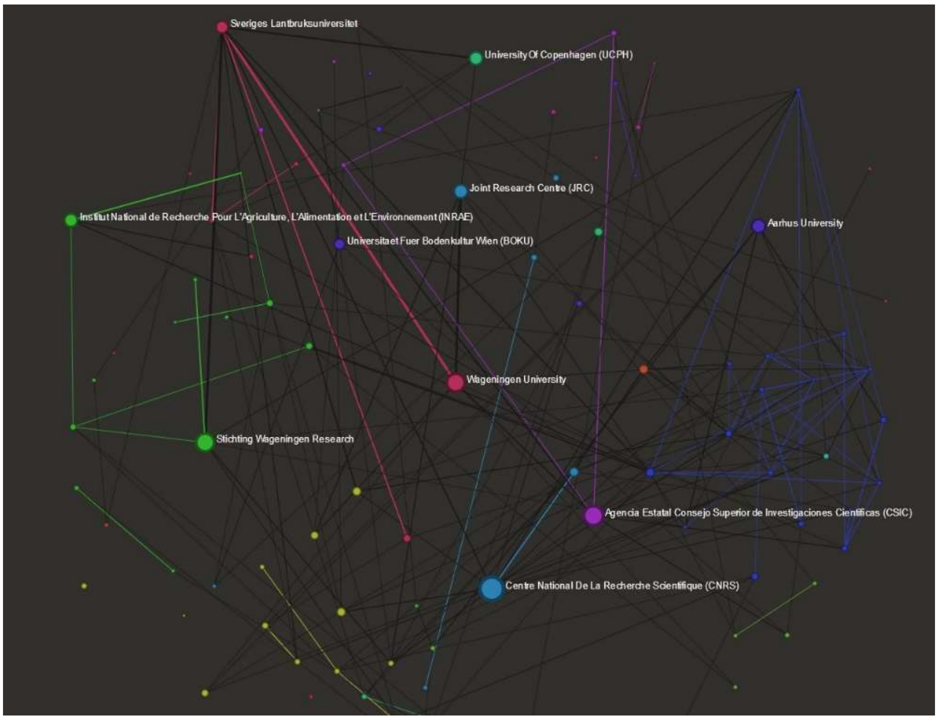
Source: JRC, 2021.

Regarding the collaboration between institutions within the different pillars, it can be pointed out that clusters are most visible in pillar 1 (Figure 7a), and partly also in pillar 3 and 4 (Figures 7c and d). In pillar 3 and 4, collaborative networks are more extensive and less restricted to core organisations. In pillar 2 (Figure 7b), there is less strong collaboration between the main organisations but a very extensive collaboration network with minor organisations.

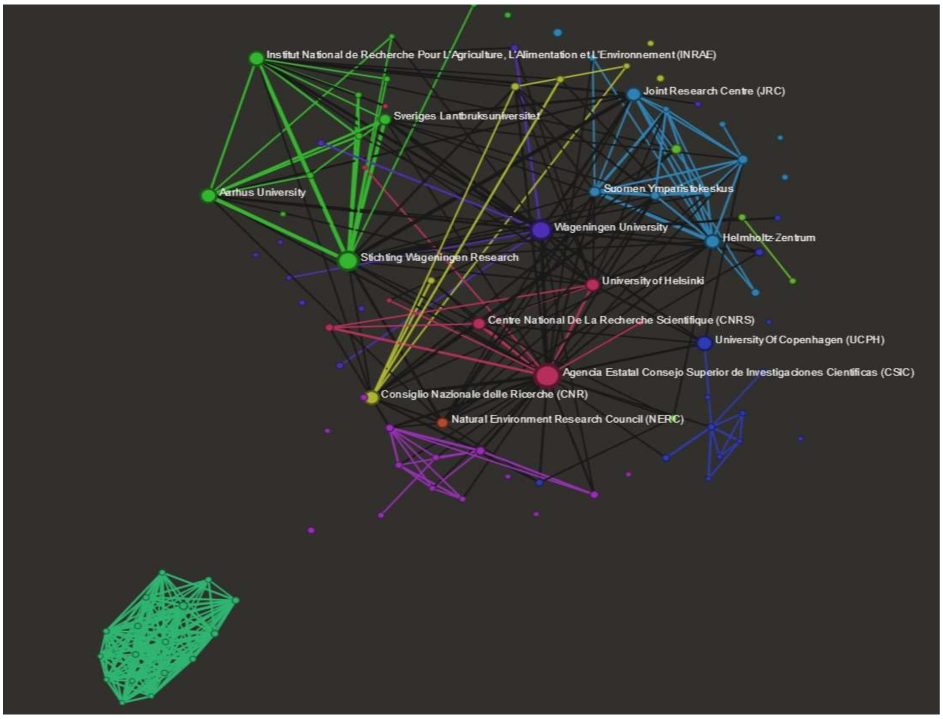
Figure 7. Collaboration axes between institutions for pillar 1 (a), pillar 2 (b), pillar 3 (c), and pillar 4 (d). Only the names of the main institutions are displayed. The same colour is assigned to institutions that collaborate more frequently.



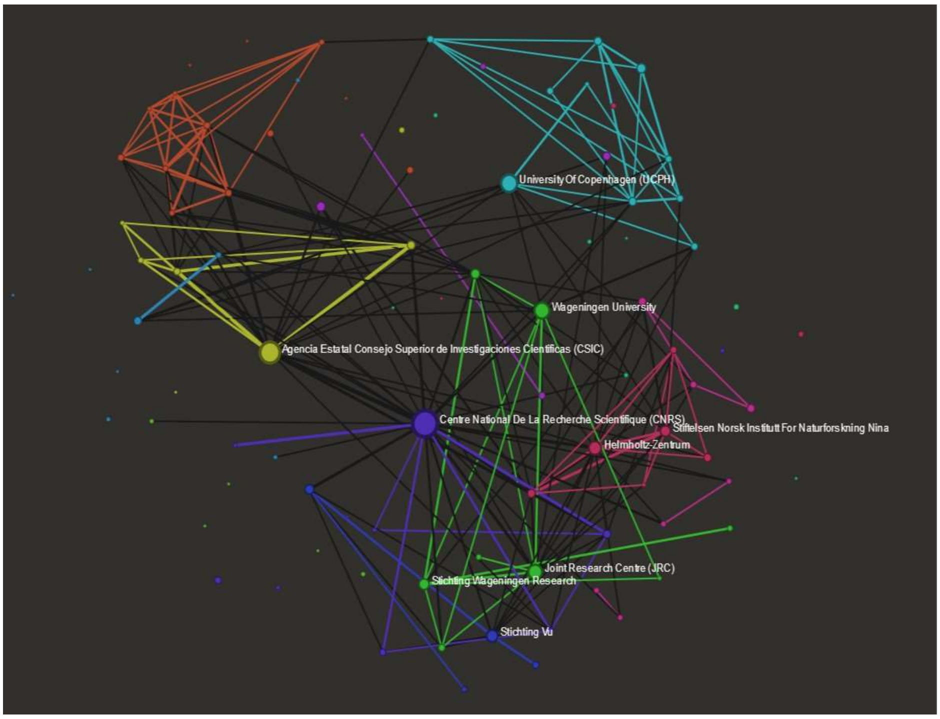
(a)


Sveriges Lantbruksuniversitet
University Of Copenhagen (UCPH)
Joint Research Centre (JRC)
Institut National de Recherche Pour L'Agriculture, L'Alimentation et L'Environnement (INRAE)
Universitaet Fuer Bodenkultur Wien (BOKU)
Aarhus University
Wageningen University
Stichting Wageningen Research
Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC)
Centre National De La Recherche Scientifique (CNRS)

(b)


Institut National de Recherche Pour L'Agriculture, L'Alimentation et L'Environnement (INRAE)
Joint Research Centre (JRC)
Sveriges Lantbruksuniversitet
Aarhus University
Suomen Ymparistokeskus
Wageningen University
Helmholtz-Zentrum
Stichting Wageningen Research
University of Helsinki
Centre National De La Recherche Scientifique (CNRS)
University Of Copenhagen (UCPH)
Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC)
Consiglio Nazionale delle Ricerche (CNR)
Natural Environment Research Council (NERC)

(c)



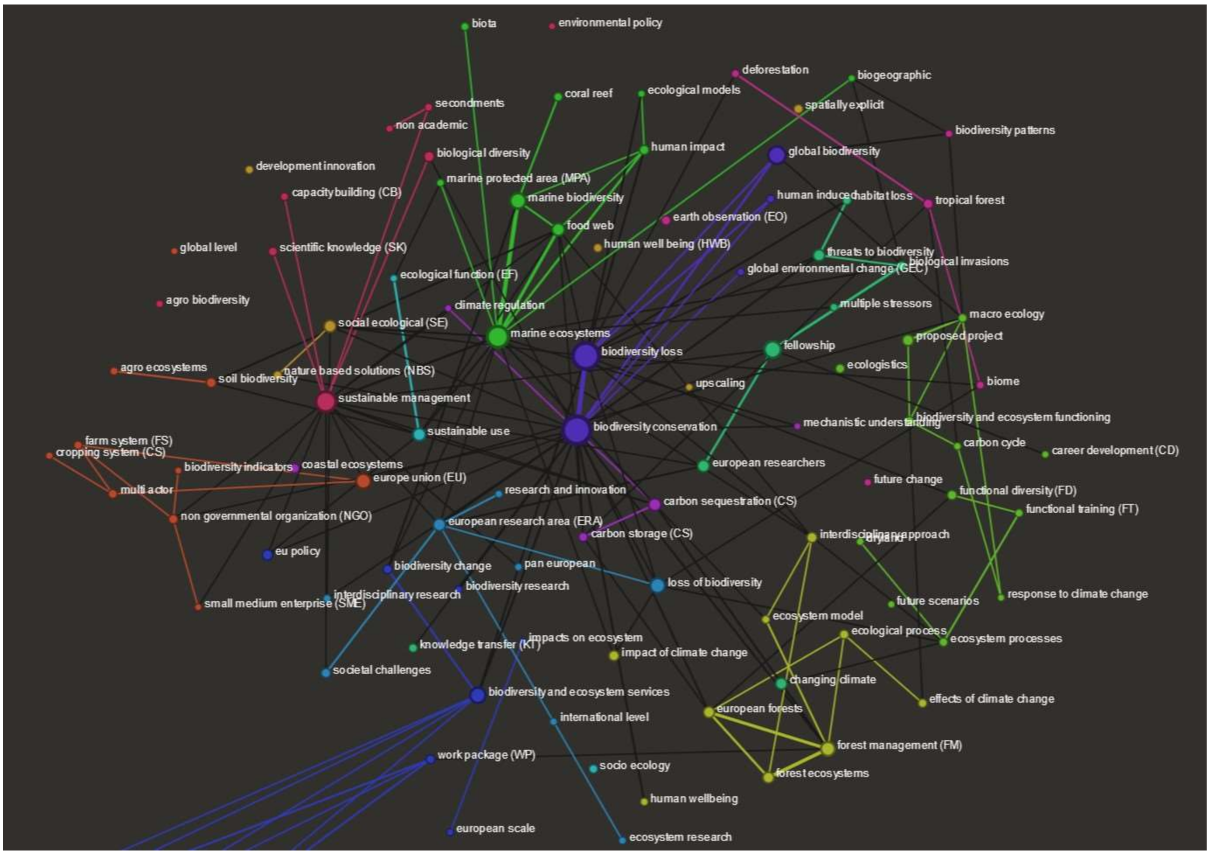
(d)

Source: JRC, 2021.

Thematic focus

The last step in the current data analysis is about capturing automatically the thematic foci of EU-funded research projects by text mining algorithms. The keywords generated - and their clusters for the ones most frequently occurring together - perfectly reflect all the main aspects of the Biodiversity Strategy projects in general and at the level of each pillar (Figure 8). Two keywords are systematically found: “Biodiversity loss” and “Biodiversity conservation”. These together with other terms such as “Global biodiversity” constitute the core group highlighted in purple in Figure 8. In addition, there is also the group related to forests, with a separate group for tropical forests, marine ecosystem, research and innovation, cropping and farming systems, and sustainable management (Figure 8).

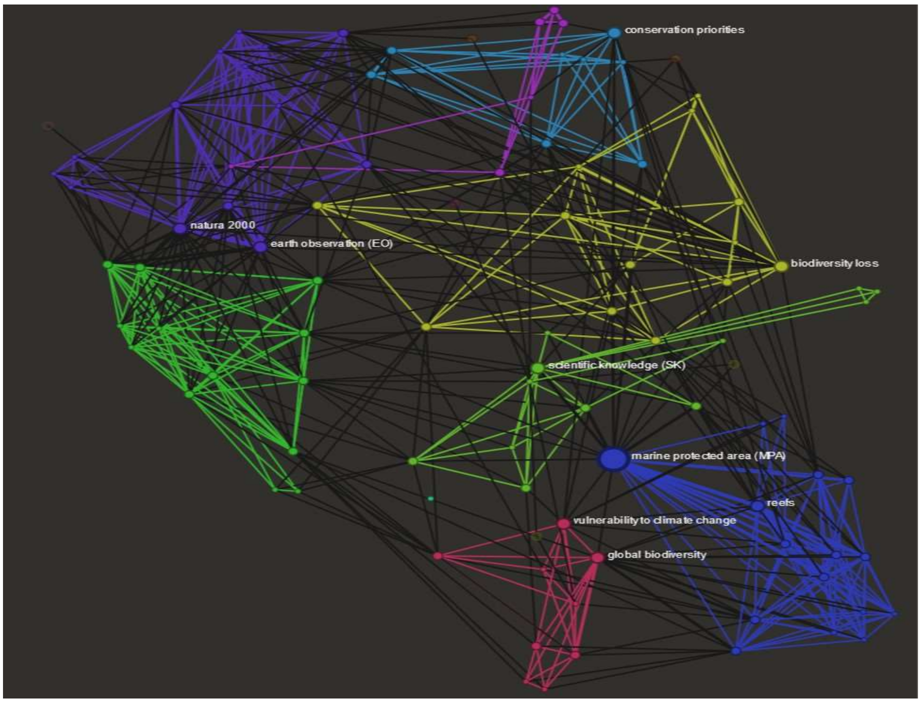
Figure 8. Thematic networks of keywords automatically extracted from EU projects relevant to the Strategy. Each network is assigned a colour and includes the keywords that most frequently occur together.



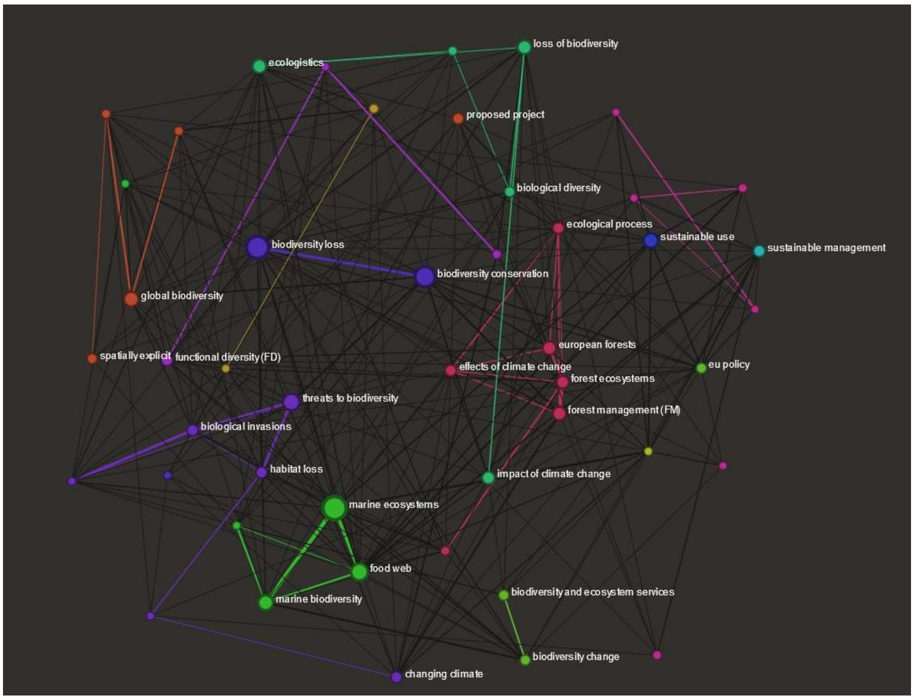
Source: JRC, 2021.

TIM enables exploring in detail the results for each pillar and zooming on clusters for any keyword of interest, it is possible to detect emerging themes and focus areas. In pillar 1 (Figure 9a) a focus on Marine protected areas suggests that in the last two Framework Programmes for Research and Technological Development particularly addressed the marine environment. We also noticed the emerging theme of Earth observation linked to the Natura 2000 sites. In pillar 2 (Figure 9b) there is again a focus on the marine ecosystem linked to food web and anthropogenic impact, as well as a cluster associated to forest. This suggests that restoration and conservation have focused on the marine and forest ecosystem over the last 15 years. The presence of the term “Biological invasions” linked to “Biodiversity threats” may reveal another research focus under the second pillar of the Strategy. Further, we noticed that the term “soil” is solely clustered together with agriculture and farming systems, and therefore are no keywords particularly highlighting the growing recognition of its value to biodiversity. As regards the third pillar (Figure 9c), the research seems more fragmented, and no particular clusters are identified. For the fourth pillar (Figure 9d), the global dimension of biodiversity emerges, with again the two clusters linked to the marine environment and to forests, the later particularly pointing at tropical forests and deforestation.

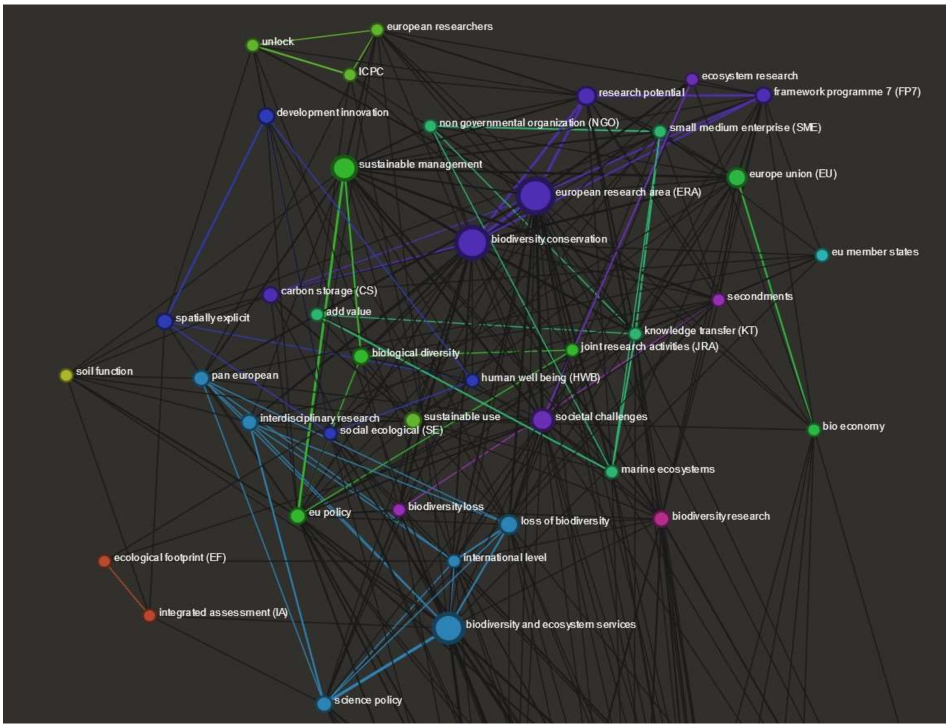
Figure 9. Thematic networks of keywords for each of the four Biodiversity Strategy pillars. Labels are only shown for the most frequent keywords. Each network is assigned a colour and includes the keywords that most frequently occur together.



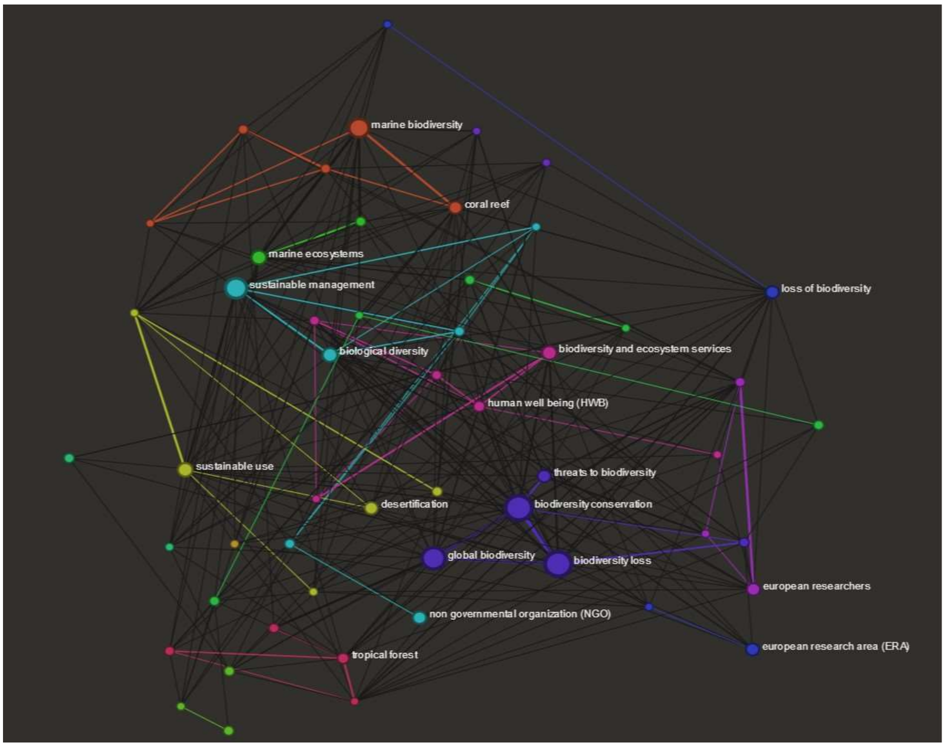
(a) Biodiversity Strategy pillar 1



(b) Biodiversity Strategy pillar 2



(c) Biodiversity Strategy pillar 3



(d) Biodiversity Strategy pillar 4

Source: JRC, 2021.

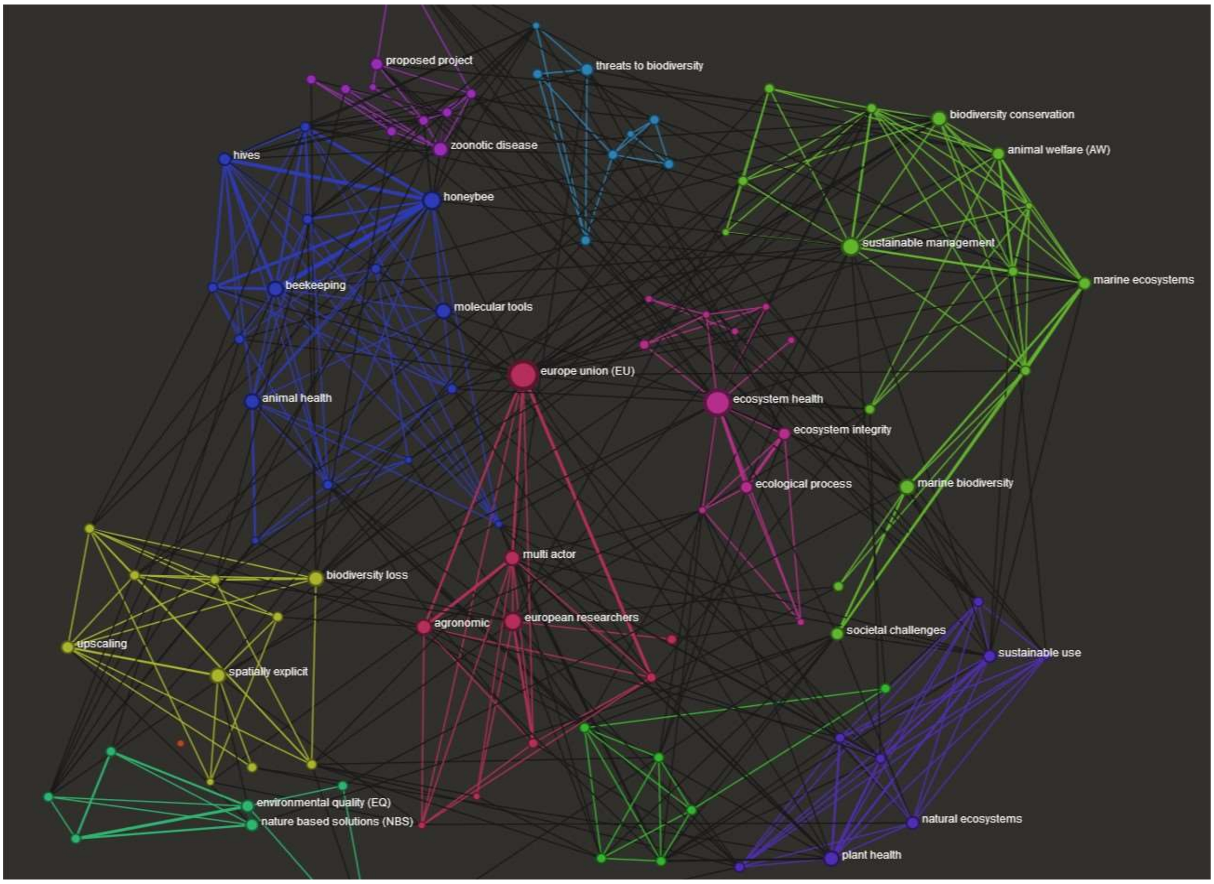
3.1.2.2 Cross-policy topic: Biodiversity and Health

We conducted the same analysis with the Biodiversity and Health search string (see Table 2) and after the quality checks, we analysed the final set of EU-funded research projects relevant to both disciplines. The outcome of these projects is potentially of interest to this cross-sectoral policy needs. The number of projects has doubled from FP7 to H2020, confirming the growing research interest over the last 15 years and the need for robust scientific evidence of the strong link between biodiversity and health, even more in the recent pandemic context. The renewed interest for the One Health (animal-environment-human) approach that is also included in the Biodiversity Strategy (see Karjalainen et al., 2017).

The UK is the country with the largest number of projects, as observed in the case of the Biodiversity Strategy, but for Biodiversity and Health the number of projects seems more evenly distributed across institutions. The top three institutions have the same number of projects. The JRC is only involved into three projects and does not appear in the top 10 institutions. In general, collaboration between institutions seems very broad, and not particularly concentrated within the top 10.

From the thematic point of view (Figure 10), several considerations can be made. In general, clusters were covering the two topics of animal health and environmental health but there was no link to human health, certainly indicating a weakness in the current interdisciplinary research. A well-defined cluster of projects was dealing with honeybees and their health, also in relation to beekeeping and population decline (blue cluster). One of the most important themes was the health of ecosystems linked to their integrity and ecological processes (pink cluster). Biodiversity loss was mainly related to new spatially explicit media (yellow cluster). Another cluster (in purple) linked sustainable use, natural ecosystems and plant health.

Figure 10. Thematic networks of keywords for Biodiversity and Health topic. Only the labels of the most frequent keywords are displayed. Each network is assigned a colour and includes the keywords that most frequently occur together.



Source: JRC, 2021.

There were no keywords enabling to link down the trophic chain, for example on the effects of chemical pollution and toxicity to the environment and the threat they pose to human health. The theme of sustainable management was introduced in relation to biodiversity conservation and animal health with more connection to marine biodiversity and societal challenges. The well-defined cluster on zoonosis included emerging diseases and mitigation strategies, in relation to control and prevention measures. The mental health keyword was missing, indicating that the link between for example, green urban areas and mental health may not be developed in biodiversity terms or simply that mental health is not a term commonly used in metadata.

3.2 Discussion and lessons learnt

The results presented in this report provide a synoptic view of research efforts in terms of scientific production and thematic foci as well as partnership for EU-funded biodiversity research projects. It is useful to know the relevance of such projects funded over the last fifteen years to biodiversity policy priorities. Stakeholders such as DG RTD of the European Commission, can learn lessons from this work and also conduct other thematic searches of their interest in order to support strategic decisions related to mid-to-long term research agenda.

Overall, projects related to the establishment and effective management of protected areas appear to be decreasing. This raises concern as this topic is one pillar of the 2030 Strategy. The emphasis found amongst all projects on marine and forest ecosystems is seen positively since these ecosystems are particularly sensitive and important for protection, conservation and restoration. However, other ecosystems and habitat types, such as grasslands, soil and urban ecosystems, seems marginally considered and only studied in relation to agricultural practices. Agriculture and food systems do not emerge clearly in the context of transformative change (pillar 3) or global biodiversity (pillar 4). This may outline insufficient or weak research efforts to link food systems (e.g., the supply/demand of food and sustainability) with the preservation of biodiversity and to address the delocalisation of deleterious land use practices outside Europe. Agriculture and its sustainable management are also partially covered under the biodiversity restoration context (pillar 2). EU-funded projects relevant to pillar 3 on transformative change did not show a clear structure and thematic foci. This suggests that biodiversity research may not yet be organised or may not have identified paths for “out of the box” thinking at the frontier with social sciences e.g., understanding its function and role to respond to relatively recent concepts like systemic and behavioural changes in the way of thinking and acting in society.

One crucial aspect of the methodology is the potential bias introduced by the experts and analysts when interpreting the policy documents and selecting keywords. Several steps within the workflow are automated, but few essential steps require the guidance of experts as already pointed out by other similar works (Borchardt, S. and Estreguil, C., 2020). This concerns the construction of the best performing search string, the manual quality check of the projects and the interpretation of the results.

The construction of the search string partly determines the accuracy of the search and the content of the final dataset. The underperformance of the automated project retrieval process (i.e., about 15% discarded projects) raises another important question related to the quality of the metadata available in the CORDIS database, i.e., for each project its content and structure, its associated keywords, abstract and factsheet and its categorisation when archived in the repository.

In particular, the abstracts are not always written using a precise language and clearly indicating the real objectives, the concrete actions and the policy relevance of the results. Often the information found in projects documents is too general, covers very broad areas, and misses on the real implications and benefits of the project. This can lead to wrong automated project selection by the TIM software. This is particularly true when the text includes many “catchy” terms, which are very distant from the scope or objectives of the project. It would be important to provide precise guidelines for writing abstracts of projects in the future and ensure that they include reporting versus policy objectives and actions. This would improve the metadata of future research projects.

The only alternative solution would be to run TIM software over the whole information attached to each project (i.e., deliverables, reports, etc.). Besides the processing time and complex analysis, this solution cannot be implemented with the Open Access version of TIM.

4 Dissemination of results on KCBD Web

The results of this study can be viewed on an interactive TIM dashboard on the *EU research project - policy link explorer*[14] page of the KCBD website. The dashboard provides access to the separate datasets that help contextualise and identify links between EU-funded research projects and biodiversity related policy priorities.

An overview of the TIM dashboard and guidance on how to explore and interpret the results are available in Annex 3. TIM dashboard can be visualised for each of the six datasets, i.e., EU projects on Biodiversity Strategy (BDS) 2030, EU projects on BDS 2030 pillar 1 - Protect Nature, EU projects on BDS 2030 pillar 2 - Restore Ecosystems, EU projects on BDS 2030 pillar 3 - Transformative change, EU projects on BDS 2030 pillar 4 - EU as a global leader, EU projects on Biodiversity and Health. For each dataset 11 interactive windows (pages) are shown to summarise the information according to the three main lenses (general information with list of projects and spatial and temporal trends, partnerships and collaboration axis, thematic foci).

A manual on how to use the TIM dashboard[15] can be consulted at the *EU research project - policy link explorer* page of the Knowledge Centre for Biodiversity website.

[14] https://knowledge4policy.ec.europa.eu/biodiversity/topic/eu-research-project-policy-link-explorer_en
[15] https://knowledge4policy.ec.europa.eu/sites/default/files/TIM_dashboard_manual_KCBD_0.pdf

5 Conclusions and way forward

This exercise allowed us to analyse quickly about one thousand metadata of EU-funded research projects archived in the CORDIS database and map their links in relation to policy priorities in the context of the Biodiversity Strategy for 2030 and the cross-policy domain of Biodiversity and Health. The analysis was conducted with the TIM Open Access software according to three main lenses (general information with interactive list of projects and spatial and temporal trends, partnerships and collaboration axis, thematic foci). A total of six conditional queries (datasets) were defined. All results are available as an interactive TIM dashboard on the *EU research project - policy link explorer*[16] page of the Knowledge Centre for Biodiversity website. Other conditional queries could easily be tested depending on user interests.

From the methodological point of view, the workflow that was developed alternates automated and manual processes. The approach can be applied to any topic and policies of interest. The TIM Open Access software has the advantage to be freely accessible to a non-specialist audience; it does not require any advanced technical skills or expertise in machine learning and text mining algorithms. In addition to listing of relevant projects (which other tools can do), it also proposes an automatic extraction of keywords and a network analysis for partnerships and thematic content.

One crucial aspect of the methodology is related to the potential bias introduced by expert judgement, notably in the formulation of the best performing search strings to translate policy documents into keywords and in the manual quality checks. Another critical point is the underperformance of the automated retrieval process which discarded about 15% of projects. This is mainly due to the lack of precision, focus and/or reliability of the metadata associated with projects that are archived in the CORDIS database. Our recommendation would be to improve the quality of projects' metadata, starting with the EU research projects funded under the Horizon Europe Framework Programme (2021-2027). Guidelines could be provided for writing fit-for-purpose abstracts, ensuring real and precise objectives and actions, precisely categorising of the research project with carefully selected keywords and explicitly identifying the science-to-policy relevance. Improved metadata would also improve TIM's automated project retrieval, thus minimising the need for human intervention in manual quality checks.

In the context of the Knowledge Centre for Biodiversity, analyses could be conducted on the relevance of EU-funded research projects to other cross-sectoral topics e.g., Biodiversity and Agriculture, Biodiversity and Trade, Biodiversity and Energy. In addition, to answer policy priorities of the Biodiversity Strategy for 2030, other conditional queries could be defined to extract EU-funded research projects that respond to specific biodiversity actions and commitments, such as the restoration of free-flowing rivers or the reduction of 50% of chemical pesticides.

[16] https://knowledge4policy.ec.europa.eu/biodiversity/topic/eu-research-project-policy-link-explorer_en

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List of abbreviations and definitions

BDS	Biodiversity Strategy for 2030
EC	European Commission
EU	European Union
FP	Framework Programme
JRC	Joint Research Centre
KCBD	Knowledge Centre for Biodiversity
TIM	Tool for Innovation Monitoring

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Annexes

Annex 1. Pillar(s) assignment: Topics

BDS 2030 First pillar: PROTECT NATURE

All projects covering the following topics are considered relevant to the first pillar:

- Protected area and marine protected area (establishment, management, design, effectiveness)
- Connectivity, Ecological corridors

BDS 2030 Second pillar: RESTORE ECOSYSTEMS

All projects, explicitly related to biodiversity, covering the following topics are considered relevant to the second pillar:

- Monitoring of particular habitats/ecosystems/species; data collection for better management of particular ecosystems (in particular agro-ecosystems, freshwater ecosystems, marine ecosystems, forest ecosystem, soil ecosystem)
- Improving the condition/health of particular habitats/ecosystems/species (and restoring them and their natural functions (e.g., free-flowing rivers))
- Reducing pressures and threats (climate change, anthropogenic pressure, land use change, pollution, etc.) affecting particular habitats/ecosystems/species; assessment of how ecosystems/species respond to threats
- Monitoring ecosystem services
- Monitoring pollinators and reducing threats
- Assessment pollution of soil/water/air; how to prevent pollution; addressing nutrient pollution in soil/water/air at source; addressing marine litter
- Monitoring, collecting data and increasing the coverage and improving the health of forest ecosystems (and planting trees and afforestation processes)
- Assessing and quantifying the impact of unsustainable practices (intensive practices in forestry, farming, fishing); making fishing, forestry, farming practices more sustainable; sustainable use of forest biomass for energy production; use of biofuels
- Prioritising renewable energy solutions more biodiversity-friendly
- The use of more sustainable practices in agriculture such as precision agriculture, organic farming; reducing the use of environmentally problematic pesticides and fertilisers; preventing the decline in the genetic diversity of crops; genetic resources of biodiversity
- Preventing soil degradation; monitoring soil conditions; monitoring soil biodiversity
- Impact assessment of invasive alien species; management of invasive alien species; study of biological invasion processes
- Greening urban and peri-urban areas
- Management of coastal ecosystems
- Nature-based solutions (if relevant to restoration/recovery)

BDS 2030 Third pillar: TRANSFORMATIVE CHANGE

All projects, explicitly related to biodiversity or not, covering the following topics are considered relevant to the third pillar:

- Biodiversity governance at European level
- Stepping up implementation and enforcement of EU environmental legislation
- Integration of biodiversity into public and business decision-making at all levels; also developing business based on biodiversity values (eco-tourism, green jobs…)
- Economic aspects of biodiversity and ecosystems
- Measuring and integrating the value of nature, natural capital accounting initiative
- Significant public and private investment at national and European level for biodiversity (use of all relevant EU programmes and funding instruments); biodiversity financing should not only rely on public funds, importance of developing private business sectors
- Measuring and reducing the environmental footprint and impact of products and organisations at European level in Europe and beyond (i.e., developing countries the so-called embodied impact - impact of European production and demand - sustainable production and consumption - impact of the European market) with reference to some benefit to the environment (or deleterious to biodiversity like emissions, pollution, impact of raw materials, etc.)
- Green recovery and the deployment of nature-based solutions (if relevant to transformative change)
- Improving knowledge, education and skills (education for environmental sustainability and biodiversity education, research and innovation on green solutions, knowledge exchange, public dissemination), networking research and collaboration for biodiversity and environment, sustainable life styles
- Environmental compliance (check illegal logging for example thanks to Earth Observation)

BDS 2030 Fourth pillar: EU AS A GLOBAL LEADER

All projects, explicitly related to biodiversity or not, covering the following topics are considered relevant to the fourth pillar:

- Biodiversity/ecosystem monitoring, conservation and restoration projects with actions taking place in at least one non-European country
- Biodiversity Governance at global level
- The principle of equality (respect for the rights and the full and effective participation of indigenous peoples and local communities in conservation activities)
- International/global Ocean Governance. Also include specific actions for Marine Protected Areas in the Southern Ocean (beyond jurisdiction)
- Global illegal wildlife trade; illegal practices with environmental impact; wildlife trafficking (ivory trade)
- The environmental footprint of importing products into Europe from the rest of the world (in particular products associated with deforestation) with reference to their impacts (positive or not) to the environment (emissions, pollution, impact of raw materials, etc.)
- the assessment of the impact of global trade agreements on biodiversity; biodiversity-friendly trade; Global fair Trade policies as support and part of the ecological transition
- Measuring and reducing the environmental footprint and impact of products and organisations from countries outside the Europe. All products which production have

an impact on biodiversity (deforestation/forest degradation are the most obvious, but may also be land degradation, pasture degradation due to cattle grazing, etc.)

- One Health approach (intrinsic connection between human health, animal health and healthy resilient nature)
- NaturAfrica (protection of wildlife and key ecosystems – opportunities in green sectors for local populations)

Annex 2. Country collaborations on dataset "EU Projects on BDS 2030"

Figure 11. Country collaborations on dataset "EU Projects on BDS 2030". On the left are shown the top 10 countries ordered by the number of projects, and the percentage of Single org. projects (no collaboration at all), Domestic projects (projects with participants by two or more organizations but all organizations located in the same country), and International projects (projects with participants by two or more organizations located in different countries). On the right is shown the in-depth table for the UK and the number of collaborative projects with other countries.

Collaborations

SWITCH TO DATASET LIST

Country collaborations on dataset *'EU Projects on BDS 2030'*

How to treat EU countries: consider separated countries

Rejected invalid d

	Documents	Documents in collaboration					
		Single org.		Domestic		International	
Country	Total	Count	%	Count	%	Count	%
United Kingdom	251	71	28.29%	8	3.19%	172	68.53%
Spain	203	58	28.57%	0	0.00%	145	71.43%
Germany	194	22	11.34%	2	1.03%	170	87.63%
France	179	35	19.55%	1	0.56%	143	79.89%
Netherlands	150	12	8.00%	3	2.00%	135	90.00%
Italy	145	13	8.97%	0	0.00%	132	91.03%
Belgium	114	8	7.02%	1	0.88%	105	92.11%
Denmark	104	25	24.04%	0	0.00%	79	75.96%
Sweden	92	6	6.52%	1	1.09%	85	92.39%
Switzerland	86	13	15.12%	4	4.65%	69	80.23%

Number of documents in common with other countries

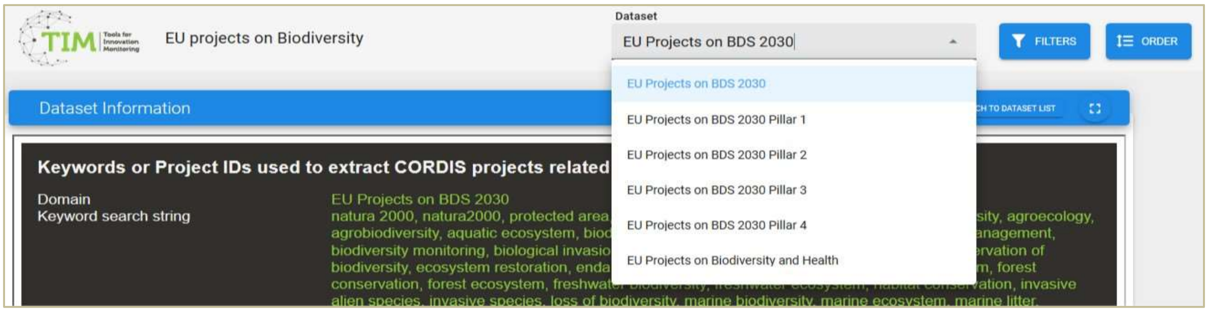
Country	Documents
Germany	130
Netherlands	117
France	108
Spain	100
Italy	98
Belgium	80
Sweden	68
Denmark	65
Portugal	59
Switzerland	55
Norway	50
Austria	46
Greece	46
Poland	42
Finland	40
Hungary	40
Romania	35

Source: JRC, 2021.

Annex 3. Guidance to explore TIM dashboard

The case studies that were presented in this report are available as an interactive TIM dashboard that can be visualised for each of the six datasets (Figure 12), i.e., EU projects on Biodiversity Strategy (BDS) 2030, EU projects on BDS 2030 pillar 1 – Protect Nature, EU projects on BDS 2030 pillar 2 – Restore Ecosystems, EU projects on BDS 2030 pillar 3 – Transformative change, EU projects on BDS 2030 pillar 4 – EU as a global leader, EU projects on Biodiversity and Health. For each dataset 11 interactive windows (pages) are shown to summarise the information according to the three main lenses (general information with list of projects and spatial and temporal trends, partnerships and collaboration axis, thematic foci). They can be explored applying filters (spatial and temporal) and adjusting display options for graphs and tables. Some pages provide detailed explanation through a note box or a help ('i') button.

Figure 12. KCBD "Biodiversity Projects" dashboard and the six different datasets.

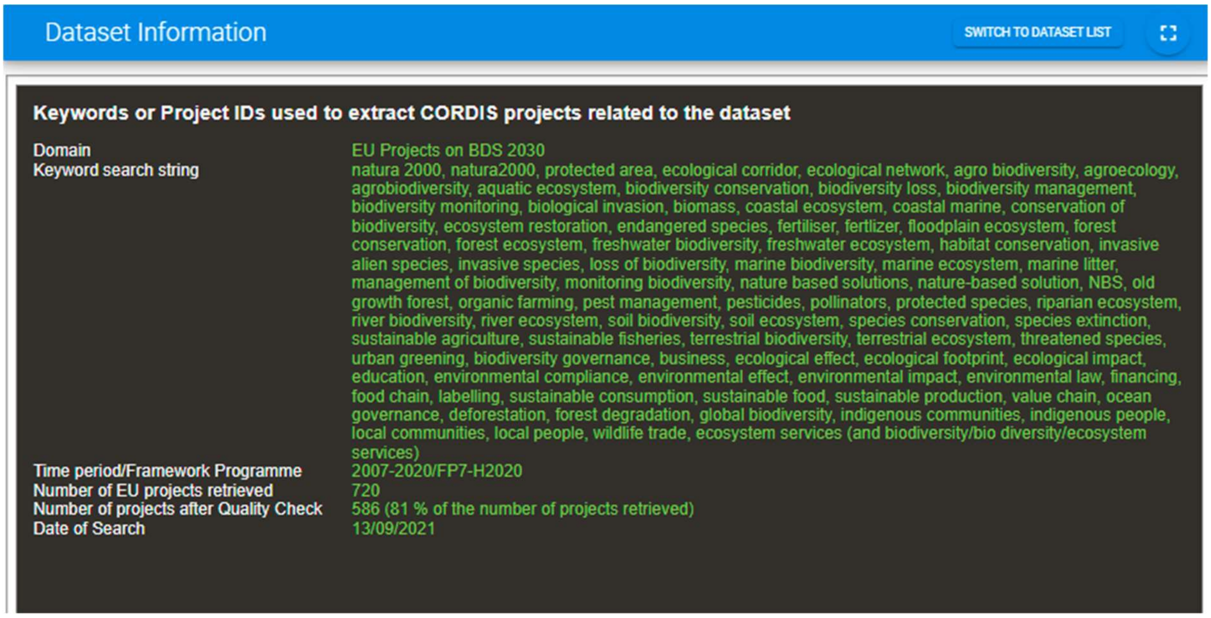


Source: JRC, 2021.

It is possible to compare different datasets by switching to dataset list, and explore the same page for different datasets, order and filter pages, and show all results by organization, country or time range.

The first page includes the general information about the dataset and projects: the dataset definition string, the time period, the number of projects retrieved, the number of projects after quality check, and the date of creation of the dataset, in order to provide a temporal reference for the analysis (Figure 13).

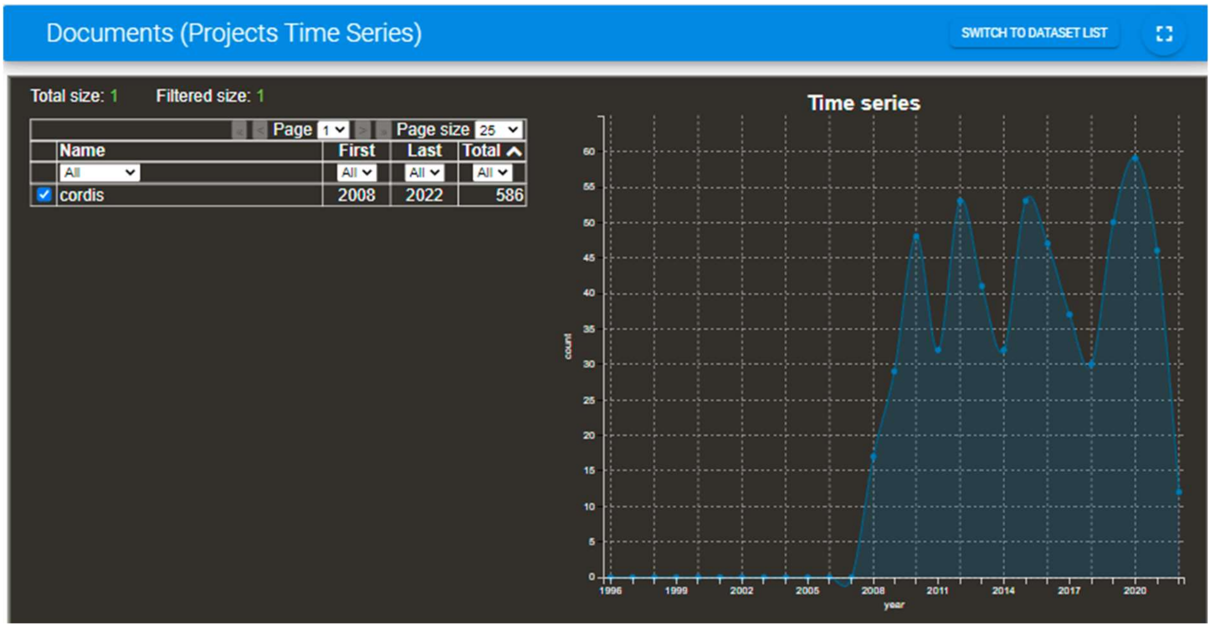
Figure 13. Dataset Information page of "EU Projects on BDS 2030" dataset.



Source: JRC, 2021.

Then the temporal trend of the projects is represented by a graph, which shows the yearly distribution according to the number of projects and the starting year (Figure 14).

Figure 14. Time trend page of "EU Projects on BDS 2030" dataset.



Source: JRC, 2021.

The list of the relevant projects per dataset is represented by a page with a table (Figure 15) composed of several columns and containing for each project, information on project ID, acronym, title, start and end year, total project cost, EU budget contribution, coordinating organisation name and country and the URL link to the page in CORDIS database.

Figure 15. List of relevant projects page of "EU Projects on BDS 2030" dataset.

Documents (Project List)

SWITCH TO DATASET LIST

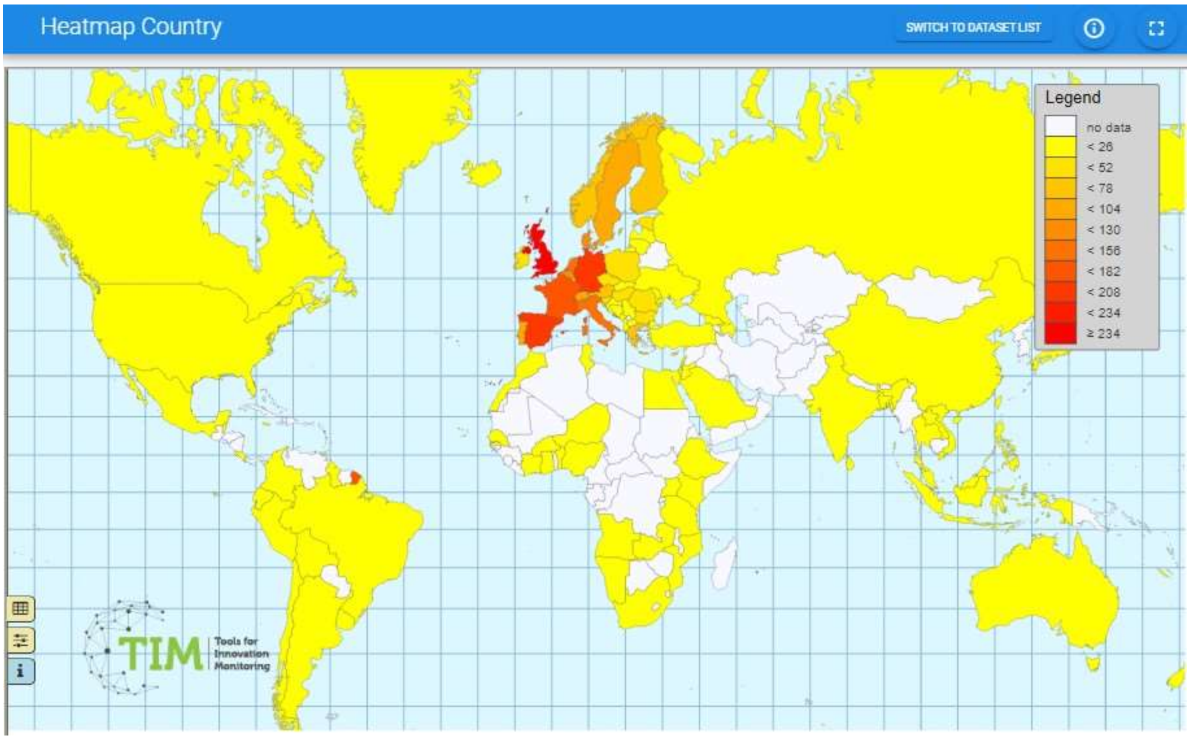
Entries: 584

title	Va	Project acronym	link	Star	End Y	Total cost	EU cont	Coordinator	Co	P
A global approach t...	1.0	BIODIV-LOG	https://cord...	2011	2014	45000	45000	CENTRE NATIO...	FR	
A Holistic Opto-Aco...	1.0	SYMBIOSIS	https://cord...	2017	2020	1602460	1399960	UNIVERSITY O...	IL	
A new automated b...	1.0	BeeHome	https://cord...	2020	2022	3145125	2201587,5	BEEWISE TEC...	IL	
A Pan-European S...	1.0	PESI	https://cord...	2008	2011	4057628	2640000	UNIVERSITEIT ...	NL	
A reliable, effective ...	1.0	XCell	https://cord...	2018	2018	71429	50000	ATANA LTD	UK	
A sustainable futur...	1.0	BEE NATURAL	https://cord...	2021	2026	1499703	1499703	SVERIGES LAN...	SE	
A sustainable orga...	1.0	MICRO4BEE	https://cord...	2016	2016	71429	50000	MICRO4YOU S...	IT	
A web-based Decis...	1.0	UnderSCORE	https://cord...	2019	2020	150000	150000	UNIVERSITEIT ...	BE	
Accommodating N...	1.0	SUSTAINABLEOCEAN	https://cord...	2015	2021	1051500	1051500	UNIVERSITEIT ...	NL	
Achieving sustaina...	1.0	CHOCOLATE4LIFE	https://cord...	2019	2021	195454,8	195454,8	UNIVERSITY O...	UK	
Acoustic Imaging o...	1.0	AIM-HI	https://cord...	2010	2012	172740.8	172740.8	UNIVERSITY O...	UK	
Adapting to Global ...	1.0	ECOGENES	https://cord...	2010	2013	4705895.7	2761415.82	AGENCIA ESTA...	ES	
Adaptive plasticity ...	1.0	INVASOMICS	https://cord...	2021	2024	246669,12	246669,12	JOHANN WOLF...	DE	
Adaptive Strategies...	1.0	REFRESH	https://cord...	2010	2014	9895943.67	6997746.7	UNIVERSITY C...	UK	
Addressing key ch...	1.0	KeyDynamics	https://cord...	2017	2019	212194,8	212194,8	AARHUS UNIV...	DK	
Advanced multifun...	1.0	ARANGE	https://cord...	2012	2015	3802775.79	2991077	UNIVERSITAET...	AT	
Advancing dryland ...	1.0	ECOHYDRY	https://cord...	2016	2018	173076	173076	CENTRE NATIO...	FR	
African Sky Forests...	1.0	AFRI-SKYFOR	https://cord...	2017	2020	251857,8	251857,8	UNIVERSITY O...	UK	
AGFORWARD	1.0	AGFORWARD	https://cord...	2014	2017	8009806.24	5994766	CRANFIELD UN...	UK	
Altered eco-evoluti...	1.0	ECOFEED	https://cord...	2019	2024	1983565	1983565	CENTRE NATIO...	FR	

Source: JRC, 2021.

Finally, the analysis of geographic distribution is given by a heat map (Figure 16) that shows globally, through colour coding, the number of EU projects for each country (based on the geographic location of the project`s coordinating organisation).

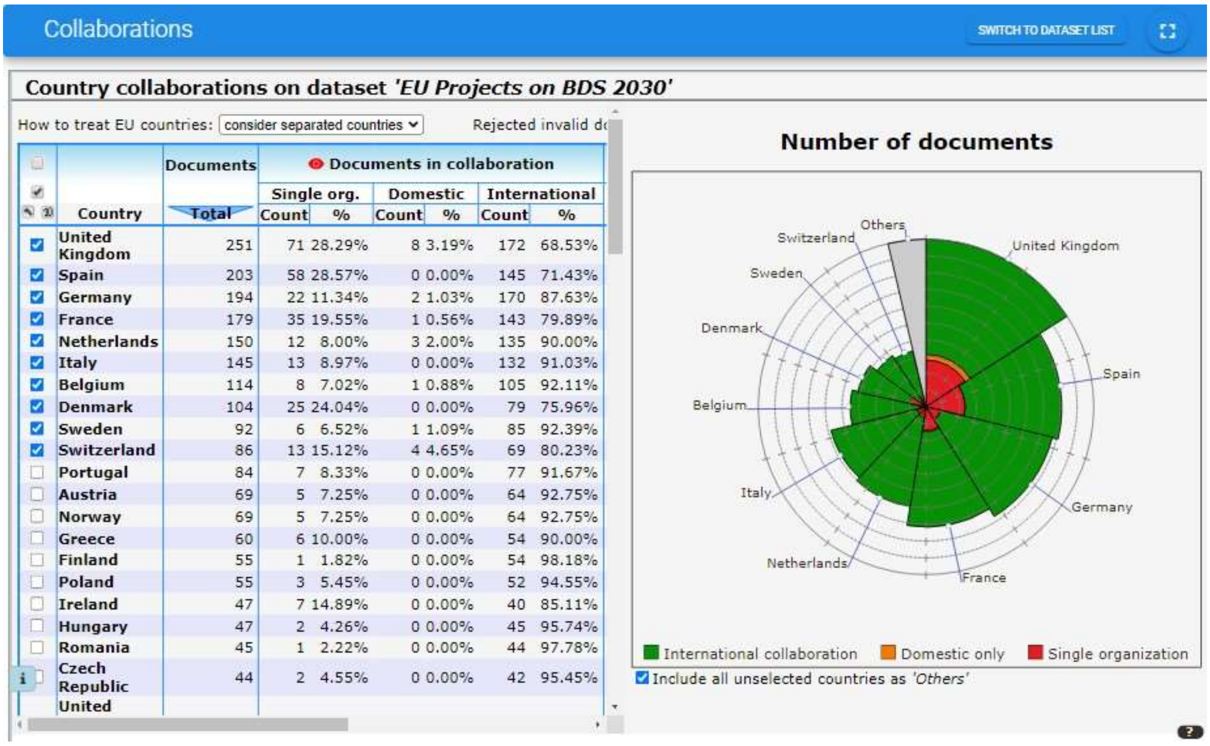
Figure 16. Heatmap page of "EU Projects on BDS 2030" dataset.



Source: JRC, 2021.

It is also possible to identify the countries/organisations most active in the research, to visualise their trend over time and how the collaborations are structured at institutional level. For example, the next figure shows the countries sorted by number of projects and the collaboration between them (Figure 17).

Figure 17. Country level page of "EU Projects on BDS 2030" dataset.

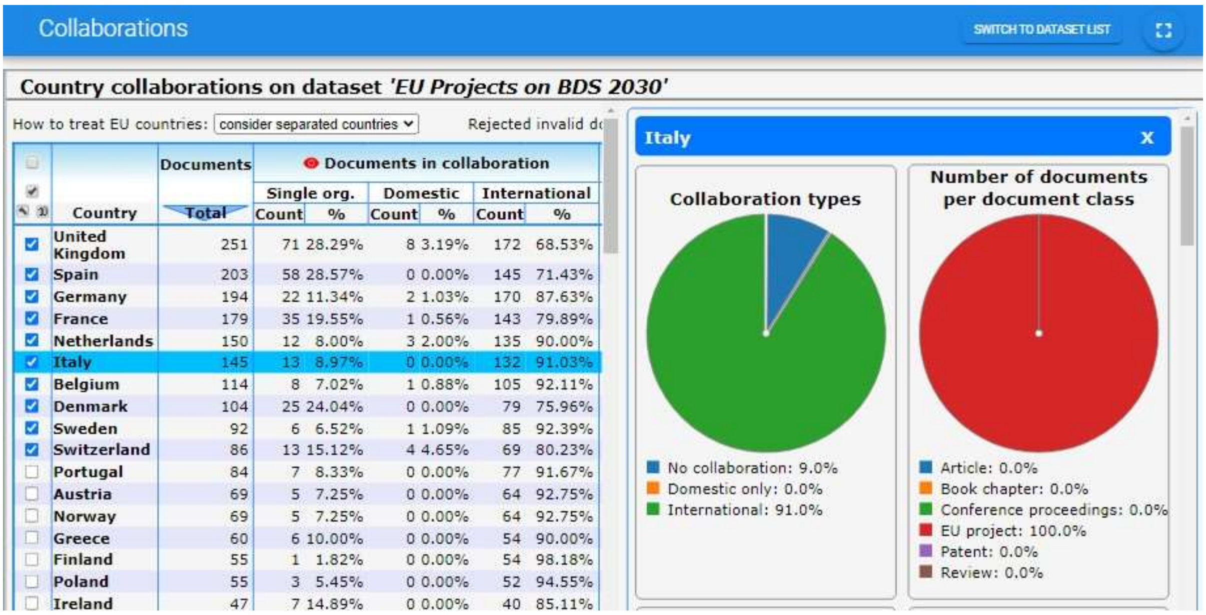


Country	Documents Total	Single org. Count	Single org. %	Domestic Count	Domestic %	International Count	International %
United Kingdom	251	71	28.29%	8	3.19%	172	68.53%
Spain	203	58	28.57%	0	0.00%	145	71.43%
Germany	194	22	11.34%	2	1.03%	170	87.63%
France	179	35	19.55%	1	0.56%	143	79.89%
Netherlands	150	12	8.00%	3	2.00%	135	90.00%
Italy	145	13	8.97%	0	0.00%	132	91.03%
Belgium	114	8	7.02%	1	0.88%	105	92.11%
Denmark	104	25	24.04%	0	0.00%	79	75.96%
Sweden	92	6	6.52%	1	1.09%	85	92.39%
Switzerland	86	13	15.12%	4	4.65%	69	80.23%
Portugal	84	7	8.33%	0	0.00%	77	91.67%
Austria	69	5	7.25%	0	0.00%	64	92.75%
Norway	69	5	7.25%	0	0.00%	64	92.75%
Greece	60	6	10.00%	0	0.00%	54	90.00%
Finland	55	1	1.82%	0	0.00%	54	98.18%
Poland	55	3	5.45%	0	0.00%	52	94.55%
Ireland	47	7	14.89%	0	0.00%	40	85.11%
Hungary	47	2	4.26%	0	0.00%	45	95.74%
Romania	45	1	2.22%	0	0.00%	44	97.78%
Czech Republic	44	2	4.55%	0	0.00%	42	95.45%
United							

Source: JRC, 2021.

By selecting one country, more detailed information is given about its collaborations and associated number of projects (see example of Italy below, Figures 18 and 19).

Figure 18. Italy collaborations page of "EU Projects on BDS 2030" dataset.



Country	Documents Total	Single org. Count	Single org. %	Domestic Count	Domestic %	International Count	International %
United Kingdom	251	71	28.29%	8	3.19%	172	68.53%
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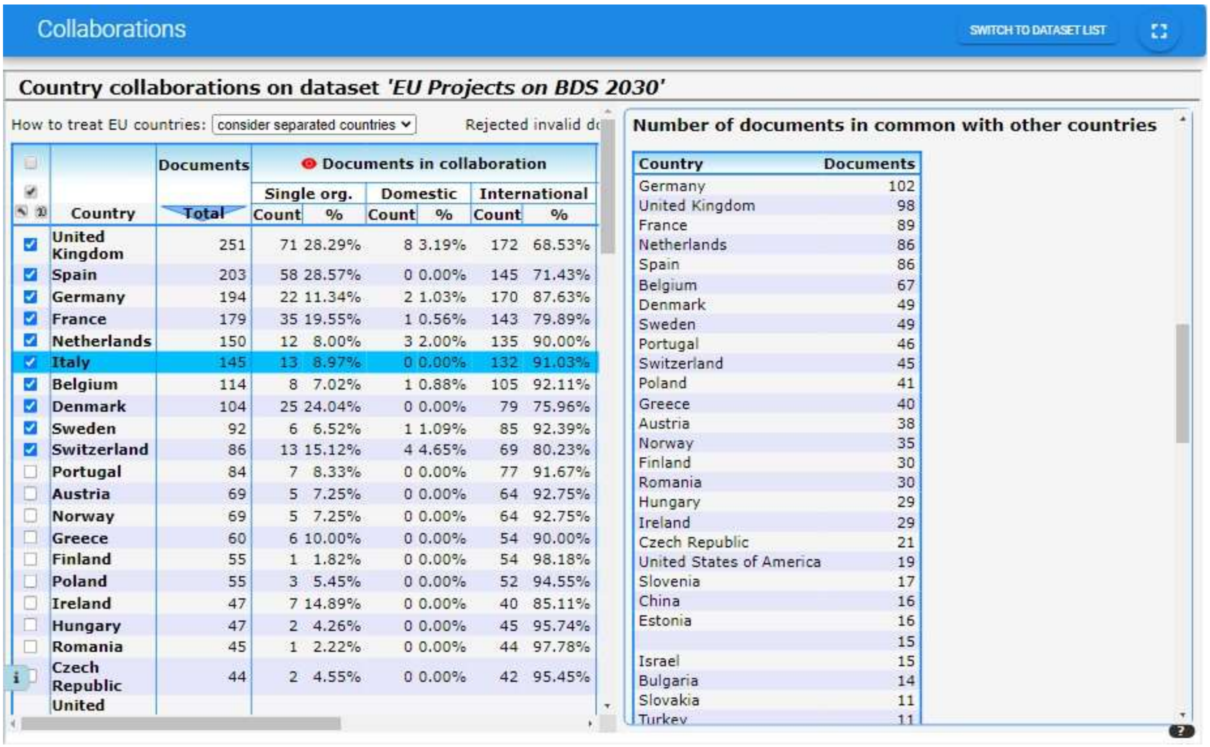
Netherlands	150	12	8.00%	3	2.00%	135	90.00%
Italy	145	13	8.97%	0	0.00%	132	91.03%
Belgium	114	8	7.02%	1	0.88%	105	92.11%
Denmark	104	25	24.04%	0	0.00%	79	75.96%
Sweden	92	6	6.52%	1	1.09%	85	92.39%
Switzerland	86	13	15.12%	4	4.65%	69	80.23%
Portugal	84	7	8.33%	0	0.00%	77	91.67%
Austria	69	5	7.25%	0	0.00%	64	92.75%
Norway	69	5	7.25%	0	0.00%	64	92.75%
Greece	60	6	10.00%	0	0.00%	54	90.00%
Finland	55	1	1.82%	0	0.00%	54	98.18%
Poland	55	3	5.45%	0	0.00%	52	94.55%
Ireland	47	7	14.89%	0	0.00%	40	85.11%

Source: JRC, 2021.

For example, Italy has 145 projects within "EU Projects on BDS 2030" dataset, relevant to the Biodiversity Strategy and 91% of these projects are conducted with international collaborations. In Figure 19, the number of projects in common with other countries can be retrieved as for example, Italy has 102 common projects with Germany, and 98 with United Kingdom, etc.

Figure 19. Insight into Italy's collaborations page. Number of projects in common with other countries in the dataset "EU Projects on BDS 2030".



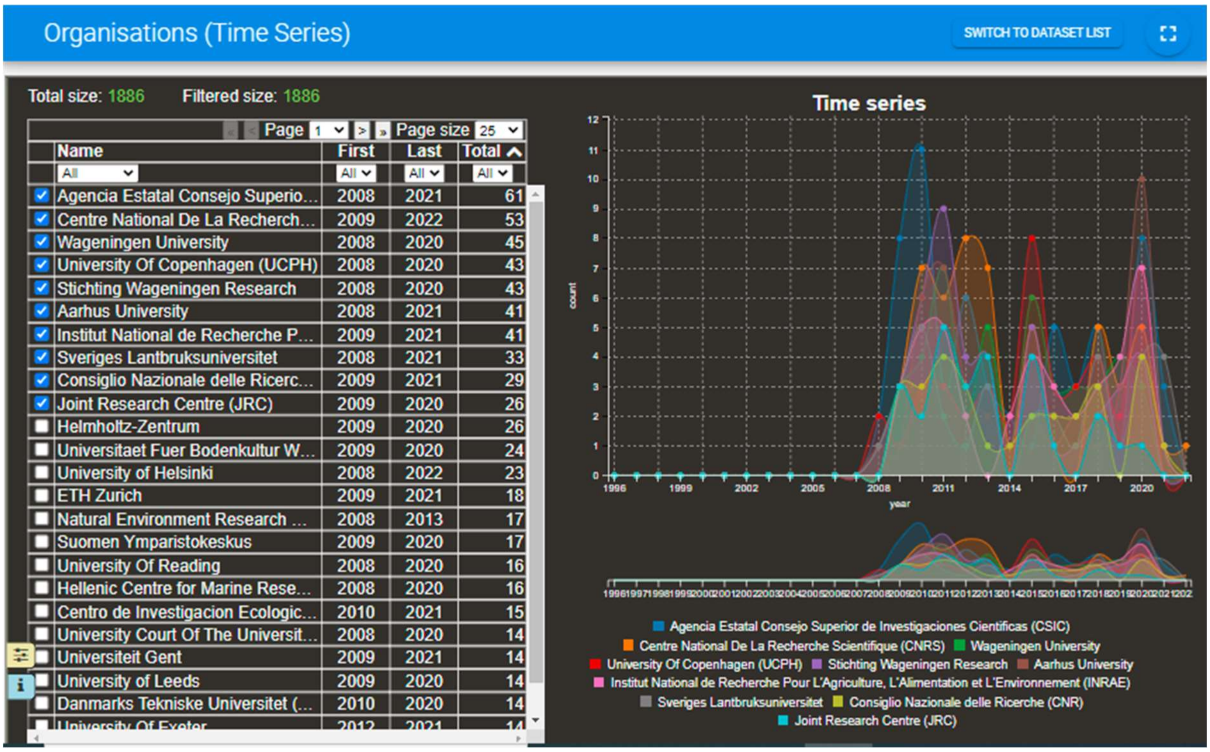
Country	Documents	Documents in collaboration					
		Single org.		Domestic		International	
	Total	Count	%	Count	%	Count	%
United Kingdom	251	71	28.29%	8	3.19%	172	68.53%
Spain	203	58	28.57%	0	0.00%	145	71.43%
Germany	194	22	11.34%	2	1.03%	170	87.63%
France	179	35	19.55%	1	0.56%	143	79.89%
Netherlands	150	12	8.00%	3	2.00%	135	90.00%
Italy	145	13	8.97%	0	0.00%	132	91.03%
Belgium	114	8	7.02%	1	0.88%	105	92.11%
Denmark	104	25	24.04%	0	0.00%	79	75.96%
Sweden	92	6	6.52%	1	1.09%	85	92.39%
Switzerland	86	13	15.12%	4	4.65%	69	80.23%
Portugal	84	7	8.33%	0	0.00%	77	91.67%
Austria	69	5	7.25%	0	0.00%	64	92.75%
Norway	69	5	7.25%	0	0.00%	64	92.75%
Greece	60	6	10.00%	0	0.00%	54	90.00%
Finland	55	1	1.82%	0	0.00%	54	98.18%
Poland	55	3	5.45%	0	0.00%	52	94.55%
Ireland	47	7	14.89%	0	0.00%	40	85.11%
Hungary	47	2	4.26%	0	0.00%	45	95.74%
Romania	45	1	2.22%	0	0.00%	44	97.78%
Czech Republic	44	2	4.55%	0	0.00%	42	95.45%
United							

Country	Documents
Germany	102
United Kingdom	98
France	89
Netherlands	86
Spain	86
Belgium	67
Denmark	49
Sweden	49
Portugal	46
Switzerland	45
Poland	41
Greece	40
Austria	38
Norway	35
Finland	30
Romania	30
Hungary	29
Ireland	29
Czech Republic	21
United States of America	19
Slovenia	17
China	16
Estonia	16
	15
Israel	15
Bulgaria	14
Slovakia	11
Turkey	11

Source: JRC, 2021.

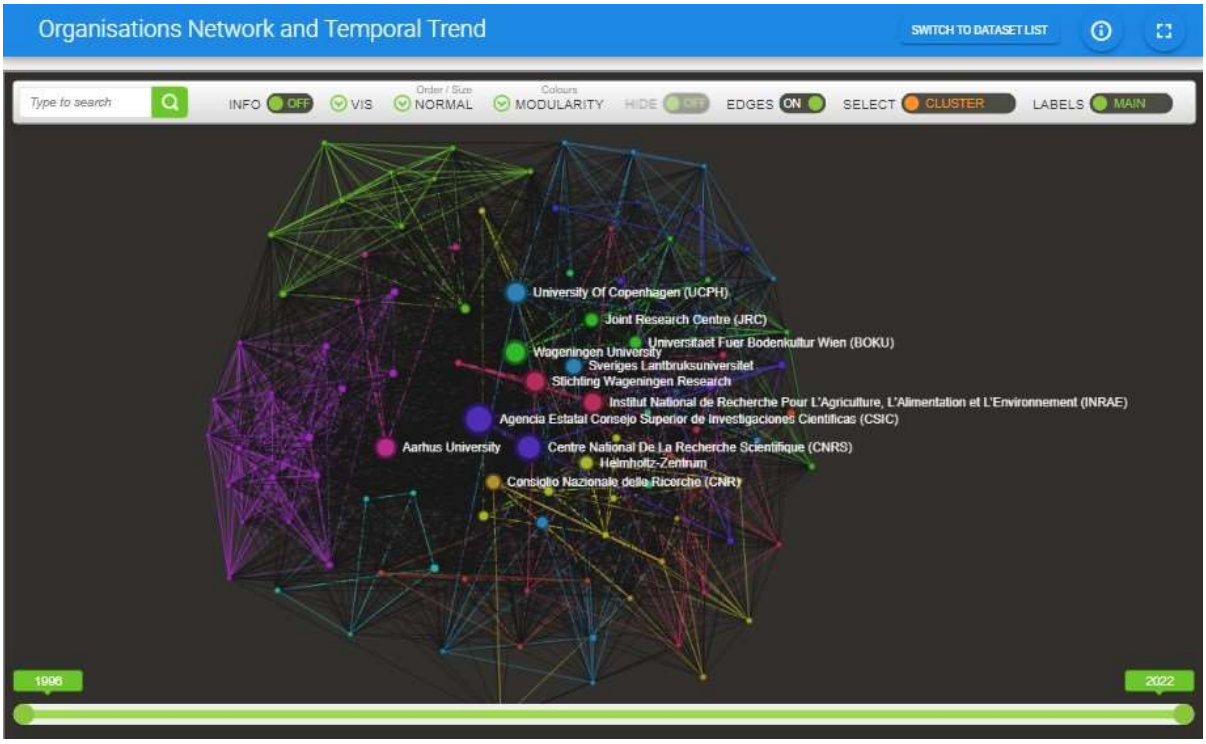
In addition, it is possible to get insights into the time trend (Figure 20) and the network of collaborations (Figure 21) at institutional level.

Figure 20. Time trend page at institutional level of the "EU Projects on BDS 2030" dataset.



Source: JRC, 2021.

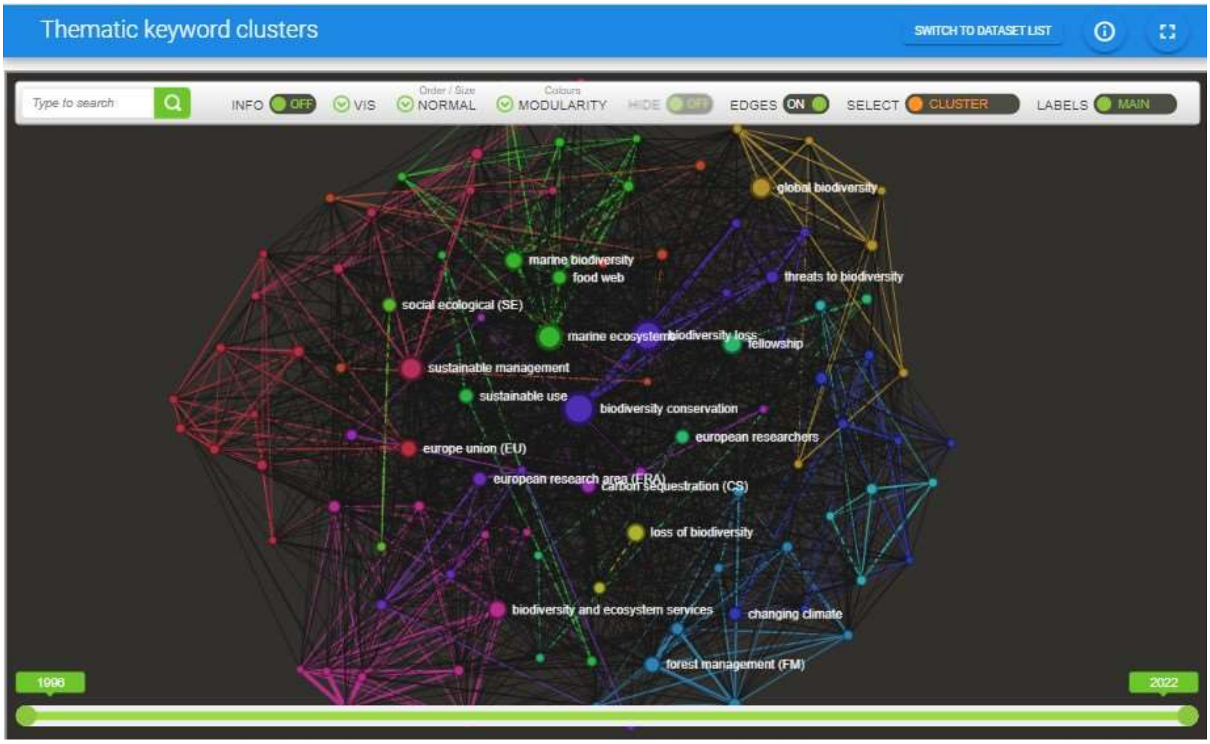
Figure 21. Collaborative network page at institutional level of the "EU Projects on BDS 2030" dataset.



Source: JRC, 2021.

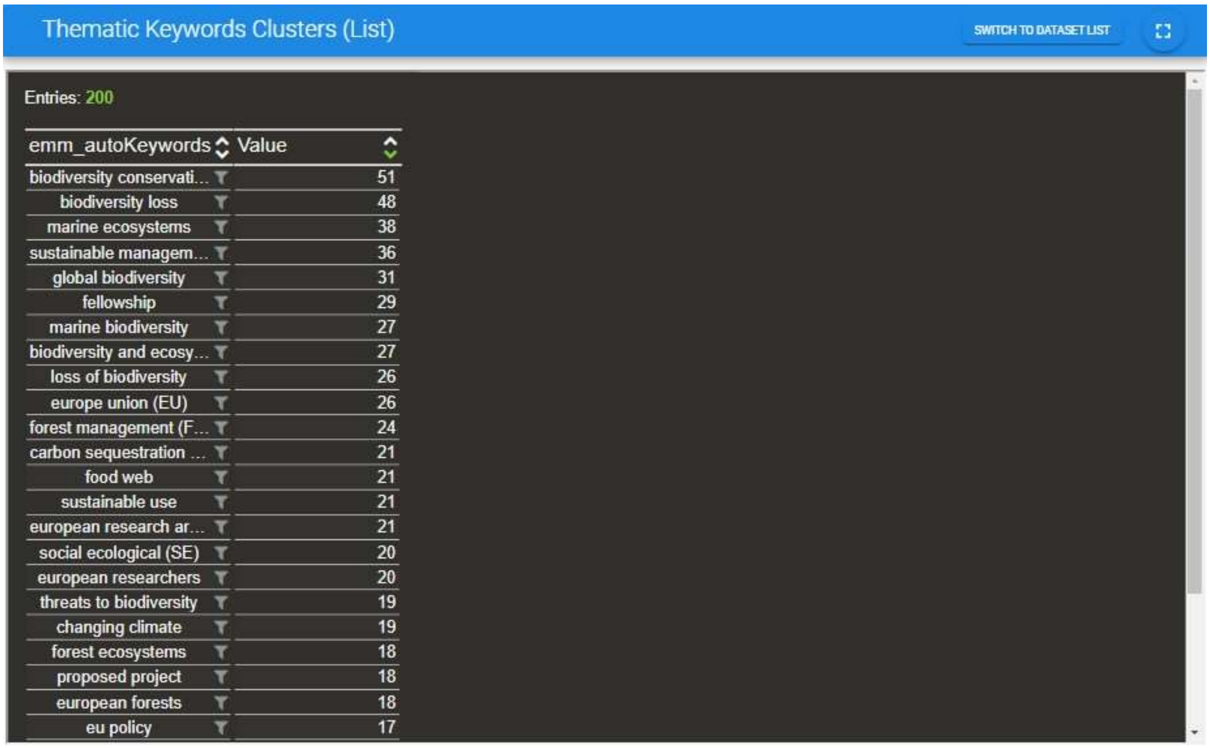
The last two pages show the results of thematic analysis through automatic keyword extraction. Links between keywords can be explored and thematic clusters with most frequently associated keywords are assigned a colour (Figure 22). Keywords and their frequency are also listed in a table (Figure 23).

Figure 22. Automatic keyword network page of the “EU Projects on BDS 2030” dataset.



Source: JRC, 2021.

Figure 23. Page with table of automatic keywords and their frequency from the dataset "EU Projects on BDS 2030".



Thematic Keywords Clusters (List)

SWITCH TO DATASET LIST

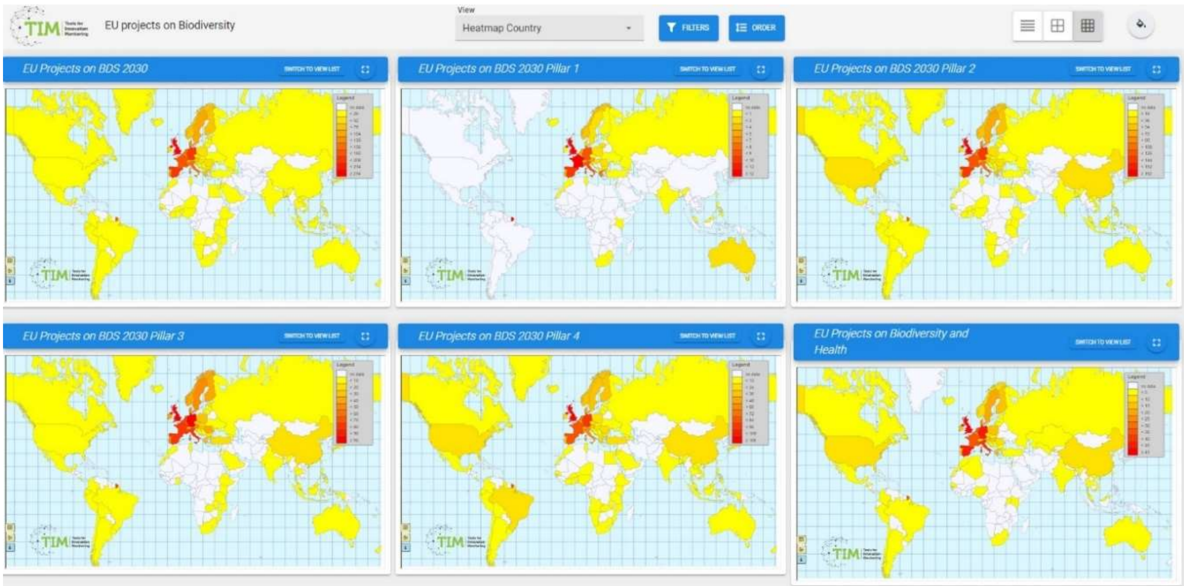
Entries: 200

emm_autoKeywords	Value
biodiversity conservati...	51
biodiversity loss	48
marine ecosystems	38
sustainable managem...	36
global biodiversity	31
fellowship	29
marine biodiversity	27
biodiversity and ecosy...	27
loss of biodiversity	26
europe union (EU)	26
forest management (F...	24
carbon sequestration ...	21
food web	21
sustainable use	21
european research ar...	21
social ecological (SE)	20
european researchers	20
threats to biodiversity	19
changing climate	19
forest ecosystems	18
proposed project	18
european forests	18
eu policy	17

Source: JRC, 2021.

Finally, as already mentioned, the user can compare the different datasets results (Figure 24) by switching from “view list” to “dataset list” (icon at top right corner of each result page).

Figure 24. View of heatmaps of all datasets compared.



Source: JRC, 2021.

It is also possible to sort or remove the pages by clicking on “Order” and apply different filters to customise the display (by clicking on “Filters”) per year, country or organisation. The filter is applied to the whole dataset and the results are updated according to the customisation. In the example below “EU projects on BDS 2030” dataset have been filtered for the organisation “JRC”, and the “Project List” in which the JRC participates is shown in Figure 25.

Figure 25. JRC Project list page**:** subset of dataset “EU projects on BDS 2030” obtained by filtering at institutional level with JRC.

Documents (Project List)

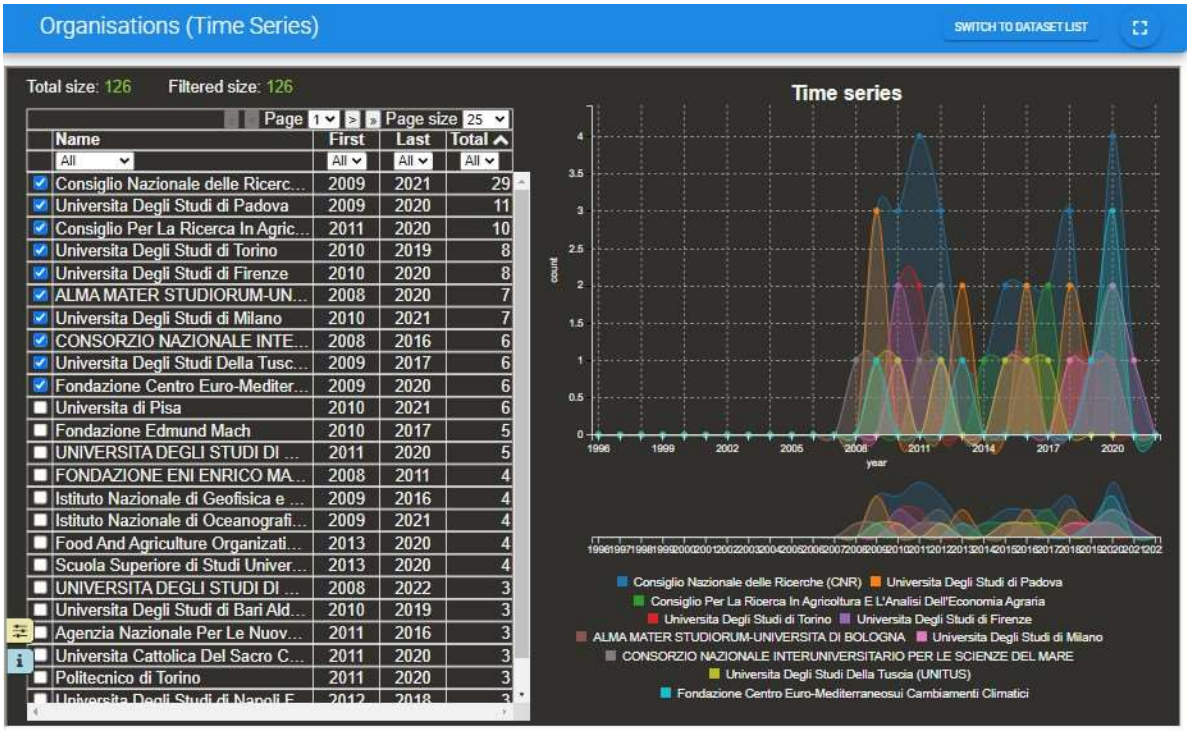
SWITCH TO DATASET LIST

Entries: 26

title	Va	Project acronym	link	Start Year	End Year	Total cost	EU contrib...
Adaptive Strategies to...	1.0	REFRESH	https://cordis.europa.eu/...	2010	2014	9895943.67	6997746.7
Alternative models an...	1.0	ALTERFOR	https://cordis.europa.eu/...	2016	2020	3997367,42	3997367,42
BESAFEBiodiversity a...	1.0	BESAFE	https://cordis.europa.eu/...	2011	2015	3775337.4	3009972.65
Biodiversity of Freshw...	1.0	BIOFRESH	https://cordis.europa.eu/...	2009	2014	8122680.75	6465406.1
CAtastrophic Shifts in ...	1.0	CASCADE	https://cordis.europa.eu/...	2012	2017	7715999.8	5889999.15
Designing Trees for th...	1.0	TREES4FUTURE	https://cordis.europa.eu/...	2011	2016	9042182.08	7000000
DEVelopment Of inno...	1.0	DEVOTES	https://cordis.europa.eu/...	2012	2016	12086862.36	8997984.62
Development of Integr...	1.0	LANDSUPPORT	https://cordis.europa.eu/...	2018	2021	6999771,25	6999771
Ecological Function a...	1.0	ECOFINDERS	https://cordis.europa.eu/...	2011	2014	9985223.51	6999930
Effects of Climate Ch...	1.0	ECLAIRE	https://cordis.europa.eu/...	2011	2015	10931972.24	6997001
Enhancing ecoSyste...	1.0	ESMERALDA	https://cordis.europa.eu/...	2015	2018	3133306	3002166
Europa Biodiversity O...	1.0	EuropaBON	https://cordis.europa.eu/...	2020	2023	2994318,75	2994318,75
Ground European Net...	1.0	GENESI-DEC	https://cordis.europa.eu/...	2010	2012	2737170	2149711
Interactive Soil Qualit...	1.0	iSQAPER	https://cordis.europa.eu/...	2015	2020	6876625	5375375
LAND Management: ...	1.0	LANDMARK	https://cordis.europa.eu/...	2015	2019	5307551,25	4999663
Land use change: ass...	1.0	LUC4C	https://cordis.europa.eu/...	2013	2017	8005363.33	5999079
Low-Input Farming an...	1.0	LIFT	https://cordis.europa.eu/...	2018	2022	5000000	5000000
Modelling INdividual ...	1.0	MIND STEP	https://cordis.europa.eu/...	2019	2023	4000000	4000000
OPERATIONALISATI...	1.0	OPENNESS	https://cordis.europa.eu/...	2012	2017	11488446.4	8999193
Preventing and Reme...	1.0	RECARE	https://cordis.europa.eu/...	2013	2018	10917791.27	8549525
Public Ecosystem Go...	1.0	PEGASUS	https://cordis.europa.eu/...	2015	2018	3007800	2977525
Quantification of ecolo...	1.0	QUESSA	https://cordis.europa.eu/...	2013	2017	3824023	2998006

The dataset can also be filtered by country. Using the filter for Italy on the "EU projects on BDS 2030" dataset, the list of Italian organisations and their temporal pattern of participation is displayed (Figure 26).

Figure 26. Time trend page of Italian organisations**:** subset of dataset "EU projects on BDS 2030" obtained by filtering at country level.



Source: JRC, 2021.

KJ-NA-31106-EN-N

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of the European Union

doi:10.2760/37559

ISBN 978-92-76-53299-6