External Scientific Report

The EU Pollinator Hub: Operationalisation of the EU Bee Partnership Platform for Harmonised Data Collection and Sharing Among Stakeholders on Bees and Pollinators

Simon Delso Noa[1], Otalora Santiago[1], Sušanj Gregor[2], Rubinigg Michael[3], San Martin Gilles[4]

[1] BeeLife European Beekeeping Coordination
[2] Združba IP, d.o.o.
[3] dr. Mag. rer. nat. Michael Rubinigg
[4] Centre Wallon de Recherches Agronomiques

Abstract

The EU Pollinator Hub is an open-source infrastructure that aims to standardise, collect, process, and visualise bee and pollinator-related data from any relevant source hold by stakeholders. The Hub features an online collective approach to sharing harmonised data pertinent to bee and pollinator health monitoring. It provides an online platform with three basic functionalities, allowing the creation and growth of an online community focused on bee and pollinator health data. First, the Hub allows such a community to standardise terminology or promote existing standards, connecting them with uploaded datasets, thanks to its "Vocabulary". Second, it helps users comply with Open Data principles, ensuring data uploaded in the Hub is FAIR (Findable, Accessible, Interoperable, and Reusable). Finally, the Hub serves as a repository for data peer-reviewing, a pivotal process to verify the data quality, validity, and reusability of datasets made available by researchers, field practitioners, and institutional and industry stakeholders. The framework established by the EU Pollinator Hub allows datasets of varying nature, such as weather, landscape, and epidemiological data, to be analysed and processed together, providing a systems-based approach to improve data interoperability.

Summary

The EU Pollinator Hub aims at providing an online platform where pollinator-related data is collected, standardised, processed, visualised and shared. It also seeks to improve data quality, foster collaboration among various stakeholders, and support informed decision-making through a comprehensive, open-source data infrastructure. The development of the Hub is a step towards a more coordinated and effective strategy for pollinator conservation across the EU, leveraging technology and community engagement to improve knowledge and targeted action for the protection of pollinators. After developing a proof of concept for standardised data sharing and collection among stakeholders (the EU Bee Partnership), the platform was operationalised, creating an online stakeholders' community sharing and using pollinator-related data. This operational platform, called the EU Pollinator Hub, provides the necessary online space and functionalities (Vocabulary, dataset discovery, and data verification and upload) for users to share and use high quality and FAIR (Findable, Accessible, Interoperable, and Reusable) data (see also Section 1 for more background information on the scope, origin and specificities of the platform).

The present report describes the general principles and developments of the infrastructure's architecture of the Hub. Two public websites have been created: the first one is a presentation page, which explains the vision and mission of the EU Pollinator Hub, history, services, news and link to data exploitation and interaction, as well as an invitation to discover the application (Section 2). The second page is the EU Pollinator Hub Application (Section 3), the web application that includes the data, the features assisting in data standardisation, uploading and curating, and dataset discovery and download, if possible. The vision (Section 3.1), scope (Section 3.2) and values (Section 3.3) behind the platform have been described to ease the reader's understanding of the nature of the EU Pollinator Hub and the logic of its construction and operation. This section explains how the FAIR principles are integrated into the uploading data process, inherently making all the datasets included in the Hub aligned to these principles.

The data handling on the Hub is described in thorough detail, presenting its building pillar and many features ensuring data security and access, as well as auditing and incident management (Section 4.1). The report describes data-sharing privacy options and terms and conditions of use, ensured by determining different user roles and applying standards in intellectual work licensing and distribution. Then, the data life cycle within the Hub is described (Section 4.2), explaining the developed features for data standardisation (Vocabulary), processing for storage, peer-reviewing and data exploration and visualisation, among others. While most of these features and functionalities are available only for registered users, the Data Discovery and Vocabulary may also be accessible to non-registered users, reducing considerably the level of interaction with the platform, which is described in the report. Finally, the data management section explains the functioning of the Quality Management System and the management module orchestrating the EU Pollinator Hub architecture and flow.

Communication and engagement activities, including promotional, tutorial and training material are presented in section 5. During the developmental process, from the Proof of Concept to the operationalisation of the infrastructure, much knowledge and user feedback were gathered and captured in the platform. Several stakeholders' engagement initiatives have been performed and

will need to continue in the future, to achieve the adoption of the hub by the community. Only by having the pollinator community using the Hub, contributing to its standardising efforts, integrating data, *etc.*, it will achieve its full potential. Subsequently, the community will contribute to developing tools, approaches based on artificial intelligence and modelling, enriching the Hub and the pollinator-related decision-making.

Finally, the report concludes on the activities performed for the whole implementation process of the platform (Section 6), reflects on the future actions that will enlarge the data, tools and community's use and recommends actions (Section 7).

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1. Introduction

In Europe, the Green Deal[1] and the few strategies and initiatives deriving from it, such as the Farm to Fork[2] or the Biodiversity[3] or Chemical Strategies[4], integrate a multidisciplinary approach to consider the interrelation of policies and regulatory frameworks better and to address the new environmental challenges better. This new way of understanding policy and decision-making involves a great amount of data and information being generated and published (incl. surveillance data), used for modelling, and creating new operational needs, such as standardisation, tools for remote and collective working, or integration and interpretation. Yet, there are no simple, freely accessible, knowledge-based solutions that can provide high-quality data and information to support actions aimed at tackling this issue. In addition, data on pollination services provided by pollinating insects, pollinator health, and beekeeping productivity is increasingly valuable. Environmental, agricultural and food safety authorities, farmers, beekeepers and researchers require accessible information which can be provided by pollinators. Indeed, considering the essential role of pollinators in sustaining healthy ecosystems and their recognised value as excellent bioindicators for environmental protection, economic productivity, and human health, these data are of utmost importance.

The European Data Strategy is converging towards more shared Open Data. Today, European citizens count on public access to the Environmental Information Directive[5] (2004/35/EC), the Infrastructure for Spatial Information in Europe (INSPIRE Directive 2007/2/EC[6]), the Open Data Directive (Directive (EU) 2019/1024[7]), the Implementing Regulation on High-Value Datasets[8], Data Governance[10], Data[9] and Interoperable Europe[10] Acts. Still, this presents challenges when considering data related to animals as ubiquitous as insect pollinators, with the relevant data scattered at various administration levels and institutions, with different cultures regarding data sharing and with the lack of data standardisation. Furthermore, data availability does not go hand in hand with accessibility, interoperability or reusability. For this reason, it makes sense to centralise and standardise all the data and information relevant to pollinators. Furthermore, with the specific policy initiatives targeting pollinators (*e.g.,* the EU Pollinator Initiative, the EU Nature Restoration Law and the national Pollinator action plans), and the work of many stakeholders that rely on pollinators, many datasets and observations will be made available, and necessary, in the future.

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1 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

2 https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en

3 https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

4 https://environment.ec.europa.eu/strategy/chemicals-strategy_en

5 http://data.europa.eu/eli/reg/2019/1381/oj/eng

6 http://data.europa.eu/eli/dir/2007/2/oj/eng

7http://data.europa.eu/eli/dir/2019/1024/oj/eng

8 http://data.europa.eu/eli/reg_impl/2023/138/oj/eng

9 http://data.europa.eu/eli/reg/2023/2854/oj/eng

10 http://data.europa.eu/eli/reg/2022/868/oj/eng

EU Pollinator Hub

There is a plethora of scattered repositories and datasets on pollinator-related data, but there is still the need to identify, collect and analyse them. Efforts must be deployed to improve the analytical capacities necessary to link the available pollinator-related data with other relevant environmental data. Additionally, finding data providers among relevant stakeholders who meet the quality requirements is also challenging. A comprehensive, output-driven and up-to-date overview of ecologically[11] and economically[12] relevant information on insect pollinators and pollination services is still too scant. Such comprehensive platforms would strengthen evidence-based policies, allow more holistic risk assessments (*e.g.,* with exposure to combined stressors), and guide and help with the framing of research questions on pollinators.

The EU Pollinator Hub[13] offers an opportunity for data centralisation, standardisation, processing, visualisation and reporting on *e.g.* pollinators (ecology, abundance), pollination services, beekeeping production, and landscape and environmental conditions.

During the EU Pollinator Week of 2017 hosted by the European Parliament, the institution and stakeholders called for a framework for action to review and strengthen the collection and sharing of data on bee health in the EU (EFSA et al., 2017; More et al., 2021). It was concluded that Europe needs to share information and data from different stakeholders to understand the field situation of pollinators and, consequently, implement efficient policies for their preservation. This led to the establishment of the EU Bee Partnership, a discussion group composed of stakeholders with EFSA that facilitates discussions on data sharing, standardisation, and centralisation. In its founding Terms of Reference (EFSA, 2018), the partners engaged themselves to start contributing to making data sharing a reality. These were starting steps towards implementing the concept of a systems-based approach recently described by EFSA as the future for Environmental Risk Assessment (ERA) of chemicals to protect insect pollinators better (EFSA et al. 2022; Williams et al. 2023). Such an approach goes in the direction of the development of a more holistic ERA framework for insect pollinators, integrating RA tools, methodologies and data (including, for example, pesticide-related data, surveillance data, combined exposure to multiple chemicals, contextual data (landscape and weather, farming practices, insect pollinators health in agro-ecosystems, *etc.*), modelling, different stakeholder needs and nature, *etc.*). The elements for systems-based data have been recently defined by Williams et al., 2023, and involve the development of a data-intensive framework for which the EU Pollinator Hub represents an essential milestone.

BeeLife, as a member of the EU Bee Partnership, created the first developmental step of an interoperable data centralisation, sharing and visualisation platform in 2019 called the Bee Hub Proof of Concept[14], with funding from the Internet of Bees project (IoBee Fast-Track to

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11 http://www.atlashymenoptera.net/default.aspx, https://www.gbif.org/, https://www.inaturalist.org/taxa, https://pollinatoracademy.eu/, https://sdi.eea.europa.eu/catalogue/biodiversity/eng/catalog.search#/search?query_string=%7B%22th_eea-topics.default%22:%20%7B%22Biodiversity%22:%20true%7D%7D&from=1&to=30

12 https://www.fao.org/faostat/en/#home

13 https://pollinatorhub.eu and https://app.pollinatorhub.eu

14 https://io-bee.eu/

Innovation project, 2019). This was the kick-start of developing a technological solution for data acquisition, processing, integration, and visualisation for bees.

The Proof of Concept led to a prototype-building phase: the EU Bee Partnership Prototype Platform (Simon Delso et al., 2021). The prototype was finalised during the first semester of 2020 with EFSA funds. The prototype expanded its data sources and developed additional features from a diverse group of stakeholders (including members from the EU Bee Partnership who helped enrich the collaborative nature of this platform by providing feedback and sharing stakeholders' datasets).

The network of field practitioners, researchers, industry, civil society and policy-related representatives widened during these developmental steps. Many efforts have been put to increasingly convince and build trust within the network to enrol them in the collective approach that frames the platform's development. EFSA has facilitated multiple discussions and supported the collaboration and engagement of stakeholders, mainly institutional, at the EU and national levels. Additionally, a great deal of experience has been gained in dealing with different institutions, data hunting strategies, data quality checks, processing and visualisation of information to render it as accessible as possible.

However, throughout the platform's development process, it became increasingly clear that fragmentation, lack of data quality verification (even from published data), and limited accessibility to information hamper efficient decision-making related to environmental protection and productive measures at different levels (regulatory, managerial, institutional, practitioner, *etc*.). Some consortium partners took additional initiatives to benefit from the platform's future development, creating data standards and collaboratively exploiting centralised data. These activities include knowledge exchange and community engagement, as exemplified in external collaborations with the European Parliament for the organisation of the EU Pollinator Week (previously known as EU Bee Week). This major EU pollinators event featured a workshop on standardising non-invasive pollinator monitoring systems (EU Pollinator Week 2021[15]). Since the start of the work in 2019, workshops on data standardisation have been organised in collaboration with the Apimondia BeeXML Group (*e.g.,* Hojsik et al., 2021).

An essential goal for the EU Pollinator Hub, or any other pollinator-related platform, is its acceptance by all potential users. It has been a guiding light across the various levels of development that the data quality provided by the field operators, beekeepers or farmers, their associations and other non-academic stakeholders must be checked and confirmed. In doing so, users will trust the data shared on the platform. The latest development stages have emphasised creating and improving data checkups and validation procedures while ensuring an open dialogue with stakeholders.

Three factors are commonly recognised as key to the acceptance of new technology: (1) perceived ease of use, (2) perceived usefulness and (3) enjoyment (Cazier et al., 2018). To meet the first requirement on the "ease of use", it is crucial to develop a user-centred design for the

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15 https://pollinatorweek.eu

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platform (Goodwin 2011). Regarding ease of use, any platform should be conceived so that no data experts can become users and share their data. This should be done by providing as many intuitive steps for data upload, processing, and visualisation, together with descriptive tutorials and training material. Yet, a certain degree of data management knowledge is required to use it. Key components of platform development were prioritised (*e.g.*, multilingual information, providing data considered useful by different stakeholders) to meet the "usefulness" require-ment. Responding to the users' needs by developing specific tools and functionalities which in-dividuals or organisations perceive as useful is imperative. As for the enjoyment criteria, the platform should provide an intuitive framework with interactive features to foster discoverability, the possibility to play with data, gamification of the options, *etc*. Addressing those requirements, users have also been defined as pivotal for the future of the platform's sustainability. Users are also active agents since they are data providers and collaborators in cleaning, using, and inter-preting data. Members of the EU Bee Partnership are a current example of such a dual role. It might be worthwhile to develop the inclusion of features (*e.g.*, high-quality interactive graphics and maps) further to meet the "enjoyment" requirement without damaging the seriousness and scientific rigour of the platform. These features improve usability and help widen the platform's audience to non-scientific users. Finally, the participation of the pollinator research community, beekeeping information and research centres, such as specialised laboratories in the project, will provide the necessary hands-on experience to understand pollinator-related data thoroughly. Enhanced comprehension will thus provide improved knowledge of pollinator status, conditions and challenges of the beekeeping and farming industry as well as the impact and effectiveness of public policies.

The focus of the EU Pollinator Hub relies on a non-profit scheme. More sustainable and innovative agricultural practices and improved collaborations between farmers and beekeepers are part of the vision for the future of everyone involved in the development of the Hub. Achieving its core objective of protecting bees and pollinators relies on cooperation among institutional agents, researchers and stakeholders. The goal is to achieve a multiparty collaboration between bee-keepers, researchers, farmers, environmentalists, industry, citizens and European institutions. Ultimately, the EU Pollinator Hub will be able to integrate as many data sources linked to insect pollinators as possible and use the data for modelling and data processing to ease decision-making while stimulating continuous collaborations and communications among stakeholders.

1.1. Background and terms of reference as provided by EFSA

In 2018, the European parliament mandated EFSA to develop a scientific opinion on the science behind the development of an integrated holistic approach for the risk assessment of multiple stressors in managed honey bees (*Apis mellifera*). Under this mandate (M-2018-0155), EFSA published the requested scientific opinion (EFSA SC et al., 2021) and was also specifically re-quested to support the work being developed by stakeholders to achieve harmonised data col-lection and sharing on bee health in EU and by doing so, support the EU Bee Partnership initiative by providing guidance for harmonised data collection and evidence-based risk assessments. This is under this request, supported by EFSA and the EU Bee Partnership, that the EU Pollinator hub, was developed.

EU Pollinator Hub

This contract was awarded by EFSA to: BeeLife

Contractor: BeeLife European Beekeeping Coordination and partners (Centre Wallon de Recherches Agronomiques, ZDRUŽBA IP, D.O.O. and dr Mag. Rer. Nat. Michael Rubinigg).

Contract title: "Towards an implementation of the EU Bee Partnership platform for harmonised data collection and sharing among stakeholders on bees and pollinators" with "Integration of research data into the EU pollinator hub"

Contract numbers: OC/EFSA/SCER/2021/09 with NP/EFSAPLANTS/2024/01

2. EU Pollinator Hub – Presentation Page

2.1. Logic

A public website has been designed and made available to showcase the development of the EU Pollinator Hub better. The presentation website serves as the window to the public, featuring essential information on the Hub, its history, and its future. The presentation website counts with its independent URL (http://pollinatorhub.eu/) separate from the platform app (https://app.pollinatorhub.eu/). Whereas the platform app is the integral product where users and data providers operate, the presentation website is the first contact point and source of information for users, potential collaborators and partners. It provides direct access to the app's functionalities and visualisations.

Above all, the presentation website serves as a place where the storytelling for the EU Pollinator Hub can be centralised and disseminated. Instead of focusing on the operability of the platform, the website highlights the nature and vision of the Hub. It allows us to tell the story of a growing movement of collaborative and open-source nature, which is continuously growing thanks to a diverse set of stakeholders, data providers, and users. However, the tool requires the space to communicate this narrative to its primary audience (users, data providers, potential partner institutions) and the secondary audience (general public). The website serves as the main channel to convey a narrative for the EU Pollinator Hub as a collaborative and valuable tool to improve pollinator health through data. The website is the main repository of communication and dissemination material produced to promote the Hub. Finally, the presentation website also provides a path to reach the App, with call-to-action buttons for visitors wishing to use the EU Pollinator Hub.

2.2. Content

The presentation website seeks to fulfil two interconnected objectives: i) ensuring a coherent narrative about the EU Pollinator Hub; ii) making essential and functional information about the platform app available to the public. The website achieves these two goals by including the following key elements:

- Centralising information about the Hub to disseminate and establish the EU Pollinator Hub as a known and respected, with an integral visual identity;

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- A promotional home page showcasing the innovative development of the platform, the need for its development, its collaborative nature, and its objectives to empower data providers and users to work for the 'good of pollinators;
- A promotional video showcasing the EU Pollinator Hub;
- A blog page with a series of blog entries ranging from general information on the platform, latest developments, research reviews, updates and key results from training sessions and workshops, and new collaborations with data providers;
- A media page where new partners and potential disseminators can access and download promotional material, including promotional and tutorial videos, logos and articles;
- A services page specifying the platform's available services;
- A contact page to facilitate direct contact;
- Calls-to-action to prompts that redirect visitors towards the platform app for various purposes ("Become a data provider"; Start using the EU Pollinator Hub").

Figure 1 shows the welcome page of the Presentation Page.
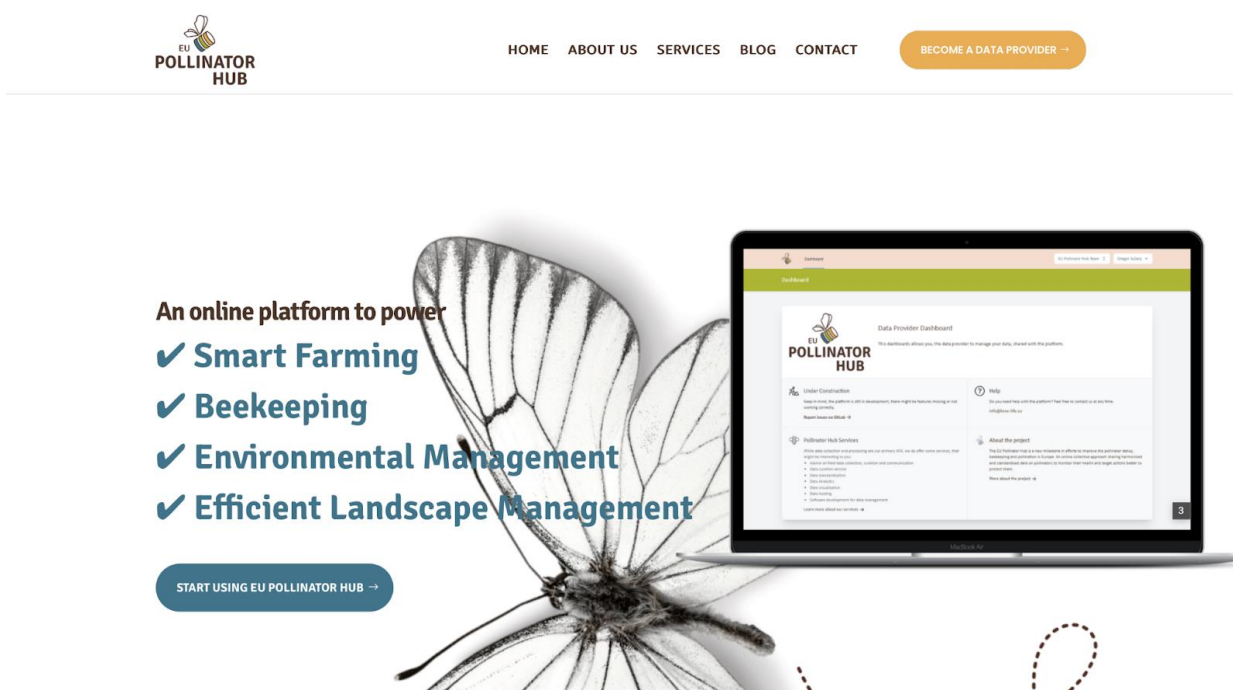
Figure 1: 　　　　　EU Pollinator Hub Website Home page

3. EU Pollinator Hub – Online Platform

3.1. Vision

3.1.1. One-Stop-Shop: EU Pollinator Hub answers different needs

The EU Pollinator Hub aims to establish a one-stop-shop approach for anyone interested in pollinators. It is a tool and service provision specialised in the standardised collection, processing and dissemination of pollinator-related data from validated sources and the analysis and reporting of pollinator-related information following the requirements of the platform customers. These

requirements mainly refer to, but go beyond, data quality, data security and intellectual property. The multiple exchanges with stakeholders and users of the platform revealed that these three requirements were the most worrying potential users.

Furthermore, the EU Pollinator Hub establishes a central knowledge base accessible to all relevant stakeholders. It engages with them - in a collaborative approach - in data collection and further development of the services/tools according to the users' needs. It has a strong customer-oriented strategy in developing and maintaining the platform. This is done on the one hand by offering the platform available in several EU languages (*i.e.*, for the moment, English, French, German and Spanish), which is crucial for its acceptance by many users who are not necessarily fluent in English. In addition, a database for technical terms, especially related to the beekeeping and pollination fields (like IATE[16]), has been created on this occasion. The EU Pollinator Hub includes a Data Definition and Translation feature (the Vocabulary), a collaborative tool that relies on the pollinator community to enrich the list of technical terms and their respective translations.

In the past years of development, several potential users expressed doubts regarding the added value of sharing their data or engaging with the EU Pollinator Hub. For this reason, some ad hoc case studies were performed in collaboration with users and organisations, such as beekeeping organisations or other members of the EU Bee Partnership, to test the practical feasibility of the platform outputs (*e.g.* graphs, tables and statistics for reports, periodic risk analyses for diseases, location of quarantine areas, hive scale network). In doing so, best-practice examples were created for other organisations, making the tool more practical and useful for others, and hopefully facilitating the EU Pollinator Hub's adoption by other users.

3.1.2. Creating a Web of Knowledge

The type and nature of the data potentially contributing to the EU Pollinator Hub are very varied. Indeed, the previous developmental steps allowed the acquisition, preparation, and integration into the platform of several types of datasets (Simon Delso et al., 2021). The EU Pollinator Hub, thanks to the integration of datasets containing a wide variety of data counts today, has an important variety of data models already available for the integration of further datasets.

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16 Interactive Terminology for Europe - https://iate.europa.eu/home
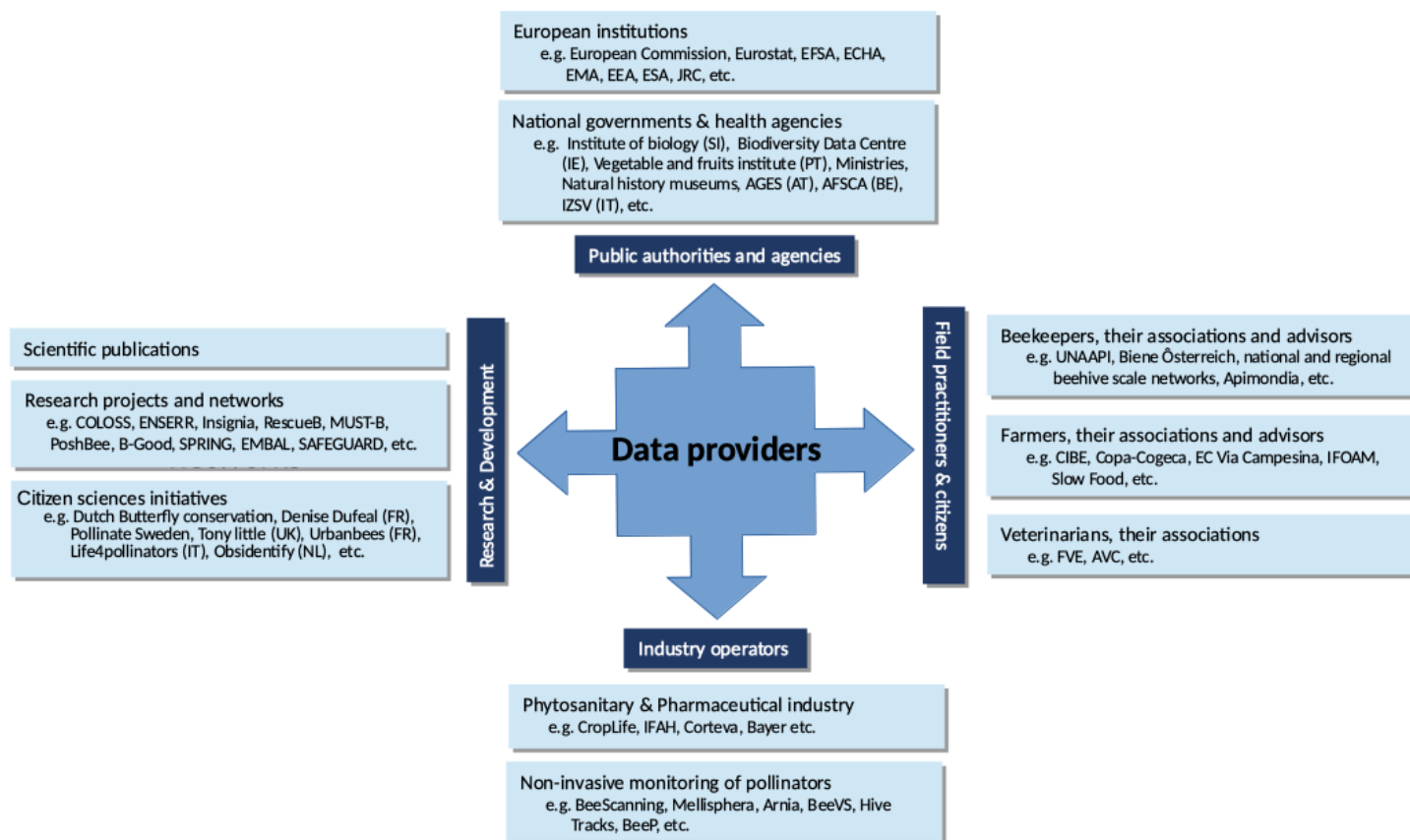
EU Pollinator Hub

Figure 2: Scheme of Data provider types identified and some examples of data types. The list of Data providers contacted or identified can be found in Appendix A

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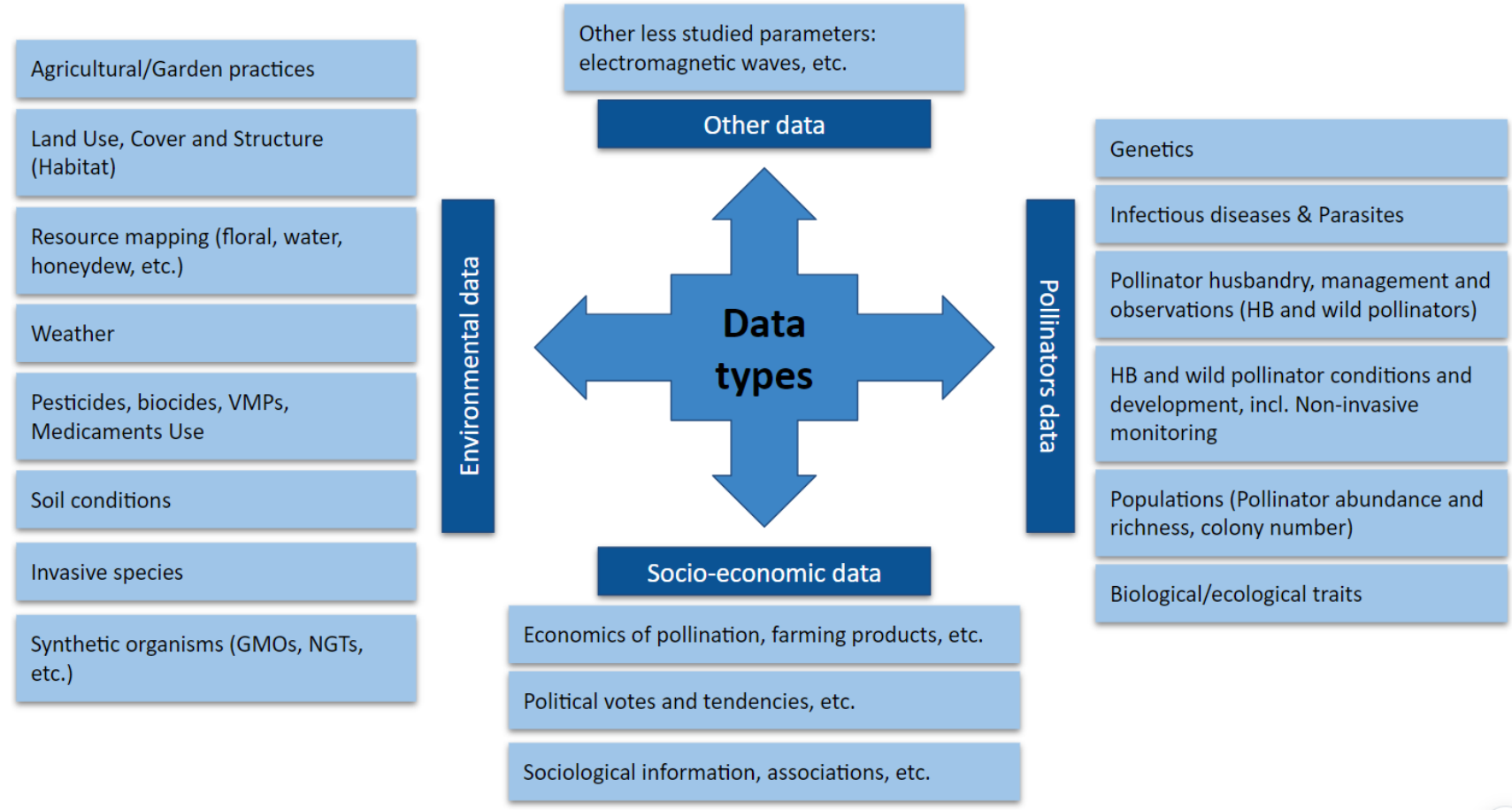
Figure 3: Scheme of identified data types with some examples. The list of Data providers contacted or identified can be found in Appendix A

Several datasets and data providers were identified to have a relevant role in insect pollinators and pollination, and their typology can be found in Figures 2 and 3. Some of these are, for example:

(1) International schemes and EU projects performed by public authorities and agencies (*e.g.,* SPRING, LUCAS or INSIGNIA Projects, data from the European Statistical Office (Eurostat), European Space Agency (ESA), EFSA (*e.g.,* MUST-B data from Portugal and Denmark, OpenFoodTox Data, Bee Guidance Document, Ipol-ERA project, *etc.*)) or databases and reports of statistical offices and public authorities of all EU Member States), or international relevant data platforms (*e.g.,* GBIF, Food and Agriculture Organisation Corporate Statistical Database (FAOSTAT), the United Nations Statistics Division (UNSD), National Centers for Environmental Information (NCEI)). The newly published Statistics on Agricultural Inputs and Outputs (SAIO) regulation[17] will make some additional datasets available at high NUTS levels from 2028. The Epilobee datasets were already part of the platform.

(2) the industry initiatives, *e.g.,* (agro)chemical industry's studies and initiatives, non-invasive monitoring of pollinators and smart farming products, *etc.*;

(3) Field practitioners' datasets, such as data from beekeeping or farmer associations.

(4) Open access scientific publications coming from research and academia. Former EU-funded research was screened via CORDIS to recover the publicly available results. It is important to note that EU research has increasingly embraced the principles of Open Science in recent years. Unfortunately, the large majority of the former publicly funded projects available on the CORDIS website do not contain any data or results. For those that publications or data are available, only a minority are in line with FAIR Open Science principles. More data must be openly published in a place that is accessible.

During the project, there was contact with some EU-funded projects like B-GOOD, PoshBee, Insignia, EMBAL, EU-PoMs, LUCAS, STING, COLOSS, and ABLE[18]. Only B-GOOD engaged with the EU Pollinator Hub and worked to publish their data following the FAIR principles. Epilobee datasets available at the EFSA's Knowledge Junction Community of Zenodo had already been integrated into the prototype phase (Laurent et al., 2016). The INSPIRE[19] platform was also searched for relevant data. However, to date, no data was available, but the data models and

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17 https://eur-lex.europa.eu/eli/reg/2022/2379/oj

18 https://b-good-project.eu/; https://poshbee.eu/; https://www.insignia-bee.eu/; EMBAL-https://wikis.ec.europa.eu/pages/viewpage.action?pageId=25560696; EUPoMs -https://wikis.ec.europa.eu/pages/viewpage.action?pageId=23462107; LUCAS -https://wikis.ec.europa.eu/display/EUPKH/LUCAS+grassland+survey; STING - https://knowledge4policy.ec.europa.eu/participatory-democracy/science-technology-pollinating-insects-sting_en; https://coloss.org/; https://butterfly-monitoring.net/able

19 https://knowledge-base.inspire.ec.europa.eu/index_en

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descriptions already proposed were considered, and some national datasets could be identified. Data models can be found in Annex A.

3.1.3. Ensuring the platform's usefulness

The real potential and added value of the EU Pollinator Hub will be deployed when more persons coming from the pollinator community will use it. For this reason, several engagement activities have been performed during its development with end users and data providers to gather needs and expectations and integrate them into the tool.

To date, the platform has already considered the feedback from field practitioners, such as beekeepers, farmers, veterinarians, and their associations, to understand their priorities, needs, and willingness to use such a platform. Additional market research activities were performed to understand customers' needs with respect to platform input (raw data) and output (processed data, analyses, reports). Several workshops and bilateral exchanges were held with institutions, researchers, technology suppliers, *etc.*, to understand their needs. As far as possible, the stakeholders' feedback was addressed when implementing the hub. However, future developments will be needed to improve the experience and versatility of the Hub's features. Indeed, the more the platform is used, the more opportunities there will be to develop useful tools, such as automatisation, visualisations, or reporting for the users.

The platform has been conceived to perform a continuous assessment of the implementation of its products (*i.e.* datasets, single web pages) by (1) monitoring (and reporting) online accesses to the website, using other analytical tools (*e.g.* Google Analytics or similar) and collecting this data in the database; (2) including any other requests by users (*e.g.* personal communications within the platform) and collecting this data in the database; (3) collecting feedback (incl. complaints) in a database.

In the future, further development of tools/procedures should be made to continuously analyse data and incorporate these analyses in the platform and for its promotion.

3.2. Scope

3.2.1. From bees to insect pollinators and environment risk assessment

The EU Pollinator Hub is envisaged to be a helpful tool and a unique information platform for the whole community that depends on the investigation, exploitation and protection of insect pollinators and pollination, such as beekeepers, farmers, researchers, (Phyto-)pharmaceutical industry or veterinarians, and risk assessors/managers. A Hub potential users' pains and gains analysis was performed to identify their motivations for using or accessing the EU Pollinator's Hub functionalities. The results can be found in Table 1.

Table 1: List of end-users of the platform and interest identification

User Type	Main Interest

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	R&D[a]	Commercial[b]	Educational[c]	Promotional[d]	Policymaking[e]
Public authorities and agencies					
EU and international institutions and agencies			x	x	x
National governments, institutions and health agencies			x	x	x
Field practitioners and citizens					
Beekeepers, their associations and advisors			x	x	
Farmers, their associations and advisors			x	x	
Veterinarians and their associations			x	x	
Industry operators					
Phytosanitary and pharmaceutical industry	x	x		x	
Non-invasive monitoring of pollinators and smart farming	x	x		x	
Honey packers industry		x		x	
Industry of beekeeping and farming machinery and equipment	x	x		x	
Research and Development					
Scientific publications	x			x	
Research projects and networks	x			x	
Citizens science initiatives	x			x	
Civil society					
NGOs			x	x	x

Citizens	x

(a): for Research & Development
(b): for trading, marketing and production
(c): for training, information
(d): to increase visibility
(e): to identify parameters to regulate and follow up policy implementation.

3.2.2. Internationalisation and Localisation

The EU has 24 official languages. The EU Pollinator Hub envisages serving as a tool to discover or share relevant pollinator-related data/information with the end-users in their native language. Doing so improves its usability. That is why the Hub is built upon a translation interface, which considers the multiple languages and the non-uniform naming of different languages. Databases of technical/scientific terms have been constructed within the Hub, and a translation feature allows the community to develop the translation of related terminology further. These are the foundations for further developmental stages enabling the creation and implementation of the technical terms database in the databases and information generated by the Hub.

3.3. Values

Even though Open Science is now the rule that governs data management in publicly funded projects, trust in the service used for the data to be made public has proved to be a key motivation for sharing or not data. The EU Pollinator Hub aims to create this trust, which is why it complies with Open Science principles and full transparency. The software is open and available in GitLab (see Section 4), and the data generated by the processing of merged data (aggregated or processed data) is also publicly available and well-documented to ensure its reusability.

The EU Pollinator Hub aims to create a community of data providers that contribute and have full access and management control over the datasets shared with the platform. The platform provides different sharing and credit options that each data provider can establish and modify. Several features have been made available to data providers to help them manage their data accessibility and licensing options. In doing so, data providers have full control over their data, deciding if they want third parties to have access and how they would like their data or work to be referenced. These features are key to building trust in the users and providing relevant authorship to the work shared within the Hub.

The EU Pollinator Hub carefully analysed the legal implications of data sharing and the different users and stakeholders that may intervene in the process, such as data providers, data peer reviewers or external data processors. For this reason, clear intellectual property and rights have been established in legal rules and Terms of Reference proposed to each user profile with access to data. As a result, instructions such as Privacy Policies, Terms of Use, and user case rules are created. They are provided to the registered users and are permanently available on the website for consultation (website footer).

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For the above-identified data providers, several types of datasets, differing in size and formats (*e.g.,* live sensor data, data from existing repositories, text, images, videos and soundtracks), are acquired using different technical approaches (*e.g.*, APIs, back-end applications for uploading). However, all in all, the objective is that independently of how the data is acquired or communicated, the data stored in the Hub must comply with the FAIR principles. This implies that in the process of uploading the data, it must be fully documented, described, standardised, and quality verification needs to ensure the technical integrity of the datasets. So, whenever the data provider decides to make its dataset public, it complies with the Open Science rules. Should the data provider decide not to make the datasets public, they will remain stored in a standardised way. For this reason, they can contribute to the Big Data approach and data processing of the Hub whenever the Hub publishes reports referring to aggregated data contained in the Hub.

The standardisation work performed as the foundation of the Hub was performed in parallel with the work of the BeeXML[20] working group of Apimondia, the Hub development team being also members of the working group. Therefore, the EU Pollinator Hub applied the methodology and protocols developed by the group and accomplished the final standard for data sharing and communication, the BeeXML standard. The BeeXML standard will also be made available as an exporting language of the data contained in the Hub in the coming months.

3.3.1. Data Quality

The EU Pollinator Hub has only limited possibilities to verify the data quality made available by the data providers. However, by focusing on data quality and usability during the design of software applications and operational workflows, the platform ensures that the quality standards used for the data collection are documented against the Open Science principles. Moreover, all collected data go through systematic checks (*i.e.*, data profiling and peer-reviewing), assuring the highest possible degree of data quality.

An assessment framework for data quality has been developed to facilitate data classification according to their quality. It consists of classifications on controls related to data quality assessment in section 4.2.2[21] (as described in Tier 1, point a), and a **Criteria Catalogue** for Peer reviewing. The Criteria Catalogue can be accessed from the Data Provider Dashboard or by clicking a link in the app website footer. Once the data enters the platform, every process follows standardised procedures that guarantee full traceability along its life cycle, and it is subject to a practical test of the content and its relationships by platform operators (*i.e.* data exploration). A regulatory framework of standard operating procedures (SOPs), work instructions (WI), software specifications, validation and qualification protocols and data standards for the acquisition, preparation, storage and analysis of data were developed (see later) to ensure full traceability as well as General Data Protection Regulation (GDPR) compliance of the entire process[22]. Stored

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20 https://community.hiveeyes.org/t/beexml-exchanging-data-about-bees-and-beekeeping/3528

21 SOP 016 (Release management)

22 https://eur-lex.europa.eu/eli/reg/2016/679/oj

data are available in formats as referred to in Article 39f and g of Regulation (EU) 2019/1381[23], to ensure interoperability with existing standard data formats adapted within the framework of the regulation.

Once available, the non-proprietary standards developed by the BeeXML group of Apimondia are applied for data integration and utilisation.

4. Data handling on the Hub

Intellectual property rights and data security are at the forefront of the EU Pollinator Hub. Property rights on datasets are guaranteed throughout the entire process of data acquisition, preparation, storage, utilisation and the whole dataset life cycle.

4.1. Data security and access

4.1.1. Software and hosting

The platform source code is open-source and available to be reviewed and improved upon. It is available within an external DevOps[24] software package GitLab[25]. The GitLab already includes the history of issues managed during the developmental phase of the Hub for traceability, as well as a list of tasks for future development.

The EU Pollinator Hub uses primarily a PHP programming language with support from JavaScript front-end packages and MySQL database. The platform is hosted by the Slovenian hosting provider Webicom d.o.o., which satisfies the minimal hosting requirements, except for ISO 27001 certification (ISO, 2022). Despite not including this certification, an equivalent level of security is ensured because the data centre infrastructure provider in which the hosting provider resides has, indeed, the certificate in addition to ISO 9001 - quality management systems, ISO 14001 - environmental management systems and ISO 50001 - energy management (Telemach d.d.)[26]. All data is encrypted with a private key, which involves that it is protected from physical access. Other security measures applied to the EU Pollinator Hub data are: (1) security is provided as physical and technical protection with 24/7 security, (2) servers are located within a fully climate-controlled environment, (3) active fire protection services, (4) physical entry is allowed only to authorised personnel. (5) Server is a dedicated virtual server with physical hardware backups, hot-pluggable hard drives within RAID 5 or 6 arrays, a dedicated UPN system with backup generators for continuous operation and has documented disposal of hardware.

Webicom d.o.o. manages the EU Pollinator Hub hosted on a dedicated server and regularly applies security patches to the software. In addition, the platform is regularly maintained and kept

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23 https://eur-lex.europa.eu/eli/reg/2019/1381/oj

24 https://www.atlassian.com/devops/what-is-devops

25 EU Pollinator Hub Issue Management on GitLab https://gitlab.com/bee-life/pollinator-hub

26 https://telemach.si/o-nas/politike-sistemov-vodenja

up-to-date to patch any known security vulnerabilities. Daily incremental and weekly full backups are performed.

4.1.2. User roles and permissions

Several platform user types have been identified and assigned roles and permissions, which can be managed in detail by platform administrators. There are 9 roles, which are further managed by individual policies within the platform (Figure 4).

Most platform functionalities, like browsing published datasets and downloading data, are accessible to everybody, including unregistered users. With registration, more interactivity becomes available, including but not limited to voting, rating, and interacting with data providers. A user may register but stay anonymous, as only an e-mail address is required.

For any further interactions, a full user profile is required, which an anonymous user can upgrade to at any time. As soon as the user is registered, more advanced features become available, like proposing translations within the Vocabulary, uploading datasets or even peer reviewing.

There are also multiple levels of administrators within the platform that limit the amount of access based on "need to know", "least privilege" and "deny all" principles (Table 2).
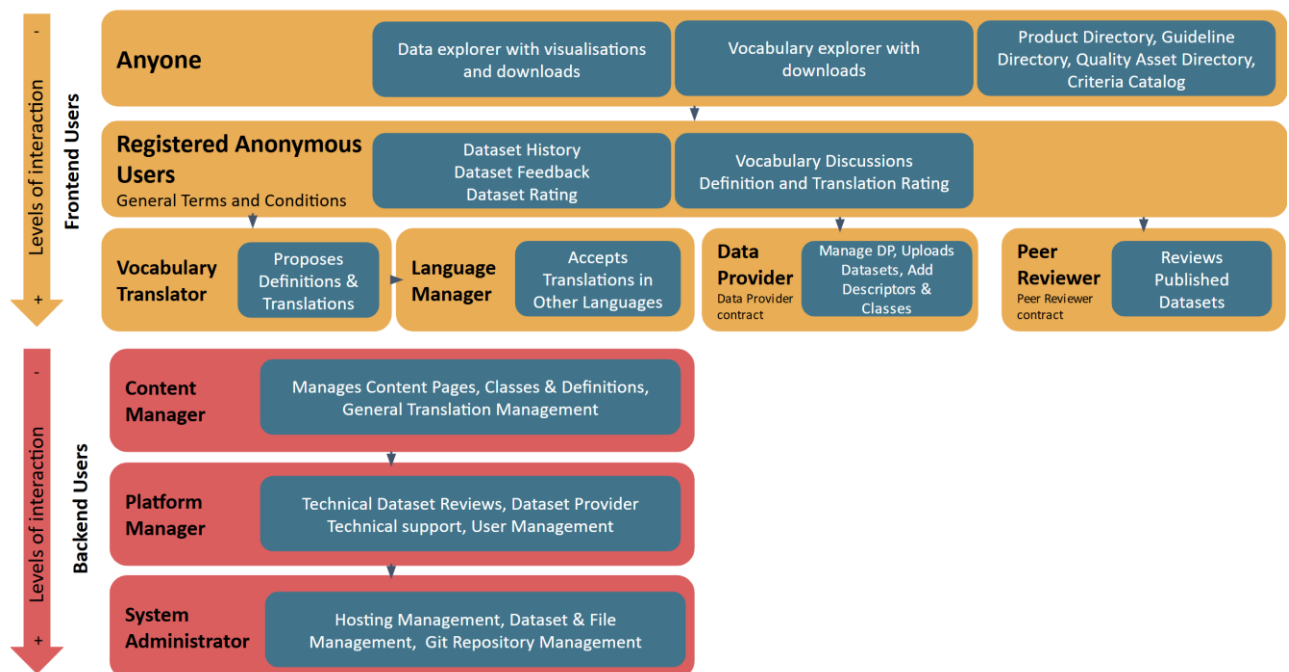
Figure 4: Graphical summary of the EU Pollinator Hub user roles interactivity. Orange: Levels of interaction of users of the front-end; Blue: available functionalities; Red: Level of interaction of back-end users. Registered anonymous users must agree with the Terms of Use[27]

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27 https://pollinatorhub.eu/terms-of-use/

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and Privacy Policy[28] of the EU Pollinator Hub. Data Providers (DP) and Peer Reviewers agree with the Data Providers[29] and Peer Reviewers conditions, respectively

Table 2:   Types of platform users, their respective access to functionalities and terms of references.

User Type		Functionalities		Vocabulary			Data	Peer Review	Content	Management	Hosting & Admin
		Public EUPH[a] website, Blogs, Datasets research and download, visualisations and reports	Profile customisation, Feedback tools, rating options	Commenting and rating	Translation of terms	Manage translations	Upload, management, visualisation, reporting, Metadata discovery, processing, profiling analytics and statistics	Peer review tools (no contact with Data provider)	Static content management, news (blog) management and translation of these contents		vhkuf uyfuf
Anonymous user		✓									
Registered user[1]	Basic	✓		✓							
	Data provider[2]	✓	✓	✓			✓				
	Peer reviewer[3]	✓		✓				✓			
	Translator[4]	✓		✓	✓						

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28 https://pollinatorhub.eu/privacy-policy/

29 https://pollinatorhub.eu/data-provider-agreement/

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Mana gers	Lang uage[4]	✓		✓	✓	✓				
	Conte nt[4]	✓						✓		
	Platfo rm[5]	✓		✓	✓	✓	✓	✓	✓	
System administrator		✓	✓	✓	✓	✓	✓	✓	✓	✓

(a): EU Pollinator Hub (EUPH)

Note : To become a registered user, the process requires filling out a basic form with email and password fields. After doing so, there is an email verification step to reduce the amount of potential spam accounts. 2: A Registered user can opt-in to upgrade the process anytime. To do that, some additional information is required from the user to establish authorship and licensing and agree with the Data Provider's established conditions. 3: A Registered user can opt-in at any time. Additional information is required from the user to facilitate exchange, and the EU Pollinator Hub manager manually verifies the user[30], and the user agrees with the Peer Reviewer agreement (incl. precautions to avoid data breaches or security issues. 4: Registered user invited by the manager. 5: Can only be assigned manually by other Platform managers. From the back-end administration panel, he/she manages features like Dataset approval pipeline, Peer Reviewer approval pipeline, Visualisation creation, Catalogue management, Organisation management, User management and Quality asset management (SOPs and WIs).

4.1.3. Privacy and incident management

The platform works on a minimum of user data collection, so data is only requested from users when it is absolutely necessary. In accordance with GDPR, any user can request the deletion of their data from their profile at any time.

There are multiple mechanisms available to inform users in case of incidents. The primary way is through email addresses and messages from within the platform. Secondary channels are social media and presentation websites.

4.1.4. Audit and accountability

Following good practices in action traceability, all changes within the platform are tracked for auditing reasons. All login attempts (failed and successful) are logged with the corresponding date and time, IP address, login credentials (without password) and the number of attempts. These logs are accessible within the platform file system, so they are only accessible to System Administrators. Any changes to User authentication data, profiles, metadata, static content, user roles, and permissions are logged and accessible within the management console to Platform Managers. Access logs can be exported on demand. Integrating with an external Security

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30 as referred in SOP 015 - Peer Reviewing

Information and Event Management (SIEM) is possible. Further explanation is provided later in this regard when the Life Cycle Management is described as both functionalities overlapping.

4.1.5. Privacy Policy and Terms of Use

Several legal texts are permanently available on the presentation website (footer of the website), where users can read about the Terms of Use[29] and Privacy Policy[30]. In addition, users must accept the relevant legal texts during the registration process. As users upgrade their accounts, they must accept additional contracts and terms and conditions linked to the users, *e.g.,* Data Provider Agreement[31] or Peer Reviewer Agreement. External legal advisors have proposed all these legal documents under EU privacy laws and GDPR. (Intellectual) property rights on datasets are guaranteed throughout the entire process of data acquisition, preparation, storage, and utilisation and the whole dataset life cycle.

4.2. Data management

The EU Pollinator Hub has been designed to host information assets consisting of data, metadata assets, and dataset reports. Data and metadata assets refer to all entities that are comprised of data and metadata, respectively. **Data assets** are datasets (defined as a collection of data) and their constituents (tables, data elements), output files of application programming interfaces or raw data files. **Metadata assets** are properties of datasets and their constituents (tables, data elements), supplements to datasets and tables, descriptors of data elements and their properties documenting the data.
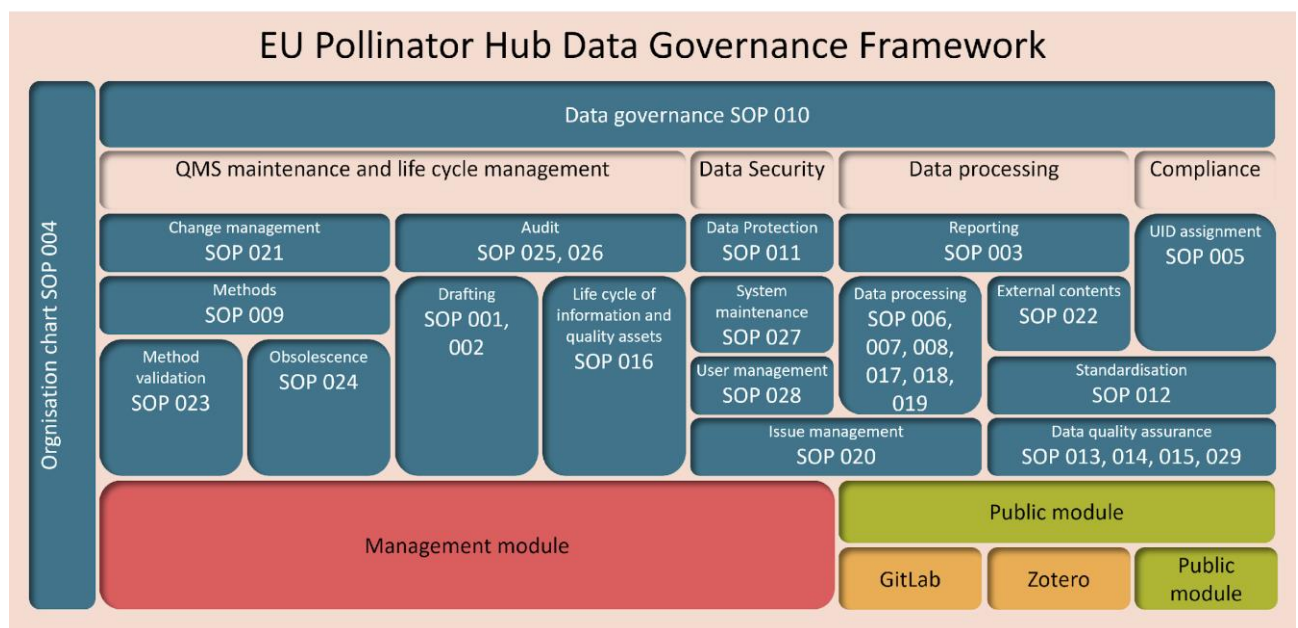
Figure 5:   Graphical summary of the EU Pollinator Hub Data Governance Framework. Blue: Standard Operating Procedures (SOP) of the Quality Management System (QMS); red: EU Pollinator Hub platform management module with restricted access; green: EU Pollinator Hub

application with (partly) open access; orange: external software application used for issue management and citation. The list of SOPs and WIs can be found in Appendix B

If we consider the EU Pollinator Hub as a Data Government Framework (DGF), defined as "a system of decision rights and accountabilities for information-related processes, executed according to agreed-upon models which describe who can take what actions with what information, and when, under what circumstances, using what methods" (DGI, 2024), then it comprises two basic components (Figure 5): The Quality Management System (QMS), consisting of a formal framework of Standard Operating Procedures (SOPs) and Work Instructions (WIs) and the EU Pollinator Hub Application31, which implements the necessary controls, rules and accountabilities at software level. The EU Pollinator Hub Application (Figure 6) consists of the openly accessible Public Module and a module with restricted access, the Management Module (Section 4.2.7). The Public Module comprises features accessible to users, including a Vocabulary Module, a Dataset Module, and a Data Provider Module. The Vocabulary Module manages the openly accessible part of data standardisation. The Dataset Module contains the searchable Data Catalogue and the dataset-specific Dataset Views and Table Views, which give access to all information assets published by a Data Provider. The Data Provider Module summarises all activities of a Data Provider and manages the entire dataset life cycle, from uploading into the staging area of the EU Pollinator Hub to its publication. The Management Module is only accessible to users with the necessary access rights.

Compliance with FAIR Guiding Principles for Scientific Data Management and Stewardship (GFISCO, 2024) is integral to the Horizon Europe funding program. The Data Governance Frame-work (DGF) of the EU Pollinator Hub (Figure 5), therefore, implemented the FAIR principles as its general data-sharing policy both at the process and software level, which is an important prerequisite for being used as a data-sharing platform for research projects funded under the Horizon Europe scheme.

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31 https://app.pollinatorhub.eu/
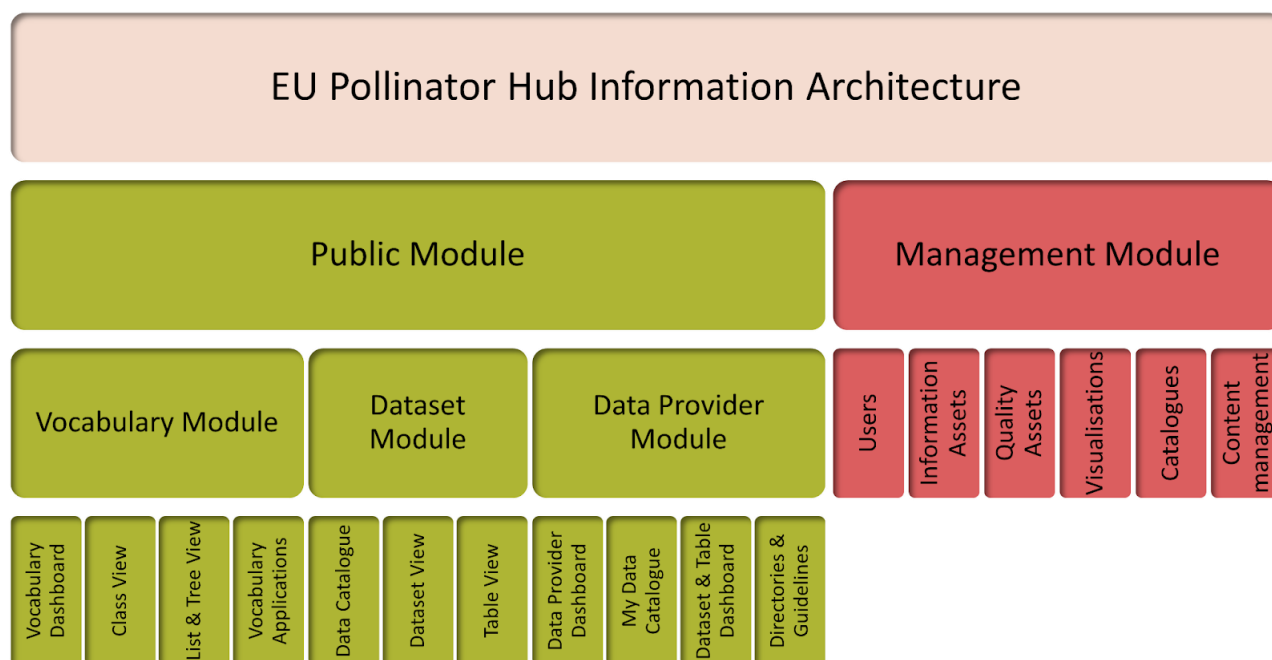
Figure 6: Graphical summary of the EU Pollinator Hub Information Architecture. EU Pollinator Hub platform management module with restricted access; green: Pollinator Hub platform Hub application with (partly) open access

The most important principle to ensure the **Findability** of data and metadata within the framework of FAIR Guiding Principles is the assignment of globally unique and persistent identifiers. The EU Pollinator Hub assigns globally Unique and persistent IDentifiers (UID) to data assets (datasets, tables) and metadata assets (descriptors, classes). Datasets, tables and descriptors receive a UID composed of three code blocks, each consisting of a combination of letters and numbers. The first block identifies a dataset, the second a table and the third a descriptor. Depending on whether the respective elements (dataset, table, descriptor) represent an independent entity or are linked to another element (*e.g.*, tables and private descriptors are connected to a dataset; global descriptors represent independent entities, as they are not linked to a dataset), the block of the respective element contains the number 0 or the code block of the respective element. Each code block is generated from a predefined selection of 5 characters extracted from the element's name and the unique record identifier of the element in the database. Using characters extracted from the element's name would not have been strictly necessary to guarantee uniqueness. However, letters extracted from a name usually facilitate the identification by human operators. For this reason, they were placed in front of the respective numerical codes. Classes of the EU Pollinator Hub vocabulary used in data standardisation, on the other hand, receive a unique EU Pollinator Hub-Code (EUPH-Code), consisting of the unique record identifier of the class. As requested by the FAIR Guiding Principles, these identifiers are clearly and explicitly included in the metadata (*e.g.*, part of file names and UID in documents). Moreover, the process of dataset publication by data providers was designed at the software level in such a way that an adequate number of standardised metadata is available that ensures

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a rich and detailed data description. Finally, the Data Catalogue offers the option of searching for specific metadata.

Accessibility of published data and metadata is ensured through the open, free and universally implementable HTTPS-protocol, which contains the UID of a data/metadata asset (dataset, table, descriptor) or the EUPH-code of a class, for example:

- https://app.pollinatorhub.eu/dataset-discovery/MUSTB76.0.0 for dataset MUST-B, having the UID MUSTB76.0.0

- https://app.pollinatorhub.eu/Vocabulary/classes/8 for the class *beehive* having the EUPH-code 8

Finally, any metadata from datasets is not deleted but merely marked as deleted, as far as this is GDPR compliant.

Interoperability has been fully implemented at various levels. Firstly, all data elements are described by standardised metadata, referred to as Descriptors. Descriptors either have their own description (private descriptors) or relate to classes (Global Descriptors)[32]. In both cases, they are clearly defined using the English language and (optionally) images. In addition, classes may be translated to a (potentially) unlimited number of human languages and follow the FAIR principles. Global Descriptors allows cross-referencing data elements in different datasets from different data providers. They also contain qualified references, for example linkage to datasets that provide a generally recognised description for the data. Most importantly, both data and metadata are available in a standard machine-readable format. The current exchange format in which data is provided is CSV, but the basis for other standards, such as JSON or BeeXML, have been implemented at the software level.

Reusability is ensured by adding a clear and accessible usage licence to each dataset or, alternatively, to every single part of a dataset. A clear priority is given to Creating Commons licences. However, for practical reasons, custom licences issued by Data Providers such as public authorities or international organisations have been included. For data collected from publicly accessible resources, it is possible to add standardised citations based on Citation Style Language (CSL)[33].

4.2.1. Data Standardisation & Related Features

Data standardisation is important for regulatory compliance, namely with interoperability requested by Article 39f of Regulation (EU) 2019/1381, and with the FAIR Principles, as discussed before. Internationalisation may be regarded as a major component of data standardisation, if not only the technical aspect of interoperability is considered, but also the interaction with the user.

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32 Definition and translation of classes is regulated by SOP 012.

33 as regulated by SOP 022.

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The **Vocabulary Module** of the EU Pollinator Hub provides the necessary infrastructure to create a standardised terminology (vocabulary) and to translate this terminology to a potentially un-limited number of languages, including structural and functional rules for the translations. Both the terminology and its translations can be provided with references to authoritative sources and images. The representational primitives of this system consist of **Classes**, properties and rela-tions among classes that create an ontology, which serves as a three-dimensional backbone for (1) global data descriptors used for the internal standardisation of data elements, (2) for data itself, where the persistent and unique identifiers for each single class, the EUPH-Codes, may be used to describe nominal scale data, and (3) for the alignment of terminologies. In Figure 7, the information model of the vocabulary of the EU Pollinator Hub is given, which is partly managed in the Vocabulary Module and the Management Module.

A community-based approach has been implemented at the software level to drive this process. This enables accurately defined data to be shared at the highest possible level of accessibility for the broadest possible range of users. So far, this process has yielded 7205 approved classes and 21,174 approved translations into 27 different languages. Beyond that, the EU Pollinator Hub Website is currently available in 5 languages. A by-product of this database is a technical term database, which can be accessed by the application **Translator** for translating technical terms into different languages and the application **Encyclopaedia**, which contains definitions of terms in English for technical terms provided in different languages.

Standardisation of **citations** is an important aspect of data standardisation, as data quality may depend on accurately referencing resources that are not physically present on the EU Pollinator Hub (referred to as external resources). A standardised system for external references, based on Citation Style Language (CSL), an open-source citation style language used in various soft-ware products, has been adopted as an internal standard on the EU Pollinator Hub. Currently, Zotero (Corporation for Digital Scholarship), an open-source software application for managing bibliographic information and related research documents, is used to provide citations in the required format[34].

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34 This process is regulated by SOP 012.

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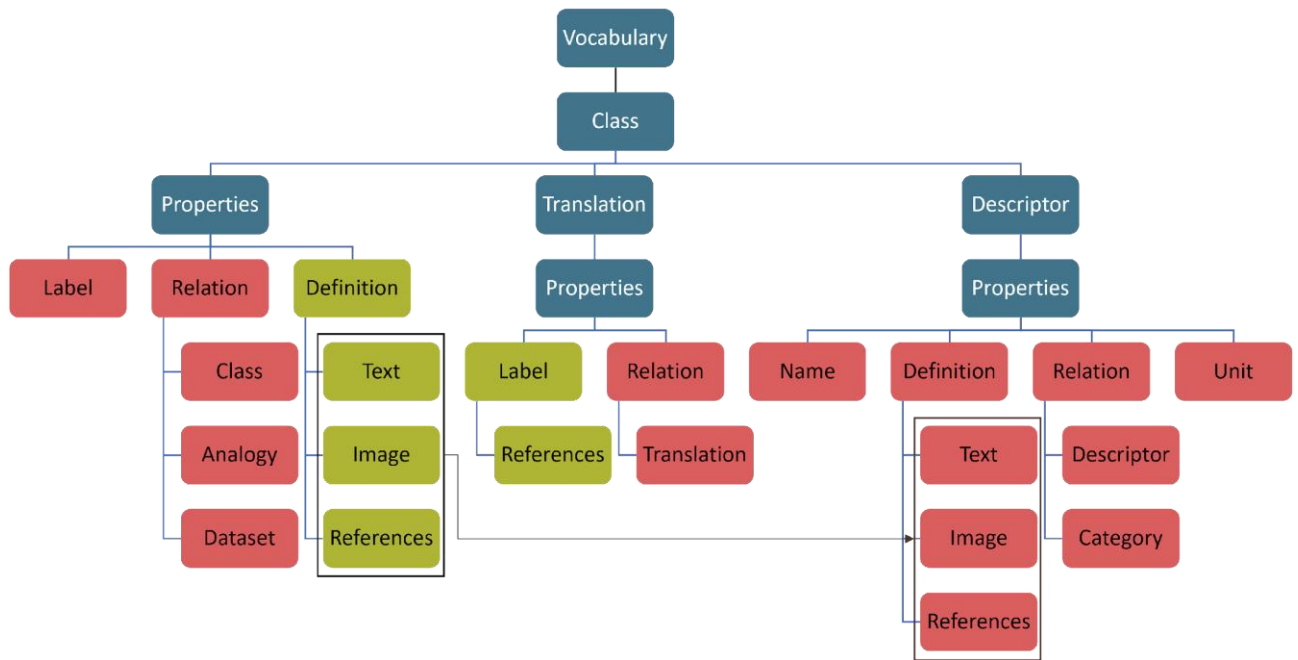
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Figure 7: Information model of the vocabulary used by the EU Pollinator Hub; green: components managed by a publicly accessible process; red: components defined by individuals operating within the DGF of the EU Pollinator Hub. Definitions of a class overrule definitions of a descriptor if the descriptor is global

Another crucial aspect of data standardisation is the handling of units. **Units** are stored in the Units Catalogue managed in the Management Module and only accessible to roles with platform manager rights. The Units Catalogue contains constants and algorithms for converting non-base units or multiples and submultiples of a unit to an accepted unit used by the EUPH as a base unit (referred to as EUPH base unit, not to be confused with base units of the International System of Units, SI) for storage and calculations. For units not included in the units catalogue, a procedure involving the process of change management exists, which regulates the validation and uptake of new units into the catalogue. While ingesting datasets into the EU Pollinator Hub data model, values are stored in the original unit in which they were provided and in the EU Pollinator Hub base unit to improve the overall performance of the system.

Descriptors are the representational primitives of a system that describes data elements and creates dependencies between them. They contain properties and relations among descriptors and may relate to classes and units (Figure 7). Descriptors may be global and private:

- Global Descriptors must relate to a class and, if applicable, to a unit. This enables the system to link data from different datasets on the EU Pollinator Hub (referred to as local interoperability). In addition, global descriptors are the basis for providing data in various standardised data formats, such as JSON or BeeXML (referred to as global interoperability).

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- Private Descriptors, in contrast, are only valid within a given dataset and fulfil the function of linking data elements within the same dataset.

The decision to distinguish between private and global descriptors has been pragmatic. Global descriptors require a more comprehensive, in-depth knowledge of the system and probably also increased support from the EU Pollinator Hub team during the reviewing process of a dataset. Private descriptors, on the other hand, can be managed by the data provider itself. For the nomenclature of descriptors, the standards produced by the Apimondia working group *Standardization of data on bees and beekeeping* and, where applicable and useful, Darwin Core (TDWG 2024) have been used, whereby the BeeXML standard was given priority over other standards.

The creation of the basis for the XML data format **BeeXML**, an initiative proposed by Walter Haefeker and institutionalised by Joseph Cazier in the Apimondia working group *Standardization of data on bees and beekeeping* (Cazier et al. 2018a, 2018b, 2020), has been an important by-product of the EU Pollinator Hub. The process for the creation and definition of classes, implemented in the Vocabulary Module, together with the system of global descriptors, implemented in the Dataset Management Module, allows the conversion of appropriately formatted datasets to a data format compliant with the data standard defined by the requirements proposed the Apimondia working group (in preparation).

Providing reference datasets for data providers is also important in standardising data. Datasets such as NUTS (UID NUTSA3.0.0, containing the most recent version of the nomenclature of territorial units for statistics), SI units (UID SNITS17.0.0, containing a selection of SI units provided by the Bureau International des Poids et Mesures BIPM), Regulation (EU) 2017/269 (UID RGLTN80.0.0, containing the harmonised classification of substances according to Regulation (EU) 2017/269 amending Regulation (EC) No 1185/2009), but also datasets of regional importance such as Division Austria (UID DVSNS29.0.0, containing divisions of the national territory of Austria according to different criteria not contained in other datasets) were published in the EU Pollinator Hub to support data providers in their effort to provide standardised data.

At the organisational level, data standardisation is regulated by SOP 012 and SOP 022. The former SOP (012) regulates the process and controls accountability for managing classes, descriptors and units, while SOP 022 regulates the citation process of external resources. The persons assigned the task of data standardisation and content management within the organisation are responsible for the processes in SOP 012 and SOP 022, respectively. The uptake of new units into the Units Catalogue involves the process of method validation, regulated by SOP-23.

The software and process architecture of the EU Pollinator Hub considers the fact that data standardisation, in particular the definition and translation of classes, is a continuous process and that it requires resources that are not available to this product. The engagement of stakeholders in this process will be crucial for its success. It should also be noted that parts of the process, particularly the management of global descriptors and the management of classes, require the intervention of experts who have in-depth knowledge of the available resources. If this infrastructure is to be kept alive,

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it would be necessary to develop a sustainable business model that includes a clear regulation of the property rights to the platform.

4.2.2. Data Upload

Data upload to the EU Pollinator Hub comprises the following steps: (1) **registration** of the Data Provider; (2) **preparation of the collected data**, including a first loop of quality assessment; (3) the (optional) creation of a standardised **Dataset Report** (DR); (4) the actual **transfer of the data to the staging area** (the Dataset Dashboard) of the EU Pollinator Hub, including another data quality assessment loop; (5) the creation of **standardised metadata** based on the information entered by the Data Provider; (6) the transmission of the data to a **technical review** or an (optional) **peer reviewing process**; (7) implementation of the changes requested in the (peer) reviewing process and subsequent **publication of data** on the EU Pollinator Hub and finally (8) the rating of the data by users. Several controls requiring human intervention are added to ensure high data quality.

4.2.2.1 DATA COLLECTION AND PREPARATION

On the EU Pollinator Hub, data collection and preparation and the assurance of data quality along this workflow are regulated both at the process and the software level. At the process level, data preparation and data quality assurance follow SOPs, which can, of course, only be enforced on individuals operating within the Data Governance Framework (DGF) of the Hub. Workflows, functions and catalogues have therefore been implemented at the software level to allow users to prepare data, set up a quality management system for data collection and preparation in their own working environment that meets their specific requirements, and measure data quality once the data has been uploaded to the staging area of the EU Pollinator Hub.

At the software level, publicly accessible catalogues were created, which contain guidelines for establishing Quality Management Systems. All SOPs and WIs can be found in the **Quality Asset Directory**. The **Guideline Directory** contains a collection of general and specific guidelines for data collection and processing. Both directories can be found in the **Data Provider Dashboard** or at a link in the footer of the App website.

During the **Registration** process on the EU Pollinator Hub platform, the contractual relationship between data providers and the data collector (currently BeeLife European Beekeeping Coordination), including data ownership, is defined[35], and consent is obtained regarding managing personal data[36]. This also defines the rights and obligations regarding data stewardship[42].

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35 as regulated in SOP 010.

36 regulated in SOP 011.

Data preparation starts outside the EU pollinator Hub Application[37]. Parallel to the start of the data preparation process, a standardised **Dataset Report** is created[38], in which the entire process of data processing, from data collection and cleansing to the actual publication of data is tracked, enabling full traceability. Data preparation includes one or more loops of data profiling cleansing, data exploration and visualisation[39], and every step that modifies the data along this process should (Data Providers) or must (individuals operating within the DGF of the Hub) be tracked in the standardised dataset report. The EU Pollinator Hub provides several guidelines and software tools for local data processing with various tools (*e.g.,* SQL, Python) inside Work Instructions and in the **Product Directory[40]**.

4.2.2.2 DATA TRANSFER AND STORAGE

Under the assumption that its quality is considered adequate for publication on the EU Pollinator Hub, the data and metadata are transferred to the staging area of the EU Pollinator Hub.[41]

Creation of a dataset. At the software level, a data provider first creates a new **dataset** and provides some standardised, structured and unstructured metadata to describe the dataset. Apart from name and title, this includes the years covered by the dataset, freely selectable keywords, a short description, an image and citations of external references. In addition, a list of contributors, their roles, and contact information may be provided. Licences may be defined either at the dataset or data table level. The latter option will be selected when data has been collected from different sources which have been published under distinct licences. Once this process is completed, the Data Provider enters the **Dataset Dashboard**. Here, the Data Provider may add non-standardised metadata (*e.g.,* protocols, methods, *etc.*) as files to the dataset.

Creation of data tables. The next step in this process is the preparation of metadata for **data tables**, in which the data is stored. It should be noted that data is not actually stored as tables in the EU Pollinator Hub data model. The term *table* used in this context merely represents an object containing a group of data elements representing a functional unit. However, this term has been used for practical reasons – users usually process data in tables consisting of columns and rows. The Data Provider may add a name, a description, an image, and citations of external references. At this point, data providers decide on the technology that will be used to ingest the data: single or multiple files uploaded to the staging area, access to data through a cloud interface or via an API (in which case additional technical information must be provided). Once this

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37 The process of preparing data and metadata is regulated in SOP 006 and its dedicated WIs, which can be accessed in the Guideline Directory.

38 regulated by SOP 003. SOPs 003 and 006 are only mandatory for individuals operating within the DGF of the EU Pollinator Hub but can serve as a good practice guideline for all Data Providers.

39 regulated by SOP 007, 008, 018 and 019, respectively.

40 accessible either from the Data Provider Dashboard, from the help function, symbolised by a question mark, on the left-hand side of the header, at a link in the footer or context-related buttons within the Application

41 At the process level, this is regulated by SOP 017.

process is completed, the Data provider enters the **Table Dashboard**. Here, the Data Provider may again upload non-standardised metadata (*e.g.,* protocols, methods, *etc.*) as files.

Data upload. The next step in the process is the upload of the actual data. Currently, only data in CSV format and UTF-8 encoding is accepted. The Data Provider can set some basic parameters of the raw data source (column delimiter, decimal separator, character sequence assigned to missing values). Once sent, the raw data file gets analysed (content analysis, structural analysis), and the results, both in tabular format and as graphs, may be accessed for a quality assessment. The standardised, structured and unstructured metadata for the data elements may be provided at this stage. Analogue to the previous justification related to tables, the term ***column*** is used here as a synonym for ***data element***. The Data Provider may add a description for each column, select a descriptor, data type and - if appropriate - a unit from a predefined list, or create a private descriptor that is only valid within the dataset. The significance of descriptors has previously been discussed. The system supports this process with a summary of column analytics.

If the Data Provider considers the quality of the data and metadata to be adequate for publication, it may be submitted for **technical review** or (optional) for **peer review**[42]. The dataset must comply with FAIR principles and contain a complete and correct description of all relevant columns, including units, where appropriate. The technical reviewer may request minor changes from a Data Provider, apply changes to the metadata and assign classifiers to the dataset after consultation with the Data Provider. While the technical review is mandatory before a dataset is published, a data provider may also request a peer review for a dataset, which consists of a technical review, as described before, and an in-depth assessment of the data[43]. It consists of a dataset review with an individual with a contractual relationship with the EU Pollinator Hub. Briefly, datasets are reviewed based on guidelines contained in the **Criteria Catalogue**[44]. The reviewer must provide a **Peer Review Report** and decide whether the dataset enters an additional revision cycle, is approved or rejected.

Only if either the technical or the peer reviewer has approved a dataset for publication may it be **published** by the Data Provider immediately or after a date set by the Data Provider (embargo). Users may rate published datasets according to some criteria[45] (*e.g.*, quality of the metadata, usefulness, findability, *etc.*).

The controls related to data quality assessment, described as part of the above-described process, can be summarised as follows:

Tier 1: Metadata obtained from Data Provider and data consumer.

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42 The process of a technical review is regulated in SOP 017

43 The process of peer reviewing is regulated in SOP 015

44 which can be accessed from the Data Provider Dashboard or from a link in the page footer

45 developed in a process regulated by SOP 014

a. Standardised metadata containing the classification of the dataset related to compliance with *regulatory standards* (*e.g.,* GLP, GFP, *etc.*), *technical standards* (*e.g.,* EFSA EN-1234) or the demand for *analytical capacities* required to process and analyse the data is acquired at the software level during the process of dataset preparation and reviewing. The classification is publicly displayed in the Dataset View.

b. It is possible to upload files as metadata, which document the standards, material and methods used by the Data Provider to acquire and process the data (*e.g.,* protocols, methods, *etc.*);

Tier 2: Creation and integration of tools for data profiling.

a. A profiling tool, performing structure and content analysis on data during the upload process, which provides the results as a tabular summary and in graphs, has been integrated in the Table Dashboard and Table View. This enables the provider to carry out a data quality check after data upload but also allows data users to obtain information on the content and structure of a dataset and potential data quality issues.

b. Methods to perform data profiling locally using non-proprietary software are provided in the Guideline Directory, and are accessible from the Data Provider Dashboard or a link in the page footer.

c. A rating system has been implemented that users may use to provide feedback on published datasets.

d. A process has been set up for individuals operating in the DGF of the EU Pollinator Hub that includes data exploration (content and relationship discovery) and visualisation but may also be adopted by data providers voluntarily. The guidelines for this process are available in the Guideline Directory, accessible from the Data Provider Dashboard or through a link in the page footer.

Tier 3: Facultative peer reviewing process.

a. A compulsory technical review and a facultative peer reviewing process, including the necessary contractual foundations, procedures and software tools, have been implemented within the DGF of the EU Pollinator Hub. The necessary functions are accessible in the Management module.

In contrast to many other similar products, the EU Pollinator Hub has a fully implemented Data Governance Framework that includes particularly comprehensive tools for ensuring data quality and data standardisation. With the implementation of standardised dataset reports and a peer-reviewing system as facultative elements at the process level, the foundation has been laid for preparing datasets for publication in data journals. Therefore, a feature that should be implemented is the allocation of a Digital Object Identifier (DOI) to information assets, which, however, would imply the development of an improved Life Cycle Management for information assets and the

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necessary financial resources for the registration agency fees. Among the things that could be improved is the still underdeveloped user-friendliness and data architecture that can efficiently manage much larger data volumes, the realisation of which would require significantly greater financial resources.

4.2.3 Data Exploration and Visualisation

This step involves using the datasets, after the data preparation and technical review steps, to perform an in-depth exploratory analysis using various data visualisations (graphs, maps, *etc*.) or statistical analyses. Adopting a fully reproducible approach is recommended by using a programming language and literate programming to document and explain the analysis process. The process typically involves the creation of many different graphs, which may be static or interactive. As this is an exploratory process, various approaches can be explored, including approaches that do not end up working well but can be documented.

This step can serve at least three distinct purposes:

Quality Assessment: If an external user who did not create the data can produce meaningful graphs and analyses from the dataset, this indicates that the dataset is well structured and well documented. Despite careful data preparation and technical review, it is often the case that problems or difficulties only become apparent when the data are actually used. The MUST-B dataset is a good example of a particularly complex dataset, with many different measures across multiple apiaries. Despite this complexity, the dataset is particularly well structured and well documented, which makes its analysis by a third party feasible. However, a few difficulties were encountered while analysing the data. For example, the geographical coordinates are encoded in two different coordinate systems (2 UTM zones) in the same columns, which makes their conversion more difficult. The code developed in the context of the data exploration contains a reusable function that performs such a transformation. Another example is the waggle dance table (from the MUST-B dataset), which expresses directions in degrees between -6° and +6°, an unlikely range for bee foraging. This discrepancy may indicate a problem in the data or a misunderstanding that requires improving the data description.

Graphical Summary: Most technical users will be interested in downloading and using the data. However, navigating an unfamiliar dataset can be complicated. Providing a series of data visualisations can help the user understand if the data is interesting for their purpose and if the dataset is structured. See, for example, the static reports available in the "other downloads" section for the MUST-B dataset (file "Dataset00012_mustb_static.pdf"[46]) or the Beekeeping Austria dataset (file "Dataset00008_BeeAT_static.pdf"[47]), which contain a large amount of data and benefit the most from a graphical summary.

Insights Extraction Tools: Less technical users will not necessarily be interested in downloading the data, but they may be interested in extracting information and insights from the data.

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46 https://app.pollinatorhub.eu/dataset-discovery/MUSTB76.0.0#other-downloads

47 https://app.pollinatorhub.eu/dataset-discovery/BKPNG8.0.0#other-downloads
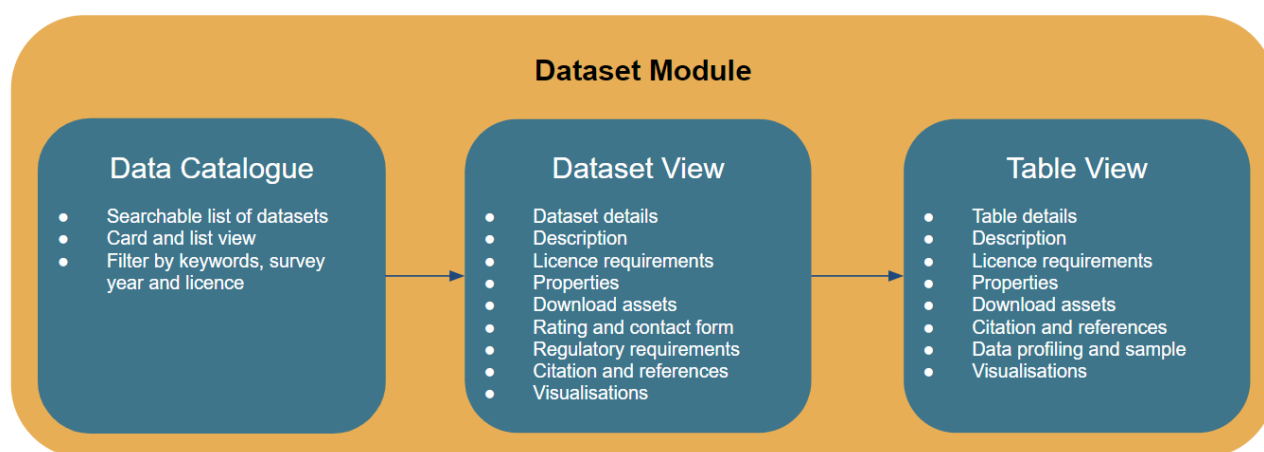
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In this case, providing static graphs showing important patterns or a data tool, such as an interactive graph or application, can help extract information from the data. A good example is the hive scale datasets, which typically provide the daily or hourly weight for numerous hives in an area. One might typically want to know when and where a weight peak was reached each year. Providing abundant raw data may be difficult for most users, while providing a visualisation Application like this one[48] (shiny app code available on the platform in the file "scales_austria.zip"[49]) will help the users interact effectively with the data.

The EU Pollinator Hub counts with various datasets that have been fully integrated. Processing and visualisations have been proposed for some of them in view of creating a data processing and visualisation arsenal available for the users. As a result, the EU Pollinator Hub users will have available a basic set of visualisations and data processing options for their data. However, performing customised data processing and visualisations is costly, for it requires dedicated resources and further development. In the future, data processing, analysis, and visualisation beyond the platform's functionalities will require additional resources in terms of time and personnel, and depending on the analysis required, additional software development and hosting capacities will be required.

4.2.4. Dataset Discovery

Users may freely access published datasets in the **Dataset Module** through the **Data Catalogue**, which leads to the **Dataset View** and **Table View** of individual datasets, where data can be downloaded. The **Vocabulary Module** gives access to the data standardisation and translation process, where the actions may depend on the user's role in the process (Figure 6).

The **Dataset Module** contains a search function for structured (year, licence) and unstructured (description, keywords) metadata associated with the datasets (Figure 8). The list of datasets can be displayed in a list and card view.

Dataset Module

Data Catalogue	Dataset View	Table View
• Searchable list of datasets • Card and list view • Filter by keywords, survey year and licence	• Dataset details • Description • Licence requirements • Properties • Download assets • Rating and contact form • Regulatory requirements • Citation and references • Visualisations	• Table details • Description • Licence requirements • Properties • Download assets • Citation and references • Data profiling and sample • Visualisations

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48 https://shinyapp.cra.wallonie.be/test/scales_austria/

49 https://app.pollinatorhub.eu/dataset-discovery/HVSCL51.0.0#other-downloads

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Figure 8:   Scheme of the Dataset Module and related features

In the **Dataset View**, users get a complete overview of the structured and unstructured metadata of the dataset. The containers on the right-hand side of the page contain mainly stand-ardised and structured information and metadata. Container **Properties** contains the dataset UID, publishing date, keywords selected by the Data Provider and years covered by the datasets. Container **Citation** contains the suggested citation of the dataset. Container **Contact** contains contact information. In addition, if set by the Data Provider, the analytical capacities required to analyse the dataset and the regulatory and technical standards applied for data collection and analysis are shown in separate boxes. On the bottom right, users' ratings can be found. The central part of the dashboard shows the name, title and description of the dataset (including an image, if available), the UID of the dataset, one or more references to the data source and a download section. The download section contains all available download options for data and metadata and the licence under which it is available. Users can download the whole package (*Download Everything*) or parts of it. The whole package comes as a compressed archive file in ZIP format containing one or more tables in ZIP format, a list of all tables and columns, including metadata in CSV format, the licence information in markdown format, the standardised dataset report (drafted according to SOP 003) in PDF format (if available), visualisations (if available), a data exploration report (if available) and a *Readme* file in markdown format that contains some of the unstructured metadata of the dataset (name, description) as well as date, time and site URL of the download. The compressed archive files of the tables contain the data in CSV format and the table's metadata. In addition to this, it is possible to download each component of the archive file separately. In the **Table View,** users get a complete overview of the structured and unstructured metadata of the table, sample data from the table and charts from data profiling (content and structural analysis). Container **Properties** include some basic metrics of the table, such as the number of columns, rows, and records. The central part of the dashboard shows the name, title and description of the table (including an image, if available), the UID of the table, one or more references to the data source and a download section. The download section con-tains all available download options for data and metadata and the licence under which the data is available. Users can download the table's metadata in CSV format and the raw data, which comes as a compressed archive file in ZIP format containing the file the Data Provider originally uploaded and the licence information in markdown format. In the section **Data Profiling,** the user can see the structural and content analysis results, displayed as tables and graphs, and a small data sample for data quality assessment.

4.2.5. Vocabulary Module

The **Vocabulary Module** may be exploited in four different ways. **List View** provides a search-able list of the classes in the Vocabulary. Users may search for a particular item, filter for classes with missing translations or definitions or search for classes related to a particular dataset. Be-sides that, new classes may be created in this view, depending on the user's permissions, and the entire Vocabulary content may be downloaded. **Tree View,** instead, provides a structured overview of the classes based on the hierarchical relationships between them. Both List View and Tree View provide direct access to the dashboard of individual classes. **Translator** offers

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the possibility to search for a term in one language and get the translation of this and similar terms (including a definition in English language and references) in another language, whereas in **Encyclopaedia,** the user may enter a term in a language and get the definition for this particular and similar terms in English, including references (Figure 9).

The **Class View** contains the summary of all relevant information related to a class and – based on the user's permissions – offers different ways to contribute to creating, defining and translating a class[50]. The dashboard contains the name of the class, its accepted definition, including references and images (if available), the log of the discussion process, its relation to other classes and a list of contributors to the creation process, definition and class translation.

Vocabulary Module

Translator
- Search by expression
- Select from and to language
- Orders results by relevance
- Includes definitions, alternative translations and references

Vocabulary Dashboard
- About the vocabulary
- List of available tools
- Vocabulary statistics

Encyclopaedia
- Search by expression
- Optionally select language
- Orders results by relevance
- Includes definitions, alternative translations and references

List View
- Searchable list of classes
- Display translations

Class View
- Class details
- Class definition and its references
- Searchable list of translations and their references
- Class properties
- Class relationships
- Contributors

Tree View
- Navigable hierarchical list of classes
- Organised into parent/child system

Figure 9:   Scheme of the Vocabulary Module and related features

The first step in the process is creating a new **class**, which can only be done by individuals having permission to manage the Vocabulary. New classes receive a name in English, which must be as brief as possible, linguistically correct and contain all essential information to distinguish it from other classes, preferably a single word or – if not possible – a group of words, or – if not possible – a phrase. Moreover, it may be linked to a particular dataset if the provider of this dataset has an understandable interest in defining it according to its criteria as well as to

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50 regulated by SOP 012.

www.efsa.europa.eu/publications   EFSA Supporting publication 2025:EN-9219

one or more existing class(es) if it is a subset of these classes (also referred to as sub-property). Newly created classes must be approved by the process manager to get published, making it possible to define the structure of a group of classes before publishing it. Individuals with permission to edit Vocabulary content may start or participate in an existing discussion in class.

Once approved, individuals having permission to add Vocabulary content may propose one or more definitions for a class. A **definition** contains a description, one or more references to this description (optional), and the possibility to add one or more attachments (documents, images, short videos) to the definition (optional). Individuals with permission to edit Vocabulary content may up- or downvote a definition of a class and may start or participate in an existing discussion on a class definition. The process manager may eventually consolidate the process of creating a class by approving one of the proposed definitions if the discussion process on its definition and its association with other classes has produced a satisfactory result.

Once a class is consolidated, individuals with permission to edit translations can translate them. In the **translation process**, the operator defines the language of the expression. A translation may be assigned to a set of existing domains if the expression is specific to a particular domain. It may receive grammatical specifications (grammatical category, grammatical number and gender, if applicable), which is important if different grammatical forms of an expression have different meanings but may also help people with limited language skills to use the expressions correctly. It may also be defined as a synonym of another expression, eventually defining certain expressions as favourites. Finally, it may be provided with one or more references to ensure traceability. Individuals with permission to edit translations may up- or downvote a translation of a class and may start or participate in an existing discussion on a translation. The process manager may eventually consolidate the translation process by approving one or more of them if the translation discussion process has produced a satisfactory result.

This process aims to engage stakeholders in standardisation efforts and to provide a platform for groups to drive a standardisation process if its goal aligns with the goals of the EU Pollinator Hub.

4.2.6. Enforcement and maintenance of the Quality Management System

The **Quality Management System (QMS)** on the EU Pollinator Hub defines the procedures to ensure data quality, data protection, processing, standardisation and compliance with FAIR principles. Issue management is an integral part of the QMS. It includes the prevention of issues by validating algorithms used in data processing and changes in software or hardware, reporting and resolution of issues and monitoring of the obsolescence of linked content.

The procedures for maintenance and enforcement of the **Quality Management System** (QMS) are defined in currently 28 Standard Operating Procedures (SOP) and 30 dedicated Work Instructions (WI), which are made available in the **Quality Asset Directory** accessible from the Data Provider Dashboard or a link in the footer of the App page.

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The QMS[51] assigns tasks to roles within the organisation within a specific time frame, and defines the reporting line, and defines data governance (QMS, data ownership, data stewardship, traceability)[52] at the process level. Each SOP is related to one or more tasks, which defines **decision rights**, **controls** and **accountabilities** within the DGF. The life cycle of quality assets is regulated by SOP 016[53], including drafting SOP[54] and WI[55]. Regular internal audits on data quality[56] and data security (SOP 026)[57] are supposed to identify problems and risks. Therefore, they should ensure a continuous improvement of the quality management system.

Validation of newly developed algorithms used for unit conversion, data profiling and data analysis before deployment is regulated by SOP 023. SOP 021 and related documents regulate **change control** at the procedure level. Briefly, software updates require an informal risk analysis on the effects of a change in software, software configuration, hardware or hardware configuration on data assets to be made before the change is implemented. If the risk analysis concludes that the integrity of data assets could be affected by the planned change, a test protocol is designed that measures the effect of the planned change on data assets. The test protocol contains, among others, standardised methods[58] measuring the effect and the acceptance criteria for the tests. Only changes for which the test has achieved the acceptance criteria may be deployed to the production environment.

Issue Reporting is processed with the external DevOps software package GitLab. Any user registered on GitLab may submit issues in a structured form[59]. Issues may be categorised according to the type of issue by assigning a predefined label, prioritised by assigning a predefined milestone and assigned to a predefined operator. Issues submitted in GitLab are, by default, public and must be labelled confidential when they contain personal data. Operators are notified via email when the issue has been assigned to them. All individuals interacting with the issue are notified of an interaction, including the closure of the issue.

Monitoring the obsolescence of linked content has been implemented at the process[60]and software levels. Content managers may insert a URL into a Link Directory in the Platform Management Module. At this point, a copy of the HTML file is stored as a reference on the EUPH server, and initial values of parameters such as file name and size, response time and request code are saved in the Link directory. An automated request to each URL in the Link Directory is made once daily, and response time, code and file size are measured and compared to the initial

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51 based on the SOP 004

52 SOP 010

53 https://app.pollinatorhub.eu/pages/sop-directory

54 SOP 001 - https://app.pollinatorhub.eu/pages/sop-directory

55 SOP 002 - https://app.pollinatorhub.eu/pages/sop-directory

56 SOP025 - https://app.pollinatorhub.eu/pages/sop-directory

57 SOP 026 - https://app.pollinatorhub.eu/pages/sop-directory

58 defined in SOP 009

59 following SOP 020

60 in SOP 024

value. Based on the criticality level assigned by the content manager to the URL, the system alerts the content manager and highlights the record in the Link Directory if certain parameters (response code, file size) exceed predefined thresholds, as defined for each criticality level.

Data quality comes at a cost because a QMS can only be enforced if there are people in the organisation to whom it may be enforced. Only a sustainable business or funding model can guarantee high data quality.

4.2.7. Management Module

The **Management Module** is used to administer the EU Pollinator Hub application by operators with the necessary access rights. It consists of the following seven sections, each with distinct access rights (Figure 4).

Section **Information Assets** contains the management functions for all data assets. The function **Dataset Pipeline** is used to manage the life cycle of datasets[61]. **Dataset**, **Tables** and Descriptors and **Descriptor Categories** manage the corresponding assets. Among these, the Platform Manager will frequently use the **Descriptors** view to manage global descriptors. The application allows the assignment of the descriptor to a category (to be edited in the Descriptor Categories view), a unit, a class and a data type. By assigning a unit and a data type, the user is restricted at the front-end to units and values belonging to the same quantity and class of data types, a measure that enables a certain degree of data quality assurance and standardisation. A class assignment adds a generally recognised definition, which is an important prerequisite for data standardisation. The assignment of the property *global* makes the descriptor available for all datasets hosted on the EU Pollinator Hub. If no class is assigned, descriptors may still be customised with an individual description using both human language and images, including references. Assigning the status *deprecated* to a descriptor keeps the current settings but prevents its further use in the standardisation process.

The section **Visualisations** contains the management function for visualisations[62]. Currently, information on data to be displayed in the visualisation and options and configuration for the generations of visualisations must be entered as JSON objects.

Catalogues section contains the **Licences Catalogue** and **Units Catalogue**, which are necessary for managing licences and units on the EU Pollinator Hub. The Units Catalogue contains information on the conversion of units to base units.

A section **Organisation** has been defined and contains the necessary management functions for defining the organisation chart including individuals managing the platform[63]. This function is important for defining reporting lines and assigning tasks within the organisation, which influences the accountabilities within the DGF of the EU Pollinator Hub, as defined in the QMS. The

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61 as defined by SOP 016

62 regulated in SOP 019

63 as defined by SOP 004

resource **Tasks** is used to define the task of a role. The resource **Roles** is used to define the role of an individual within an organisation. The resource **Individuals** assigns roles to an individual, tasks to roles and individuals to a direct superior within a given time frame. This framework sets the basis for all audit trails requiring the documentation of accountabilities within the data governance framework.

The section **Users** contains the function for user management. The resource **Users** manages personal data and access rights (roles and permissions) for natural persons, regulated by SOP-028. The resource **Entities** contains information on natural persons or organisations acting as data providers.

The section **Content Management** contains functions to manage static pages (**Pages**), translations (**Translation manager**) and **Menus** of the EU Pollinator Hub Application content.

The section **Quality Assets** contains the management functions for all quality assets. The resources **SOP directory, WI directory** and **Method directory**, with the latter containing all methods used in change management, are regulated by SOP 021 and for validating methods used on the EUPH for data transformation and data profiling[64]. **Classifications** manage the Information Asset Classification Catalogue[65], an integral part of Tier 1 of the data quality assessment. The **Link directory** is used to register external links that require periodic validation. Links registered in this directory[66] are automatically visited once per day by the system, and the actual value of the response of the requested web page is compared with a target value. The response is reported in the Link directory and added to an audit trail.

4.2.8. Use case B-GOOD: Description of the data management cycle

B-GOOD, standing for "Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making", was a project funded under the European Union's Horizon 2020 research and innovation programme (Grant Agreement 817622). The objective was to "make the Health Status Index (HIS) inspired by EFSA's Healthy-B toolbox fully operational [...] by facilitating the coordinated and harmonised flow of data from various sources and by testing and validating each component thoroughly" (European Commission, 2024). Socio-economic analyses of the beekeeping sector should be integrated, viable business models tailored to different contexts for European beekeeping should be identified and the carrying capacity of the landscape should be determined. In close cooperation with the EU Bee Partnership, an EU-wide bee health and management data platform, the B-GOOD Bee Health Data Portal (B-GOOD Consortium, 2024), was created to share knowledge and learning between scientists and stakeholders. This portal was "supposed to identify correlative relationships among factors impacting the HSI, assess the risk of emerging

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64 regulated by SOP 023.

65 regulated by SOP 013.

66 according to SOP 024.

pests and predators, and enable beekeepers to develop adaptive management strategies that account for local and EU-wide issues" (European Commission, 2024).

The data management cycle was within the data governance framework described in SOP-010 (data governance). The process was carried by they Data Scientist responsible for data preparation, as regulated by SOP 004 (Organisation Chart).

As requested by SOP-006 (Dataset preparation), all datasets downloaded from the B-GOOD Bee Health Data Portal (B-GOOD Consortium, 2024) were stored locally in the subdirectory *01 Raw Data* of the relevant directory for each dataset or each group of datasets. The delivered files were opened with suitable software, usually MS Excel (Microsoft Corporation, version 2409), Notepad++ (version 8.7), and in two cases, IBM SPSS Statistics (IBM Corporation, version 30.0.0.0 (127)) and checked for readability and face validity by visual inspection.

Subsequently, datasets, including the required tables, were created on the EU Pollinator Hub according to SOP 017 (Dataset integration), following WI 025 (Dataset creation) and WI 026 (Table creation). The newly developed automated report, deployed in September 2024, allowed online tracking of the data preparation process. The creation of a Dataset Report file, as requested by SOP-i 006, could therefore be skipped (SOP-006 and WI 025 were changed accordingly).

All data and metadata files (file names, date and time of download from the B-GOOD Bee Health Data Portal, the URL of the dataset on the B-GOOD Bee Health Data Portal) contained in the B-GOOD dataset were registered in section 5.1 (*Data Acquisition*) of the Dataset Report, as required by SOP 006. In the following, these files are referred to as raw data.

Based on the existing structure of the raw data, none of the raw data files could be integrated as delivered into the EU Pollinator Hub, and it was therefore decided to proceed to manual preparation of all raw data files, as described in WI-002 (Raw data preparation). Preparatory files in CSV format were created following the instructions of WI-002. Every step, including a specification of the software used for creating the preparatory files and the changes in structure and content of the preparatory files, were documented in section 5.2 (*Data Preparation*) of the Dataset Report, as required by SOP-006. The source code of the in-house software used to prepare the data is stored in the Guideline Directory (Specific guidelines > Data preparation) under section 2. External Software for Data Preparation of the EU Pollinator Hub.

Subsequently, all necessary changes in the structure and the content of the preparatory files were applied. All changes were documented in the Dataset Report. Changes in the structure and the content of the preparatory files were documented in sections 6.2.X.4 and 6.2.X.5, respectively, of the data table in which the preparatory file was supposed to be integrated (where X stands for the consecutive number of the table in the dataset report). As required by SOP-006, the name of the column in which changes were applied, the number of records per column affected by this change, an accurate description of the changes and a reason for the change were tracked. All issues encountered during this procedure were documented in section 6.2.X.6 of the data table in which the preparatory file was supposed to be integrated (where X stands

for the consecutive number of the table in the dataset report), as required by SOP-008 (Data cleansing). Every issue was described, and, if applicable, possible actions were proposed by the Data Provider to resolve the issue. All issues were forwarded to the Data Provider on 2024-11-08.

Once the data was uploaded, as described in WI-027 (Upload Data), a structural and content analysis of the data was performed according to SOP-007 (Data profiling) using the EUPH Profiling Tool. The results of this action were reported in the section *Description* of the relevant table in the Dataset report. If applicable, links to columns of tables in the same dataset were listed in section 6.2.X.1 *Metadata* of the dataset report (where X stands for the consecutive number of the table in the dataset report).

Finally, all dataset columns were described as requested by SOP-017 following WI-013 (Data description). Issues arising during this process (mainly as a consequence of poor documentation of the raw data) were reported as issues in section 6.2.X.6 of the data table in which the preparatory file was supposed to be integrated (where X stands for the consecutive number of the table in the dataset report). If necessary, new classes and descriptors were created, as described by SOP-012 (Data standardisation). A total of 271 descriptors, 168 classes and 609 translations had to be newly created or updated for this purpose.

The datasets were then classified according to SOP-013 (Data classification). The links to the B-GOOD Bee Health Data Portal (B-GOOD Consortium, 2024), which was used in all Dataset Reports (https://beehealthdata.org/datasets), were inserted into the link directory, as required by SOP-024 (Obsolescence of links).

Out of 68 datasets on the B-GOOD Bee Health Data Portal (B-GOOD Consortium, 2024), 65 could be integrated into the EU Pollinator Hub. Five of the 65 datasets were removed on 2024-10-30 from the B-GOOD Bee Health Data Portal. The remaining 60 datasets were recompiled and integrated into 19 datasets on the EU Pollinator Hub (listed below; all Dataset Reports are attached in Appendix C of this report).

1. B-GOOD Bee Counter Data (containing dataset Bee counters Nb daily exits/entrances, UID 48186e29-93de-44c2-8d49-8d29c72857f8)

2. B-GOOD Health Monitoring (a compilation of 43 distinct datasets on the B-GOOD Bee Health Data Portal, 24 of which are duplicates that were discarded)

3. B-GOOD CO2 Gas Measurements (a compilation of 5 distinct datasets on the B-GOOD Bee Health Data Portal)

4. B-GOOD Weather Data (containing dataset WP1 Tier 1 weather data B-GOOD, UID 08abb106-c307-45e6-8a6d-f2024b464ca6)

5. B-GOOD WP1 Tier 1 Data 2020 (containing dataset WP1 Tier 1 data 2020 B-GOOD, UID 41518b11-72ce-464d-9a4b-c7b06b996beb from the B-GOOD Bee Health Data Portal, which has been removed on 2024-10-30)

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6. B-GOOD WP1 Tier 1 Data 2021 (containing dataset WP1 Tier 1 data 2021 B-GOOD, UID d04b7779-06c3-4b7a-b444-821cde28e154, from the B-GOOD Bee Health Data Portal, which has been removed on 2024-10-30)

7. B-GOOD WP1 Tier 1 Data 2022 (containing dataset WP1 Tier 1 data 2022 B-GOOD, UID 306f571d-2497-4d6e-aed1-ec4402e1efaa, from the B-GOOD Bee Health Data Portal, which has been removed on 2024-10-30)

8. B-GOOD WP1 Tier 2 Data 2022 (containing dataset WP1 Tier 2 data 2022 B-GOOD, UID 024fcb7c-e359-48fb-a432-961065c63afa, from the B-GOOD Bee Health Data Portal, which has been removed on 2024-10-30)

9. B-GOOD WP1 Tier 3 Data 2022 (containing dataset WP1 Tier 3 data 2022 B-GOOD, UID a4a07ab2-9495-4291-8af7-8f0d084ec502, from the B-GOOD Bee Health Data Portal, which has been removed on 2024-10-30)

10. B-GOOD WP4 Beekeeper Survey (containing dataset B-GOOD WP4 Beekeeper Survey 2022 (ba6a57b1-78f4-4f59-874f-84575d3acce9)

11. B-GOOD WP4 Stakeholder Survey (containing dataset B-GOOD WP4 Stakeholder Survey 2021, UID 8fda00e3-9f5e-4953-b70d-fd8703479dca)

12. B-GOOD BIOEUNIS (containing dataset BIOEUNIS - Biogeographical EUNIS Level 2 Terrestrial Habitats: Database of Relevant Resources for Honey Bees. [WP3], UID cdf42e4c-7e8c-44cc-a72c-dd080a16494f)

13. B-GOOD Honey Bee Resources (containing dataset Database of Relevant Resources for Honey Bees. Deliverable D3.1 [WP3], UID f1c72348-1861-479a-8c40-a24cb1c92832)

14. B-GOOD WP3 Field Data (containing dataset Field data obtained from the implementation of the Field Protocols 1, 2, and 3 from WP3 UID 1642b97c-e81e-4fad-b1bd-34c6d4900f99)

15. B-GOOD Virus levels (containing dataset Genbank Accession numbers for virus sequences, UID b6d3e81d-6de3-4124-bdc7-0f9d855017e1)

16. B-GOOD Virus levels (containing dataset Virus levels in bee pools of different sizes, UID 9969da2a-ca8d-477b-96aa-0eb9c195a5cb)

17. B-GOOD Genotyping Subspecies (containing dataset genotyping SNPchip Tier1 Tier2 [WP1], UID 01476ccf-674c-42e0-86d1-0e82766deddb)

18. B-GOOD Genotyping pooled SMR (containing dataset Genotyping data - SMR SNPs - TIER1 TIER2 2021, UID ddc292fe-869e-4003-a995-34c144add835)

19. B-GOOD Genotyping SMR (containing dataset SMR genotyping Tier1 Tier2 Tier3, UID cf553e76-b65c-4dde-bec6-22ac7782a096)

The following 3 datasets (out of the initial 68 datasets) could not be integrated:

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- Dataset Landscape Suitability Map for Honey bees across Europe. Deliverable D3.5 [WP3] (UID 85d1f481-5150-48df-9ec9-c8ac23c704e3) contains only an image in JPG format. The data from the image could easily be extracted with in-house software. Files in JPG format, however, are compressed in the course of generating the image, whereby the original raw data is changed unpredictably for someone analysing the image. It would make more sense to publish the data on which the image was created, rather than transformed data that was extracted from the image.

- Dataset B-GOOD WP4 Stakeholder Interviews Transcripts 2020 (UID 26a8c121-a366-4027-b3b4-e637f96d5049) contains an unstructured interview. Of course, this could easily be integrated, but there is no added value for the potential user of the interview. It would merely make access to the information more difficult.

Dataset WP1 Tier 1_Flash logs (UID c69e411b-3f07-4afe-9c31-c1e9ba4a2041) contains backup data, which was removed on 2024-10-30 from the B-GOOD Bee Health Data Portal. Apparently, the provider is no longer interested in publishing this data.

4.2.9. Recommendations for future handling of EU research data on the EU Pollinator Hub

The requirements of the Open Research Europe policy of the European Commission (European Commission - RTD, 2024) are, to a great extent, implemented at the software level. Nonetheless, data preparation and standardisation still require considerable human input. For research data on the Hub to comply with the Open Research Europe policy, future efforts must focus on elaborating clearer guidelines and, in particular, on measures that increase the awareness of the correct preparation of data before archiving it on the EU Pollinator Hub. Scientists who participate in projects which require compliance with the Open Research Europe policy need more resources and knowledge to comply with the data and metadata quality requirements. To fulfil these requirements, support by quality managers or data managers should be provided, similar to the way operational activities of projects are handled over to project managers. The experience gained with the integration of the B-GOOD datasets in the EU Pollinator Hub was valuable and showed the importance of having an external peer-reviewing of the data. Indeed, in order to understand and possibly reuse data, it is key to provide high quality metadata.

The data structure, which is too often based on the logic of small-sized spreadsheets, made it difficult to integrate data into the EU Pollinator Hub structure, which is currently based on the logic of relational databases. This problem could be solved by giving higher visibility on the implementation of the existing guidelines in the workflow (see General Guidelines on Data preparation in the Guideline Directory of the EU Pollinator Hub). In addition, the permitted data structure could be extended, particularly to markup language-based or object-based data structures.

Even though automated procedures and the guided process at the software level may help to increase the speed of data integration and standardisation, as outlined before, considerable

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human input is still required. Permanent staff will inevitably be required to drive the standardisation process and to ensure the quality of the data assets that are integrated by data providers.

5. Communication and engagement aspects

The EU Pollinator Hub continuously develops by uploading new datasets and related data processing and visualisations. The EU Pollinator Hub seeks to acquire new users and data providers and to safeguard a sustainable user-growth environment. For this purpose, dedicated activities and tools were developed as follows:

- Platform communication and promotion to disseminate and seek new engagements;

- Platform use tutorials to facilitate its general use;

- End-user training to provide in-depth knowledge on the platform use, best practices, and tips and support in case of troubleshooting.

The above is further described hereafter.

5.1. Promotional material

Promotional audiovisual material has been created with an animated promotional video. This video displays a voiceover in English which is the main communication tool for the Hub (Figure 10). The promotional audiovisual material is composed of three video versions:

- a main 6 minutes 50 seconds version[67];

- a reduced 4-minute version[68];

- an abridged version targeted at social media[69]

The three promotional videos provide a sleek yet comprehensive overview of the platform's history and goals and a call to action for potential data providers and users.

The animation format transforms complex ideas and concepts into an accessible and attractive message. The video has been produced with an accompanying thumbnail image, and subtitle files are available in English, French, German, Italian and Spanish.

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67 https://www.youtube.com/watch?v=mb_VJGInaGg

68 https://youtu.be/2fB1fod0FZw
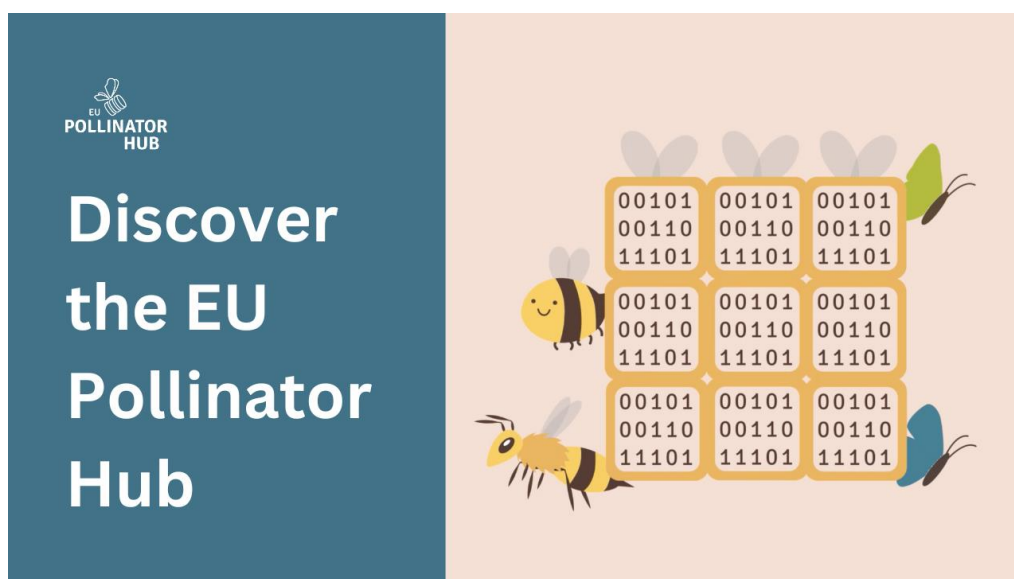
69 https://youtu.be/6pDP4ODNQhY

Figure 10:   EU Pollinator Hub Promotional Video[74]

A promotional article was drafted and circulated to be edited and published by specialised media, including the beekeeping magazines managed by BeeLife's members across Europe[70].

A series of blog entries have been made available on the presentation website to inform about the developments, collaborations, and other relevant information about the EU Pollinator Hub and matters related to the insect pollinator data.

The EU pollinator Hub has been promoted in various forums targeting relevant audiences, such as beekeeping or veterinary congresses, industry meetings, decision-making and institutional workshops and events, or international scientific congresses and workshops, but mainly in Europe. Public presentations have been conducted at major relevant events, including the EU Pollinator Week (in 2021[71] and 2023[72]) and the Apimondia International Apicultural Congress (2023[73]).

5.2. Tutorials

A tutorial video mixing voice-over narration and real Application use is available for users. The tutorial video explains in detail how to use the different features of the platform, including navigating datasets, using the Vocabulary, becoming a Data provider, and uploading datasets. A main tutorial video[74] has been produced, with different video sections published separately for

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70 https://pollinatorhub.eu/media/

71 https://www.pollinatorweek.eu/

72 https://www.eupollinatorweek.com/

73 https://apimondia2023.com/es/?p=program

74 Main tutorial video: https://youtu.be/-XpZ6kaJMM0

each main functionality (vocabulary[75], datasets[76], uploading datasets[77]). Each excerpt focuses on one of the three main functionalities of the EU Pollinator Hub App (discover datasets, vocabulary, and uploading datasets). These videos are available on BeeLife's YouTube channel and the EU Pollinator Hub App website.

Besides the main tutorial video, the training session recordings are also available to the public on the presentation page. These recordings provide insights into the three main functionalities of the app, explain in detail the logic behind them, and provide practical examples of how to best use them. The recordings also review minor troubleshooting practices, such as when errors occur while uploading data into the Hub. All these videos can be found on BeeLife's YouTube Channel and the EU Pollinator Hub App website.

5.3. Training

A total of six online training sessions have been organised for current testers, future users, data providers, and the general public along with the latest developmental process of the EU Bee Partnership. Registration was free. The first two training sessions aimed to provide guidance for best practices for data collection and cleaning. While the EU Pollinator Hub ensures the technical validity and quality of the datasets, some work remains to be done before the data can be uploaded on the platform. The first two training sessions occurred in 2022 and paved the way for those organised in 2023 and 2024 (Figure 11). The sessions dealt with how users can interact with the EU Pollinator Hub, its functionalities and the services it can provide to users.

The title of each session and the number of registrants for each session reads as:

- Online training session 1 (May 25, 2022) - Best practices for data collection: 99 registrants

- Online training session 2 (Nov 17, 2022) - Best practices for data cleaning: 32 registrants

- Online training session 3 (Sep 21, 2023) - Using the terminology vocabulary: 116 registrants

- Online training session 4 (Nov 16, 2023) - Uploading data in the Hub: 36 registrants

- Online training session 5 (Dec 14, 2023) - Using the data Hub: 75 registrants

- Online training session 6 (Jan 25, 2024) - Making the most out of my data in the hub: 61 registrants

Although training sessions were conceived as a single-directional flow of information from the development team to the participants, we noticed room to grow and improve interactions with

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75 Browsing and using terminology Vocabulary: https://youtu.be/HW60kBrIdWw
76 Navigating datasets: https://youtu.be/YlRF16TYC60
77 Uploading datasets: https://youtu.be/YNTI_capc1k

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potential users through these events. Online training sessions were also valuable spaces to stimulate discussion, interact with participants, and gather important feedback on the platform.

As specified above, recordings from the online training sessions are made available and a dedicated YouTube playlist has been created and added to a blog entry.

Finally, several Pollinator Standardisation Workshops have been organised during the different developmental phases of the EU Pollinator Hub, from the PoC to the Operational Platform. Through these, we gain knowledge about the pains and gains of potential users (Table 1), but also recommendations for feature development, information about engagement willingness and active engagement. The last workshop aimed at stimulating interdisciplinary and diverse exchanges. Experts from field practice, industry, institutions, academia and civil society participated and shared their views, which were published as a report[78].
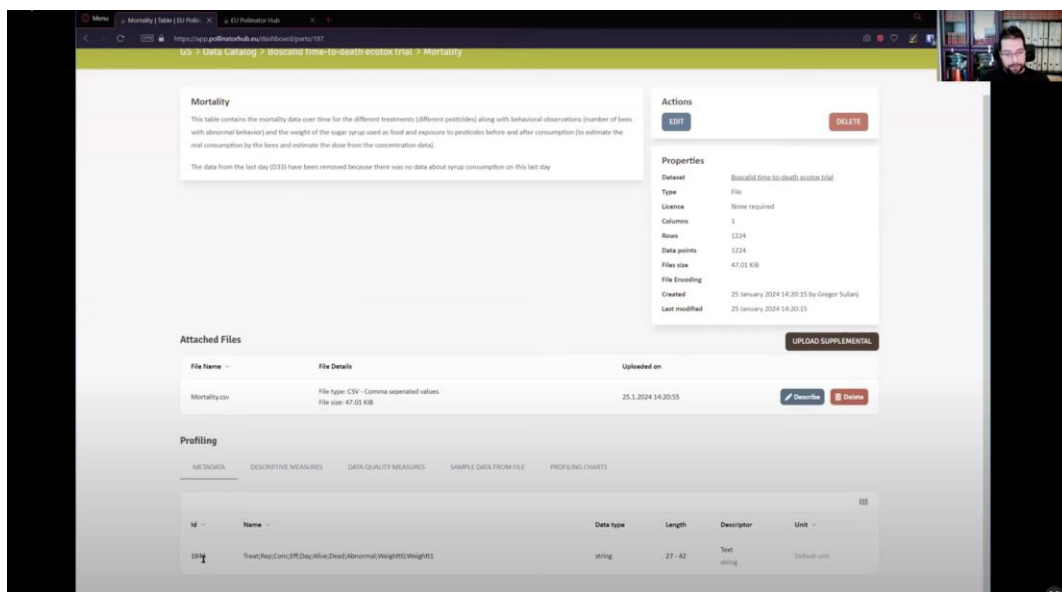
Figure 11:   Screenshot from one of the online training sessions

5.4 Engagement with Institutions

The EU Pollinator Hub is a tool commissioned by EFSA under the governance of the EU Bee Partnership. As has already been mentioned, it follows the EU and international legislation related to Open Science and allows the work of others to comply with Open Science. Extensive efforts have been devoted to engaging with other institutions, namely the European Commission

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78 https://www.bee-life.eu/_files/ugd/8e8ea4_7edeecb6d4d94daab2329890430211bf.pdf

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(DG Agriculture, Environment, Research and Santé), the European Parliament (who requested its creation initially, accessing the roll votes of pollinator-relevant pieces of legislation and initiative reports and requesting their support) other executive agencies, such as the EU Reference Laboratory for bee health, the European Environmental Agency, the European Chemical Agency or the European Medicament Agency.

International institutions have also been engaged during the discussions and activities, such as the Food and Agriculture Organization (FAO), which, in collaboration with Apimondia, is currently seeking to build up a pollinator data platform at the worldwide level. Many of their worldwide datasets have also been referred to in the EU Pollinator Hub, for they are relevant to pollinators, agriculture, crop yields and practices, *etc*. The EU Pollinator Hub contains all the necessary information, features, and functionalities to meet the requirements of an international platform. It allows for collaboration and high-quality open standards that such a platform would require. FAO continues its development of such an international pollinator platform and has acknowledged the existence of the EU Pollinator Hub.

The World Organization Animal Health (WOAH) was also contacted, seeking collaboration in exchanges of health data related to honey bee health. This institution receives information from countries on notifiable diseases which they report in the WAHIS database (https://wahis.woah.org/#/home) and therefore have no interest in another reporting database such as the EU Pollinator Hub. Exchanges have also been held with national health authorities, either bilaterally or in EU fora (EFSA activities with EU Member States, participation of EFSA in Standing Committee on Plants, Animal, Food and Feed (ScoPAFF), a managing body composed of European Commission, DG Sante, and Member States). The EU Pollinator Hub was originally designed as a tool developed by stakeholders (*i.e.* beekeepers, farmers, veterinarians, NGOs, industry, academia, risk assessors, the public and policy makers) for their sole benefit. However, the EU Pollinator Hub still lack a legal basis to ensure its sustainability in the longer-term.

Multiple exchanges have been done with research consortia participating in EU research projects (*e.g.,* PoshBee, WildPosh, PollinERA, B-GOOD, BeeGuards, Better-B, SafeGuard, INSIGNIA, VALOR, Butterfly, *etc*.) offering the projects at their starting phase to host the data, while we ensure the data quality and compliance with FAIR principles. Most of these projects created their data repository/Hub as a requirement imposed by the research program to comply with Open Science. However, given the experience with the B-GOOD data, even if the project's data is put in an open repository, it is not open, and its quality is not proven. This information has been conveyed to the relevant units in the European Commission. Experts from other fields have acknowledged their interest in the infrastructure, procedures and features developed for the EU Pollinator Hub and would be willing to reproduce a similar system for their topics.

6. Conclusions

After five years of development, the EU Pollinator Hub has become operational as a data-sharing, standardisation, processing and visualisation platform, moving further towards implementing a systems-based approach to insect pollinators.

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With this tool, monitoring and surveillance data are merged with other data from applied research and fundamental data in an interoperable way, allowing other decision support systems to be implemented. It is expected that, in the coming years, there will be datasets and modelling tools becoming available (*e.g.*, population models for honey bees, bumble bees and solitary bees (Becher et al., 2014, 2018; Brown et al., 2021; Duan et al., 2022, 2025, in press; Ziółkowska et al., 2023). This paramount milestone will enable the promotion of a wide pollinator community, promoting the understanding of the context in which pollinators develop. For examples, landscape composition, climate, farming practices, *etc*. It will also help monitoring and assessing the efficacy of the efforts performed at different levels to preserve pollinators and those who live from them.

The Hub allows centralised harmonised data, linking it with methods and tools gathered in an accessible environment. This environment is available to all actors, fostering trust in the system. The creation of the XML data format BeeXML in collaboration with the Apimondia working group on *Standardization of data on bees and beekeeping* (Cazier et al. 2018a, 2018b, 2020), has been an important by-product of the EU Pollinator Hub. Other by-products have been the generation of a specialised technical terms database, translated into several languages, and a specialised encyclopaedia. The building process of the Hub has also been the germ of a growing community of stakeholders around insect pollinators, who constructively collaborated in this data-sharing approach despite their different societal perspectives. In doing so, authorities, field practitioners, academia, industry and civil society sat together to share their views and needs, hopefully creating the required understanding to deal with the complexity of the insect pollinator data and context.

Wisely used, it avoids effort duplication and the possibility of identifying key actors related to specific topics, as they would either be more contributing, consulting or consuming specific data. However, the EU Pollinator Hub is still in its early stages. In the current phase, the foundation and structure of the building have been established. Its usefulness at all levels will grow with an increasing involvement of the data providers, enabling further development of its functionalities. The current development paves the way for increased data hunting and creating an online community around insect pollinator data. Experts from other fields (*e.g.* farmed animal health and welfare) are facing a similar situation with scattered data generation, different levels of trust and engagement among stakeholders, and with diverse definitions and quality standards. The infrastructure, processes and features developed within the EU Pollinator Hub and during its development could be adapted to no matter which field. The expertise in the vocabulary determination and peer reviewing should, however, be adapted to the respective field to tailor-make the system. The stakeholders' engagement and experience has been instrumental for the Hub development and should continue, so that stakeholders promote the use of this community tool.

7. Perspectives

In the ever-expanding landscape of scientific research and data-driven innovation, we stand at a critical juncture where data quality, reusability, and interoperability can make the difference between breakthrough discoveries and missed opportunities. The EU Pollinator Hub is a

groundbreaking solution that addresses the most pressing challenges in data management: a public data repository that sets a new standard for the handling of scientific data on pollinators.

At this stage, it would be recommendable to invest further in strategising data acquisition, harmonisation, and management, which includes data hunting and curation phases to enrich the centralisation of the data in the Hub. Data is yet too scattered, not standardised and still not FAIR so that stakeholders, including decision-makers, can use it for their respective activities, such as risk assessment or risk management. Indeed, a recent work developed for EFSA on the setting of a roadmap for action on the Environmental Risk Assessment of chemicals for insect pollinators (IPOL-ERA) (Williams et al., 2023) concluded the need for a data framework towards the implementation of a systems ERA for insect pollinators. This framework has the following objectives *"[...] 1. To provide support for infrastructure development and human resources to existing data hubs involved in data acquisition, management, curation, and standardisation; 2. To broaden data acquisition efforts to include local, national, and European contexts, ensuring a comprehensive dataset for the system-based ERA framework; 3. To support data standardisation and centralisation to enable easy retrieval and reusability for various purposes within the ERA approach [...]"*.

Researchers across disciplines face the challenge of navigating through large datasets with varying levels of reliability, accessibility, and usability. To enhance this process, the EU Pollinator Hub offers a robust framework that ensures data quality, compliance with FAIR principles, and standardisation, breaking down barriers between disciplines and research domains. Thanks to the Hub, anyone interested in pollinator data can trust the data quality they access, contributing to a global, transparent, interconnected research ecosystem while saving time by eliminating data cleaning and reformatting.

Apart from investing in data hunting, standardisation and curation, it will be necessary to deploy a specific Hub governance structure to integrate the relevant stakeholders with the potential to contribute to the common efforts. The cross-cutting responsibilities of different stakeholders in the pollinators' well-being by allowing a quantity and quality of habitat to them (*e.g.*, nesting sites, agricultural, park/garden, urban practices, fertiliser or pesticide use, veterinary medicine use, *etc.*) reveal an inter-dependency of all actors. To know the actual status of pollinators, their threats and the potential socio-economic impacts of the situation, it may be necessary to establish a governance framework that continues the logic developed by the EU Bee Partnership but enlarges it to stakeholders dealing with topics related to insect pollinators. Institutional actors need access to the data from field or academia stakeholders, and the knowledge/expertise may be too niche to develop further the pollinator network contributing to the Hub. On the other hand, according to the experience gained during the five years of the platform development, institutional actors will require official recognition of the infrastructure to ease their data sharing. Indeed, national and regional public authorities require official guidelines or a legal basis to use the EU Pollinator Hub. Institutions funding public research will need to comply with the Open Data Act requirements and make the publication of the studies' results and data generated in Open Access platforms, complying with FAIR principles, within a time frame allowing researchers a definite time to publish their work (*e.g.*, 6 months, currently Horizon Europe establishes an "as soon as possible" data publication policy (OpenAIRE, 2022). As experienced with the B-GOOD

case-study, the data peer reviewing will need to become a common practice. Data is an asset for researchers, and unfortunately, as a result, too much data remains unpublished and inaccessible to the public. Therefore, a dialogue with these institutions on their needed implication and engagement in the governance of the EU Pollinator Hub is essential. In addition, field practitioners, such as farmers, beekeepers, naturalists or advisors (veterinarians, agronomists, *etc*.), feed the platform with real-life data, multiplying the amount of monitoring data points available. They can also contribute with socio-economic data and values to be integrated into the platform. Suppliers of non-invasive pollinator monitoring data may be key data suppliers as well, but often require specific funding to develop Automated Programming Interfaces (APIs) to link their solutions with the EU Pollinator Hub and *vice versa*. The EU Pollinator Hub or its standards could support the environmental risk assessment process, but the terms and formalisation of this process would need a dialogue with involved stakeholders. The EU Pollinator Hub could, therefore, benefit from a governance framework engaging a wide diversity and multidisciplinary group of stakeholders (*i.e.*, field operators, NGOs, industry, academia, EU and National risk assessors, risk managers and policy makers).

Different collectives or stakeholder groups will require adapted engagement and action to match their specific needs/realities. Field practitioners, for example, require more training, accompaniment, and guidance already in data collection and cleaning, let aside the uploading of data in the Hub or standardising data. It would be ideal to integrate a budgetary line for data preparation and communication in publicly funded projects and initiatives, with the founders recommending the specific platforms where they would like the data to be stored/published. Academia requires insurance about the publication tools, data access control and tools allowing them to work as a close team, given the large research consortia currently exist. BeeLife has recently engaged with various research projects, such as PollinERA, B-GOOD, Better-B, WildPosh, SafeGuard and BeSafeBeeHoney, to support the research activities allowing data curation from the start of the project development, rather than at the end of the project (as it is usually the case). In doing so, there is already a FAIR formatting of all the datasets generated by these projects. Reviewing the data from these consortia as an external reviewer improves the data quality and renders it open and compliant with FAIR principles. However, the time and expertise devoted to this task should not be underestimated (e.g., the peer reviewing of the B-GOOD datasets took a 5 months full-time employment expert). Given the results, it would be advisable for institutions to invest in data verification services to ensure that public money is invested in real Open Science. It would also be advisable that researchers get trained in data management and communication during their education.

During the latest development from prototyping to operationalisation of the platform, a great deal of technological and procedural development was achieved, leading to an operational platform. However, the team considers that a list of additional tasks remains in the pipeline for future development to improve the functionalities and user experience of the EU Pollinator Hub. These tasks involve, for example, data processing, analysis, visualisation and reporting beyond the functionalities of the current platform, further automatisation, a specific translator interface, tools/procedures to continuously analyse users' behavioural data and incorporate these analyses in the platform development and promotion strategy, boosting the experience and versatility of

the features. This upgrading will require additional resources in terms of time and personnel and, depending on the analysis required, additional software development and hosting capacities.

This raises the issue of the EU Pollinator Hub's future sustainability, not only for its maintenance but also for its further development and enrichment. The EU Pollinator Hub has been built as a non-profit scheme. However, resources are needed to continue developing it, integrating datasets, and maintaining the infrastructure created.

As much as the EU Pollinator Hub will get richer in data, tools and approaches already developed or proposed (for example, by Becher et al., 2014, 2018; Brown et al., 2021; Duan et al., 2022, in press; or Ziółkowska et al., 2023), integrating the advances in artificial intelligence and modelling, will enable the enrichment of the Hub. Indeed, in the long run, improving the conditions for insect pollinators will require integrating an ERA systems-based approach for insect pollinators in a planned and coordinated way across Europe. The EU Pollinator Hub is a key milestone paving the way for this transition.

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References

Becher MA, Grimm V, Thorbek P, Horn J, Kennedy PJ, and Osborne JL, 2014. BEEHAVE: A systems model of honeybee colony dynamics and foraging to explore multifactorial causes of colony failure. Journal of Applied Ecology, 51(2), 470–482.

Becher MA, Twiston-Davies G, Penny TD, Goulson D, Rotheray EL and Osborne JL, 2018. Bumble-BEEHAVE: A systems model for exploring multifactorial causes of bumblebee decline at individual, colony, population and community level. Journal of Applied Ecology, 55(6), 2531–3010. https://doi.org/DOI:10.1111/1365-2664.13165

Bersani C, Codagnone J, David L, Fioniotis A, Galasso G, Mancini S, Michieletti R, Orphanidou C, and Pellegrino M, 2022. Roadmap for Actions on Artificial Intelligence for Evidence Management in Risk Assessment. EFSA Supporting Publications 19, no. 5: 7339E. https://doi.org/10.2903/sp.efsa.2022.EN-7339.

BeeXML – Exchanging Data about Bees and Beekeeping. (n.d.). Retrieved 1 April 2021, from http://beexml.org/

BeeXML: Exchanging Data about Bees and Beekeeping - Gemeinschaft / Community / Other projects. (2020, October 7). Hive eyes. https://community.hiveeyes.org/t/beexml-exchanging-data-about-bees-and-beekeeping/3528

B-GOOD. B-GOOD Bee Health Data Portal. [Online] 2024. [Zitat vom: 12. 11 2024.] https://beehealthdata.org.

Brown M, Breeze T, Bulet P, Chauzat MP, Demirova I, De Miranda J, Klein AM, Mand M, Metodiev T, Michez D, Nazzi F, Neumann P, Paxton R, Potts S, Stout J, Turney G and Yañez O, 2021. PoshBee: Pan-European Assessment, Monitoring, and Mitigation of Stressors on the Health of Bees [Preprint]. Research Ideas and Outcomes. https://doi.org/10.3897/arphapreprints.e72231

Cazier J and Haefeker W, 2018a. BeeXML Part I: The power of big data and analytics. Bee Culture OCT 2018, 30-34. www.beeculture.com/october-2018

Cazier J, Haefeker W, Hassler E, 2018b. BeeXML Part II: Achieving the goal of standardized data. Bee Culture NOV 2018, 26-30. www.beeculture.com/november-2018

Cazier J, Haefeker, W, & Hassler, E., 2018c. Data sharing risks and rewards for hobbyist beekeepers. Bee Culture, 12, 23–30.

Cazier J and Bruneau E, 2020. Standardizing data in bees and beekeeping. Bee Culture NOV 2020, 89. www.beeculture.com/november-2020

Commission Implementing Regulation (EU) 2023/138 of 21 December 2022 laying down a list of specific high-value datasets and the arrangements for their publication and re-use (Text with EEA relevance), 019 OJ L. http://data.europa.eu/eli/reg_impl/2023/138/oj/eng

Devos Y, De Sanctis G, Neri FM and Messéan A, 2021. EFSA is working to advance the environmental risk assessment of genetically modified crops to better protect butterflies and moths. EFSA Journal, 19(4).

DGI, 2024. The DGI Data Governance Framework. [Accessed 2024-02-02]. datagovernance.com

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Duan X, Wallis D, Hatjina F, Simon-Delso N, Bruun Jensen A, and Topping CJ, 2022. ApisRAM Formal Model Description. EFSA Supporting Publications, 19(2), 7184E. https://doi.org/10.2903/sp.efsa.2022.EN-7184

Duan X, Poulsen T, Xie L, Kondrup Marcussen L, and Topping CJ, in press. The third version of an agent-based honey bee colony model (ApisRAM.03) supported by a landscape pesticide model for the risk assessment of pesticides. EFSA supporting publication.

Dupont YL, Capela N, Kryger P, Alves J, Axelsen JA, Mette GB, Marianne B, Silvia C, Julie F, Geoff BG, Annika SJ, Birgit LK, Sara, L., Pinto A., da Silva Antonio A, Beate S, Sorensen, PB, and Sousa, JP, 2021. Research project on field data collection for honey bee colony model evaluation. EFSA Supporting Publications, 18(7), 6695E. https://doi.org/10.2903/sp.efsa.2021.EN-6695

EFSA, 2016. Assessing the health status of managed honeybee colonies (HEALTHY-B): A toolbox to facilitate harmonised data collection. EFSA Journal, 14(10), e04578. https://doi.org/10.2903/j.efsa.2016.4578

EFSA, 2017. Specifications for field data collection contributing to honey bee model corroboration and verification. EFSA Supporting Publications, 14(5), 1234E. https://doi.org/10.2903/sp.efsa.2017.EN-1234

EFSA, 2018. Terms of reference for an EU Bee Partnership. EFSA Supporting Publications, 15(5), 1423E. https://doi.org/10.2903/sp.efsa.2018.EN-1423

EFSA et al., 2017. Collecting and sharing data on bee health: Towards a European Bee Partnership. EFSA Supporting Publications, 14(9), 1299E. https://doi.org/10.2903/sp.efsa.2017.EN-1299

EFSA, 2022. 'Theme (Concept) Paper – Advancing the Environmental Risk Assessment of Chemicals to Better Protect Insect Pollinators (IPol-ERA)'. EFSA Supporting Publications 19, no. 5: E200505E. https://doi.org/10.2903/sp.efsa.2022.e200505

EFSA Scientific Committee, More S, Bampidis V, Benford D, Bragard C,Halldorsson T, Hernandez-Jerez A, Bennekou SH, Koutsoumanis K, Machera K, Naegeli H, Nielsen SS,Schlatter J, Schrenk D, Silano V, Turck D, Younes M, Arnold G, Dorne J-L, Maggiore A, Pagani S,Szentes C, Terry S, Tosi S, Vrbos D, Zamariola G and Rortais A, 2021. Scientific Opinion on a systems-based approach to the environmental risk assessment of multiple stressors in honey bees. EFSAJournal 2021;19(5):6607, 75 pp. https://doi.org/10.2903/j.efsa.2021.6607

European Parliament, 2017. 'The European Week of Bees and Pollination Event Report'. Brussels (Belgium)

European Commission. Giving Beekeeping Guidance by cOmputatiOnal-assisted Decision making. CORDIS - EU research results. [Online] Publications Office of the European Union, 09. 07 2024. [Accessed on: 13. 11 2024.] https://cordis.europa.eu/project/id/817622

European Commission, Directorate-General for DG RTD. 'Open Data, Software and Code Guidelines (PSE) | Open Research Europe. [Online]', 2024. https://open-research-europe.ec.europa.eu/for-authors/open-data-software-and-code-guidelines-pse. ISSN: 2732-5121.

EU Pollinator Hub

FAO, OIE, WHO, UNSIC, UNICEF, & The World Bank, 2008. Contributing to One World, One Health. A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal–Human–Ecosystems Interface.

GFISCO, 2024. FAIR Guiding Principles for scientific data management and stewardship. [Accessed 2024-02-02]. www.go-fair.org

Goodwin K, 2011. Designing for the digital age: How to create human-centered products and services. John Wiley & Sons. https://books.google.es/books?hl=en&lr=&id=yH6Aqr5zKJEC&oi=fnd&pg=PR23&dq=Goodwin+K,+2009.+Designing+for+the+digital+age.+Wiley+Publishing+Publishing+Inc.&ots=IJDF6_Jgto&sig=Kjhy9IgwTMHXeHIMcp1aJ_8eis4

HojsiK M, Simon Delso N, Salazar Abello A, Paulus J, Guteland J, Ries F, Mazylis L, et al., 2021. 'EU Pollinator Week 2021 Event Report. A New Deal for Pollinators'. Brussels (Belgium). https://www.pollinatorweek.eu/resources#other.

IoBee | IoT application, n.d. Retrieved 1 April 2021, from https://io-bee.eu/

ISO, 2022. ISO/IEC 27001:2022. ISO. https://www.iso.org/standard/27001

Laurent M, Hendrikx P, Ribiere M, Chauzat MP, and Epilobee consortium, 2016. 'A Pan-European Epidemiological Study on Honeybee Colony Losses 2012-2014'. ANSES, 13 January 2016.

More S, Auteri D, Rortais A and Pagani S, 2021. EFSA is working to protect bees and shape the future of environmental risk assessment. EFSA Journal, 19(1), e190101. https://doi.org/10.2903/j.efsa.2021.e190101

More S, Bampidis V, Benford D, Bragard C, Halldorsson T, Hernández-Jerez A, Bennekou SH, Koutsoumanis K, Machera K, Naegeli H, Nielsen SS, Schlatter J, Schrenk D, Silano V, Turck D, Younes M, Arnold G, Dorne JL, Maggiore A, … Rortais A, 2021. A systems-based approach to the environmental risk assessment of multiple stressors in honey bees. EFSA Journal, 19(5), e06607. https://doi.org/10.2903/j.efsa.2021.6607

Rortais A, Arnold G, Dorne JL, More SJ, Sperandio G, Streissl F, Szentes C and Verdonck F, 2017. Risk assessment of pesticides and other stressors in bees: Principles, data gaps and perspectives from the European Food Safety Authority. Science of the Total Environment, 587, 524–537.

Simon Delso N, Sušanj G and Salazar Abello A, 2021. The EU Bee Partnership (EUBP) Prototype Platform: Data model description. EFSA Supporting Publications, 18(7), 6694E.

Sousa JP, Aldrich A, Axelman J, Backhaus T, Brendel S, Dorronsoro B, Duquesne S, Focks A, Holz S, Knillmann S, Pieper S, Schmied-Tobies M, Silva E, Topping C, Wipfler L and Williams J, 2022. Building a European Partnership for next generation, systems-based Environmental Risk Assessment (PERA). EFSA Supporting Publications, 19(8), 7546E. https://doi.org/10.2903/sp.efsa.2022.EN-7546

TDWG 2024 Darwin Core. [Accessed 2024-02-02]. dwc.tdwg.org

Williams JH, Bordoni A, Bednarska A, Pinto A, Martins CAH, Henriques D, Sgolastra F, Knapp J, Loureiro J, Sousa JP, Gócs K, Marcussen LK, Rundlöf M, von Post M, Castro M, Mølgaard N,

EU Pollinator Hub

Simon N, Capela N, Thomsen P, … Topping CJ, 2023. Roadmap for action on the environmental risk assessment of chemicals for insect pollinators (IPol-ERA). EFSA Supporting Publications, 20(11), 8431E. https://doi.org/10.2903/sp.efsa.2023.EN-8431

Ziółkowska E, Bednarska A, Laskowski R, and Topping C, 2023. The Formal Model for the solitary bee Osmia bicornis L. agent-based model. Food and Ecological Systems Modelling Journal, 4, e102102. https://doi.org/10.3897/fmj.4.102102

Abbreviations

API	Application Programming Interface
BIPM	Bureau International des Poids et Mesures
COLOSS	Prevention of honey bee COlony LOSSes
CRA-W	Centre de Recherches Agronomiques - Wallonie
CSL	Citation Markup Language
CSV	Comma Separated Values
DGF	Data Governance Framework
D.O.O.	Družba z Omejeno Odgovornostjo (in Slovenian private limited company)
DR	Dataset Report
EFSA	European Food Safety Authority
ESA	European space Agency
EU	European Union
EUBP	EU Bee Partnership
EUBPPP	EU Bee Partnership Prototype Platform
EUPH	EU Pollinator Hub
FAIR	Findability, Accessibility, Interoperability, and Reuse of digital assets
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	FAO Statistic Database
FSDN	Farm Sustainability Data Network
GBIF	Global Biodiversity Information Facility
GDPR	General Data Protection Regulation
GIS	Geographical Information System
GLP	Good Laboratory Practice
GFP	Good Field Practice, derived from the application of the GLP principles to field studies
HTML	Hypertext Markup Language
HTTPS	Hypertext Transfer Protocol Secure
ISO	International Organization for Standardization
JSON	JavaScript Object Notation
LPIS	Land Parcel Information System
MUST-B	Multiple Stressors in Bees
NCEI	National Centres for Environmental Information
NGO	Non-Governmental Organisation
NMDS	Non-Metric Dimensional Scaling
NUTS	Nomenclature of territorial units for statistics

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OAuth	Open Authorization
OIE/WOAH	World Organisation for Animal Health
PHP	Hypertext Preprocessor
QMS	Quality Management System
RAID	Redundant Array of Inexpensive Disks
R&D	Research and Development
SAIO	Statistics on Agricultural Inputs and Outputs
SAML	Security Assertion Markup Language
SI	International System of Units
SIEM	Security Information and Event Management
SOP	Standard Operating Procedure
SQL	Structured Query Language
UID	Unique and persistent Identifier
UN	United Nations
UNSD	UN Statistics Division
UPN	User Principal Name
URL	Uniform Resource Locator
UPS	Uninterruptible Power Supply
WOAH	World Organisation for Animal Health
WCO	World Customs Organization
WG	Working Group
WI	Work Instruction
XML	Extensible Markup Language

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Appendix A– Data providers and sources

A.1. Verified datasets

UID	Title	Data Provider
NNICA10.0.0	Development of bee colonies in areas exposed to high levels of neonicotinoid pesticides. [published on 2023-12-18]	Steirischer Landesverband für Bienenzucht, Austria
VTCSS14.0.0	Reports of notifiable diseases reported for Apis mellifera. [published on 2023-06-13]	Biene Österreich – Imkereidachverband, Austria, and CARI, Belgium
BKPNG8.0.0	Collection of data related to honey bees in Austria. [published on 2023-12-01]	Biene Österreich – Imkereidachverband, Austria
VRRMN16.0.0	Results from a Varroa monitoring program in various apiaries in Austria [published on 2023-12-13]	Biene Österreich – Imkereidachverband, Austria
HVSCL51.0.0	A collection of hive scales data from Austria. [published on 2023-12-17]	Biene Österreich – Imkereidachverband, Austria
MUSTB76.0.0	EU efforts towards the development of a holistic approach for the risk assessment on Multiple Stressors in Bees [published on 2023-12-06]	European Food Safety Authority
DVSNS29.0.0	Division of the national territory of Austria according to different criteria. [published on 2023-04-14]	EU Pollinator Hub
HVSCL21.0.0	Network of hive scales: Piemonte.	Aspromiele, Italy

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In the pipeline	Network of hive scales: Slovenia	Slovenian Beekeepers Association, Slovenia
In the pipeline	Corine Landcover data	EU
HVSCL24.0.0	Network of hive scales	Osservatorio nazionale dei miele, Italy
FSTTM9.0.0	Definitions and standards used in FAOSTAT [published on 2024-03-09]	EU Pollinator Hub
FSTTL93.0.0	FAOSTAT Land Cover. [published on 2024-03-09]	EU Pollinator Hub
BSCLD32.0.0	Time-to-death approach to reveal chronic and cumulative toxicity of a fungicide for honeybees not revealed with the standard the-day test	Simon Delso, N and San Martin, G.
VRRMN15.0.0	Results from Varroa monitoring program in various apiaries in Italy	UNAAPI, Italy
CRTVS35.0.0	Data on colony development in the control group of a field trial S16-01455	Corteva, US
CRTVS53.0.0	Data on colony development in the control group of a field trial S18-00591	Corteva, US
SNITS17.0.0	A selection of SI units provided by the Bureau International des Poids et Mesures (BIPM) [published on 2022-11-23]	EU Pollinator Hub
CLNYD84.0.0	Brood nest measurements in hives kept in various apiaries in the surroundings of Graz/in Austria during autumn 2013. [published on	Steirischer Landesverband für Bienenzucht, Austria

2023-12-16]

HNYPR6.0.0	Honey production in Austria [published on 2023-04-17]	Biene Österreich – Imkereidachverband, Austria
PLLNT11.0.0	Data on economic dependence of pollination by animals in crops as well as observations of pollinators on plant species, in particular, crops. [published on 2023-07-26]	EU Pollinator Hub
NUTSA3.0.0	Nomenclature of territorial units for statistics [published on 2023-04-02]	EU Pollinator Hub
RGLTN80.0.0	The Harmonised Classification of substances according to Regulation (EU) 2017/269 amending Regulation (EC) No 1185/2009. [Published on 2023-12-14]	EU Pollinator Hub
BGDBN192.0.0	19 Datasets coming from the EU Research Project B-Good, obtained from https://beehealthdata.com	B-Good Project Datasets

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A.2. Not accessible by BeeLife (on November 2024)

No.	Name	Data provider
001	Insignia-bee project	DG Santé, EU (2024)
002	PoshBee	PoshBee Consortium, UK
003	COLOSS honey bee colony winter losses	COLOSS association
004	Insignia- Europe project	DG Environment, EU (2025)
005	ABLE project	DG Environment, EU (2025)
006	SPRING project	DG Environment, EU (??)
007	Hivescales Broodminder	Broodminder, Worldwide
008	Hivescales Wolfwaagen	Wolfwaagen, EU
009	EPPO Global Database	EPPO, European and Mediterranean

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Appendix B - List of SOPs and Wis

B.1. List of SOPs

STANDARDS OPERATING PROCEDURES[79]		
SOP	**Name**	**Title**
001	SOP instructions	Instructions for drafting, releasing and revising Standard Operating Procedures (SOP) by the EU Pollinator Hub.
002	WI instructions	Instructions for drafting, releasing and revising Work Instructions (WI) by the EU Pollinator Hub.
003	DR instructions	Instructions for creating a Dataset Report (DR) hosted on the EU Pollinator Hub.
004	Organisation chart	Procedure for the assignment and revocation of tasks and responsibilities among the EU Pollinator Hub team.
006	Dataset preparation	Instructions for the preparation of datasets for integration into the EU Pollinator Hub.
007	Data profiling	Instructions for profiling of datasets hosted on the EU Pollinator Hub.
008	Data cleansing	Procedure for the cleaning of data to be integrated on the EU Pollinator Hub.
009	Methods	Requirements for the drafting of methods used on the EU Pollinator Hub.
010	Data governance	Implementation of a data governance framework on the EU Pollinator Hub.

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79 Quality asset directory: https://app.pollinatorhub.eu/pages/sop-directory

011	Data protection	Procedure for protecting data hosted on the EU Pollinator Hub.
012	Data standardisation	Procedure for the standardisation of information assets on the EU Pollinator Hub
013	Data classification	Procedure for classifying datasets hosted on the EU Pollinator Hub
014	Data asset rating	Implementation and maintenance of a rating scheme for data assets on the EU Pollinator Hub.
015	Peer reviewing	Procedure for the peer-reviewing datasets hosted on the EU Pollinator Hub.
016	Release management	Procedure to create and update information and quality assets on the EU Pollinator Hub.
017	Dataset integration	Procedure for integrating datasets on the EU Pollinator Hub.
018	Data exploration	Procedure for data exploration on data hosted on the EU Pollinator Hub.
019	Data visualisation	Procedure for visualising data on the EU Pollinator Hub
020	Issue management	Procedure for managing complaints and issues observed by team members and users of the EU Pollinator Hub.
021	Change management	Procedure for the implementation, documentation and notification of software changes on the EU Pollinator Hub.
022	External contents	Procedure to display citations to external contents on the EU Pollinator Hub.
023	Method validation	Procedure for the validation of analytical methods.

024	Obsolescence of links	Monitoring of the validity of links to external contents on the EU Pollinator Hub
025	Data quality audit	Procedure for carrying out an audit for data quality.
026	Data security audit	Procedure for carrying out an audit for data security.
027	System maintenance	Procedures to be followed in case of maintenance to ensure the system to keep operating as expected.
028	User management	Procedure for the management of users of the EU Pollinator Hub.
029	Guideline Directory	Maintenance of a Guideline Directory for data collection and analysis

B.2. List of Wis

WORK INSTRUCTIONS[80]		
WI	**Name**	**Title**
001	R Run code	Run code in an R script.
002	Raw data preparation	Preparation of files of raw data for import into the preparation and profiling tool.
003	pMA Setup	Setting up of the software application phpMyAdmin for manual preparation of datasets.
004	pMA Data Import	Import of files into the database administration tool phpMyAdmin.
005	pMA Profiling	Profiling of datasets using phpMyAdmin.
006	pMA Start	Starting the database administration tool phpMyAdmin.
007	Citation management	Instruction for the management of bibliographic information and their import from external sources to the EU Pollinator Hub.
008	Link directory	Maintenance of a directory for external links.
009	Registration	Registration of users on the EU Pollinator Hub application.
010	Product Directory	Maintenance of the Product Directory on the EU Pollinator Hub.
011	Organisation management	Definition, assignment/retirement of/from skills and roles using the EU Pollinator Hub platform management application.
012	R Compile report	Compile a report from an R script.
13	Data description	Description of a data file uploaded to a dataset on the EU Pollinator Hub.

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80 Quality asset directory: https://app.pollinatorhub.eu/pages/method-directory

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014	Vocabulary management	Instructions for the management of classes and their definition in the standardisation process by the process manager.
015	Translation management	Management of translations of classes in the standardisation process by the process manager.
016	Vocabulary application	Using the vocabulary in the standardisation process by users.
017	Blurring coordinates	Methods for blurring spatial reference systems on the EU Pollinator Hub.
018	Issue submission	Submission of issues that have occurred with the EU Pollinator Hub using GitLab.
019	Access platform management	Accessing the platform management module of the EU Pollinator Hub.
020	Roles and tasks	Definition of roles and tasks in the organisation using the EU Pollinator Hub platform management application.
021	Text editing	Use of text editors on the EU Pollinator Hub.
022	Discussion management	Management of the discussion process within the standardisation process by a process manager.
023	Data Profiling	Using the data profiling tool on the EU Pollinator Hub.
024	Access application	Accessing the EU Pollinator Hub application.
025	Dataset creation	Creation of new datasets on the EU Pollinator Hub.
026	Table creation	Creation of new tables within datasets on the EU Pollinator Hub.
027	Upload data	Uploading data to data tables on the EU Pollinator Hub.
028	Upload metadata	Uploading metadata to tables on the EU Pollinator Hub.
029	R Setup	Setting up of the software application R for manual preparation of a dataset and reporting.
030	R Open script	Open an R script and change the working directory.

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Appendix C - List of B-GOOD Data Reports

STANDARDS OPERATING PROCEDURES[81]		
Report	**Title**	**Link to Dataset with access to Report**
001	Dataset Report - B-Good Counter Data	https://app.pollinatorhub.eu/dashboard/datasets/176
002	Dataset Report - B-Good Health Monitoring	https://app.pollinatorhub.eu/dashboard/datasets/178
003	Dataset Report - B-Good CO2 Gas Measures	https://app.pollinatorhub.eu/dashboard/datasets/179
004	Dataset Report - B-Good Weather Data	https://app.pollinatorhub.eu/dashboard/datasets/180
005	Dataset Report - B-Good WP1 Tier 1 Data 2020	https://app.pollinatorhub.eu/dashboard/datasets/181
006	Dataset Report - B-Good WP1 Tier 1 Data 2022	https://app.pollinatorhub.eu/dashboard/datasets/186
007	Dataset Report - B-Good WP1 Tier 1 Data 2021	https://app.pollinatorhub.eu/dashboard/datasets/185
008	Dataset Report - B-Good WP1 Tier 2 Data 2022	https://app.pollinatorhub.eu/dashboard/datasets/187
009	Dataset Report - B-Good WP1 Tier 3 Data 2022	https://app.pollinatorhub.eu/dashboard/datasets/188
010	Dataset Report - B-Good BioEUNIS	https://app.pollinatorhub.eu/dataset-discovery/BGDBN192.0.0
011	Dataset Report - B-Good WP4 Stakeholder Survey	https://app.pollinatorhub.eu/dashboard/datasets/190
012	Dataset Report - B-Good WP4 Beekeeper Survey	https://app.pollinatorhub.eu/dashbord/datasets/191
013	Dataset Report - B-Good Honey Bee Resources	https://app.pollinatorhub.eu/dashboard/datasets/193
014	Dataset Report - B-Good	https://app.pollinatorhub.eu/dashboard/datasets/19

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81 Quality asset directory: https://app.pollinatorhub.eu/pages/sop-directory

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	WP3 Field Data	4
015	Dataset Report - B-Good Virus Sequences	https://app.pollinatorhub.eu/dashboard/datasets/196
016	Dataset Report - B-Good Virus Levels	https://app.pollinatorhub.eu/dashboard/datasets/197
017	Dataset Report - B-Good Genotyping Subspecies	https://app.pollinatorhub.eu/dashboard/datasets/198
018	Dataset Report - B-Good Genotyping pooled SMR	https://app.pollinatorhub.eu/dashboard/datasets/199
019	Dataset Report - Genotyping SMR	https://app.pollinatorhub.eu/dashboard/datasets/200

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Annex A - Data model Documentation

This annex is available as a stand-alone document. It describes the fields and attributes of each data model considered within the platform.