



## D 3.9 Assets: ITINERIS Semantic Training Platform on Environmental Sciences - Update



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## 1. INTRODUCTION

This document constitutes the update of Deliverable 3.9 “Assets: ITINERIS Semantic Training Platform on Environmental Sciences – first draft” and is part of the activities of Work Package 3 (WP3) – ITINERIS Training Centre.

This document was expected to be released in Bimester 20 and to be included in Intermediate Objective IO3.9; it is produced under the responsibility of the Operative Unit (OU) of the National Research Council – Research Institute on Terrestrial Ecosystems (CNR-IRET).

The objective of this document is to provide an updated description of the architecture, functionalities, and development status of the ITINERIS Semantic Training Platform on Environmental Sciences fully released on February 2026 (<https://enviknowledgelibrary.itineris.cnr.it>) highlighting the solutions adopted to ensure robustness, scalability, and long-term sustainability that incorporate UI (User’s Interface) and UX (User’s Experience Design) best practices

The document is organized into five chapters, with this introduction serving as the first. Chapter 2 provides an overview of some existing platforms, underscoring their importance in transferring knowledge within the environmental sciences to a wide array of audiences, including citizens, students and infrastructure’s personnel. Chapter three outlines the technical features and needs of the ITINERIS Semantic Training Platform on Environmental Sciences while Chapter 4 provides an update on the platform, referring to its development status and main evolutions, with the different paragraphs describing in detail the functional areas of the platform. Finally, Chapter 5 presents the list of acronyms used in this report.



LifeWatch Italy offers a wide range of training opportunities for citizens, schools' and universities' students, researchers, and professionals working in the field of biodiversity and ecosystem functions and services, as well as communication materials. The LifeWatch platform is available at the following link: <https://www.lifewatchitaly.eu/comunicazione/>.

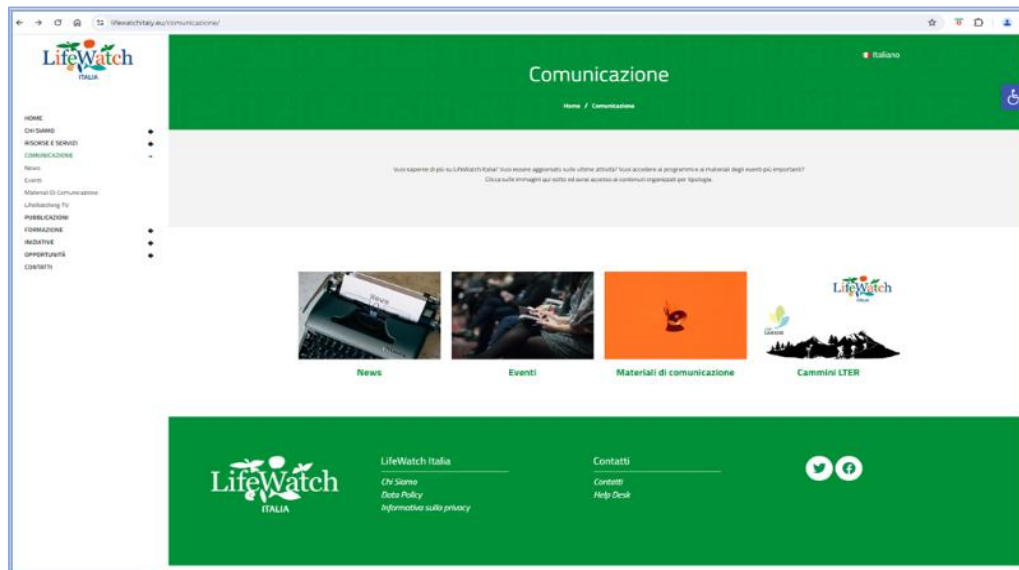


Figure 2.2. Portion of the Homepage of the LifeWatch Italy training platform.

Learning for Nature is a e-learning program offered by the United Nations Development Programme (UNDP) connecting biodiversity policymakers, changemakers, experts to promote biodiversity. The Learning for Nature platform offers a wide range of e-learning opportunities and can be accessed by following this link <https://www.learningfornature.org/en/>.

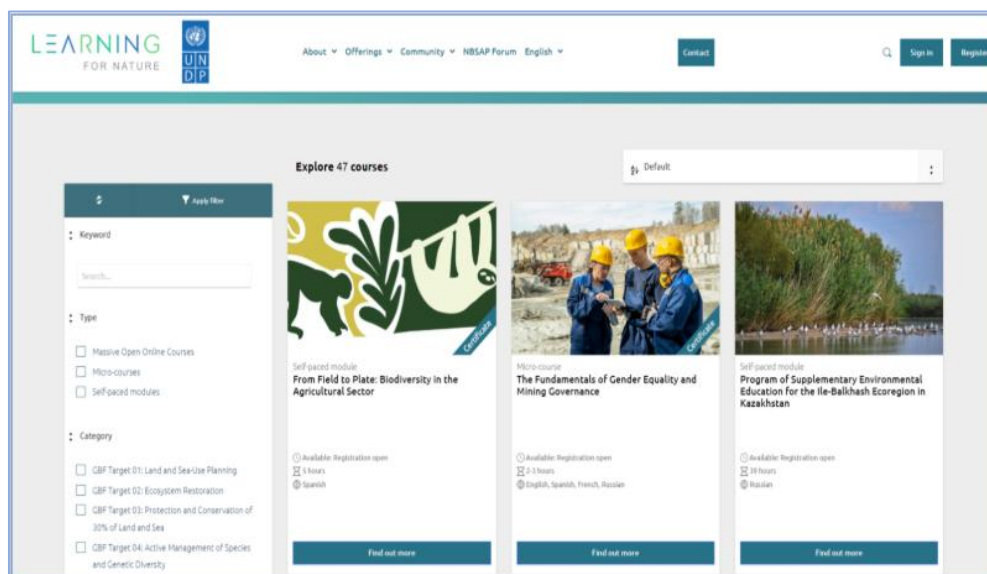


Figure 2.3. Courses section of the Learning for Nature platform.

Nearpod is a platform that allows teachers to create and share with students a series of interactive presentations, quizzes, videos, scientific games and other activities. It also offers a variety of features for tracking student progress and communicating directly with parents. The platform is available in <https://nearpod.com/>.

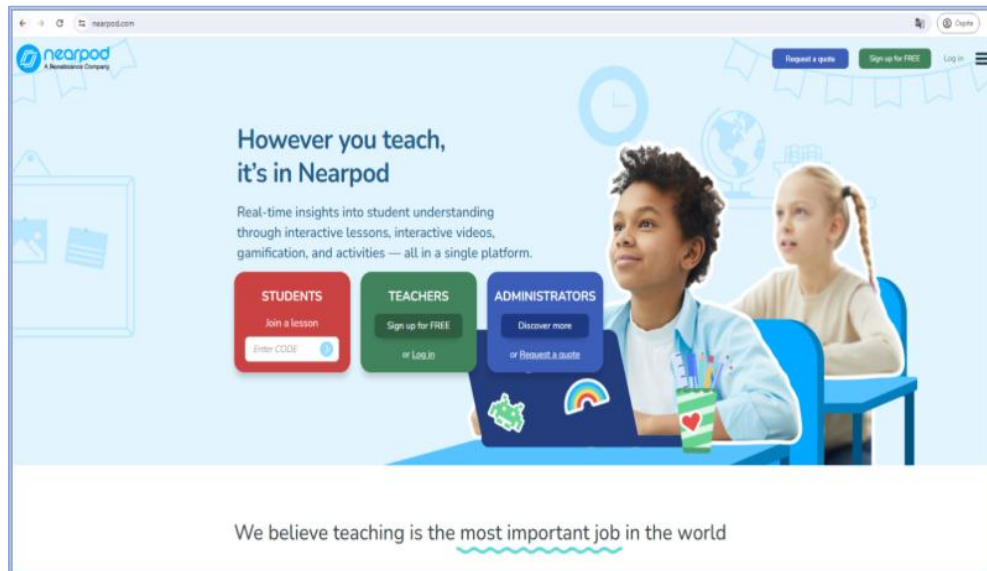


Figure 2.4. Homepage of Nearpod platform.

### 3. TECHNICAL FEATURES AND NEEDS

The ITINERIS Semantic Training Platform on Environmental Sciences, termed Semantic Training Platform for simplicity, in the Training Centre of the ITINERIS project is used with the aim of ensuring the transfer of knowledge to all components of civil society and citizens following the FAIR principles. The Semantic Training Platform is a platform for science communication and navigation of environmental science knowledge that allows users and guides them in performing searches on resources of different types, on the contents and themes of the Research Infrastructures, closely connected to the Training platform of the ITINERIS project.

In particular, the platform provides two main macro-functions:

- Navigate into the knowledge - this function allow users to consult the material and serious games of interest with topics on environmental sciences
- Interact with resources - this function allow users to insert new contents, subject to prior approval by the platform administrators.

The long-term sustainability of the platform will be guaranteed through the interconnection with the Training platform, the MetadataCatalogue and the availability of the LifeWatch Italy infrastructure.

As **access specification**, the platform is recalled in the ITINERIS project portal, and in the Lifewatch Italy Training platform, follows a customized layout according to the visual identity of ITINERIS and also be integrated with other services developed in the project for the full functionality of the ITINERIS platform.

The platform is developed with a multi-user and multi-scientific domain approach of interest and is connected to the sections relating to the ITINERIS Training Metadata Catalogue and the LifeWatch Italy Metadata Catalogue, fully guaranteeing the FAIRness of all reseaources produced for the ITINERIS project in WP3 activities.

The Semantic Training platform is therefore accessible directly from the ITINERIS HUB Portal and from the LifeWatch Italy Training platform and arranges the resources to be metadated in the Metadata Catalogue of all digital objects, accessible in the appropriate Training section.

The platform is built in all its components, including those of interfacing with the existing Training platform in LifeWatch Italy and the relative Metadata Catalogue.

Regarding the structural settings of the platform, it is developed in such a way as to have an extremely simple, effective, intuitive and fun navigation for the target users to which it is intended; therefore, the contractor is required to pay particular attention, in the design phase of the proposal, to the study of User Interface (UI) and User Experience Design (UX) suitable and consistent with the purpose of the individual areas of the platform. The platform is developed as an application derived from the open-source Content management service (CMS) WordPress, based on the PHP language that constitutes its supporting application infrastructure.

The activities are structured as better specified below:

- Design and implementation of a "Science Communication and Environmental Science Knowledge Navigation" platform, which allows the dissemination of resources and results of research activities carried out by the various RIs, in connection with the ITINERIS Training project;
- Interfacing with the ITINERIS project Portal;
- Interfacing with the ITINERIS project Training Platform;
- Interfacing with the ITINERIS project Metadata Catalogue and the LifeWatch Italy Metadata Catalogue;
- Interfacing with the Authentication & Authorization services of LifeWatch ERIC.

The Semantic Training Platform makes available to users the scientific knowledge content created by the RIs. This content is of various kinds, and in particular, the types of resources and the main formats are documents (.pdf), presentations (.ppt), videos (.mp4), images (.jpg, .png), podcasts, TedX, games. The platform is accompanied by a support area, which includes a Knowledge Base, specially structured to allow navigation, equipped with a dedicated Knowledge Base search engine

### 3.1 Target users and personalization

The platform is designed to meet the needs of an extremely diverse ecosystem of users. Below is a comprehensive list of our target categories (listed alphabetically), each of which benefits from an optimized user experience.

- Citizens: citizens who find scientific resources and materials that are consulted;
- PhD students and master's students: participants in the PhD courses and master's programs activated by the ITINERIS project;
- Research and technology infrastructure personnel working in science communication offices for the infrastructures: all the technical-administrative-scientific staff of the research infrastructures, and the European nodes, that are part of the ITINERIS project and deal with the communication section for the infrastructures for which they operate and collaborate;
- Students: students, who find scientific resources and materials that are consulted;
- Users of research infrastructure services: users of RI services, who find resources and materials related to the different services.

Through an advanced resource tagging system, the platform dynamically adapts content to suit different user's profiles modulating it based on the specific user, this ensures that every stakeholder receives the support, tools, and data most relevant to their unique objectives.

To facilitate the discovery, the platform offers multi-level search queries ensuring that users at all levels can quickly identify the elements necessary to meet their needs or utilize specific services. In particular, solutions are explored that allow for searches and navigation of concepts, topics and entities on structured data, reducing search times for information and enhancing the RI's heritage of skills and experience in the biodiversity sector. Search functionalities are designed with the aim of providing results that are accurate, relevant and meaningful, or that correspond to what the user has in mind.

## 4. ITINERIS SEMANTIC TRAINING PLATFORM ON ENVIRONMENTAL SCIENCES - UPDATES

The ITINERIS Semantic Training Platform on Environmental Sciences has been developed as a digital ecosystem dedicated to training, scientific dissemination, and the enhancement of scientific contents produced by Italian environmental Research Infrastructures. The platform realized is not only a resources repository, but rather an system capable of supporting the production, ingestion, and publication of multimedia training resources; organizing content through structured metadata and indexing systems; offering multi-level search functionalities; personalizing the user experience through profiling mechanisms and automated content suggestions using tags; integrating gamification tools in educational pathways dedicated to students, citizens, research and technology infrastructure personnel.

The platform represents a strategic bridge between the scientific community and society, contributing to the diffusion of an accessible scientific culture capable of making more understandable the contemporary environmental challenges and the technological solutions developed by research infrastructures.

It is important to emphasize that the Semantic Training Platform is a highly dynamic and evolving system, consequently, there may be slight graphic or functional variations compared to what is illustrated in this document. Such differences are to be considered physiological and linked to the continuous process of improvement, updating, and optimization of the interface and functionalities, also based on user feedback.

The Semantic Training Platform's architecture, is specifically designed around the principles of modularity, extensibility, scalability designed in accordance with modern UX and UI principles. It uses a microservices-based approach with a series of independent components that communicate through well-defined interfaces. This design ensures the flexibility needed to individually modify, add, or replace components without impacting the entire system of the platform. This architectural approach facilitates the maintenance and allows for the future expansion of new features and services ensuring long-term sustainability.

### ***Technical Stack and Software Tools***

The primary software tools identified and proposed to meet the project requirements are:

- Containers: Docker
- Content Management System: WordPress
- Plugins: MiniOrange, Elementor, TranslatePress, One Click Accessibility, Echo Knowledge Base, Help Dialog
- Storage: MinIO, MariaDB, PostgreSQL
- Processing Tools and Libraries: FFmpeg, Whisper, MuPDF, Pillow, PyTesseract
- Indexing and Search Engine Tools: Elasticsearch
- Data Analytics Tools: Elasticsearch, Kibana
- Protocols: Authentication & Authorization protocols

- Custom Modules: Purpose-built custom modules

Additional Plugins Used:

- Cookie and Privacy Policy Management: Complianz
- Slider Management: Slider Revolution
- Platform Analytics: Independent Analytics
- Content Display and Organization: The Post Grid
- Typography: Used to manage the Urbanist font required by the Itineris project's visual identity: Font Awesome

The main architectural modules of the platform are:

- Users area: user profile management area, which is directly linked to the modules for uploading, publishing, and searching for resources;
- Indexing & Search: Indexes data to enable fast and precise searching.
- Templates for Resource Production: Provides templates and guidelines for creating resources like documents, presentations, and videos.
- Resources ingestion: Manages both manual uploads and automated acquisition (harvesting) of resources from external sources.
- Publication: Manages the validation and publication process for all resources.
- Data/Metadata Processing: Processes data to extract metadata and textual content.
- BioCross Gaming: A structural module dedicated to the scientific game "BioCross" present in the School Area.

The rights of the different user profiles regarding the features of the actual platform, without prejudice to the possibility of varying the management of the different functionalities according to future specific needs are listed in Table 1.

*Table 1. Functionalities and areas accessible to different users according to their user category.*

Functionalities	Guest	Simple User	Editor	Approver	Administrator
Profile		X	X	X	X
Your Library			X	X	X
Suggested for you		X	X	X	X
Notifications			X	X	X
Users Management					X
Data Analytics					X
Harvesting					X
Download Template			X	X	X
Delete Template				X	X
Upload Template				X	X
Upload Resource			X	X	X
Approve Resource				X	X
Search	X	X	X	X	X
Resources list consultation	X	X	X	X	X
Resource consultation		X	X	X	X

Table 1. Functionalities and areas accessible to different users according to their user category.

Functionalities	Guest	Simple User	Editor	Approver	Administrator
Highlights list consultation	X	X	X	X	X
Highlights upload					X
Highlights consultation		X	X	X	X
BioCross Configurator					X
Play the game		X	X	X	X
Support Area	X	X	X	X	X

To facilitate user access, the Homepage (Fig. 4.1a) features a prominent search bar, a presentation carousel, and dedicated sections for quick access to recent resources, the *Knowledge Base*, and a schools area that includes the "BioCross" serious game. Navigation is streamlined with a slide-out side menu (Fig. 4.1b) and a top bar for language selection and login.

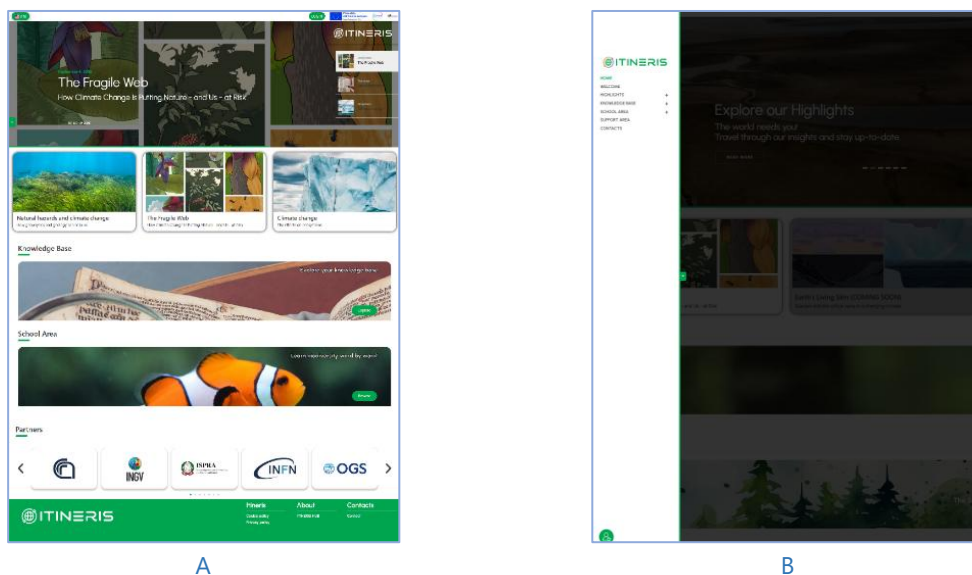


Figure 4.1. ITINERIS Semantic Training Platform on Environmental Sciences landing page view. Visualisation of the a) Homepage with the side-pop up menu deactivate and b) with the side-pop up menu active.

The Home page allows the guest or authenticated user, to access the various sections of the Platform according to the relative access rights. In particular, it is possible to access to:

- Welcome page;
- Highlight pages;
- Knowledge Base pages;
- School Area pages;
- Support Area pages;
- Contacts page.

To maximize the impact of the Semantic Training Platform and transform it into a user-centric tool, a strategy for content diversification and enrichment has been launched by WP3. Through the Highlights section (Fig. 4.2a), several cross-cutting thematic areas spanning

different scientific domains have been identified and documented. The themes selected by the WP Leaders were integrated with the vertical expertise of the personnel within each Work Package.

The editorial and scientific team has finalized, and is continuing to develop, various thematic Storylines. These are not only informative texts, but true narrative pathways that guide the user through the transformation of scientific data and concepts into content that is both accessible and scientifically rigorous. Each storyline is further enriched with in-depth analyses, bibliographic references, and high-quality imagery, including both original and open-access sources (Fig. 4.2b). The highlights currently under development cover Biodiversity and Ecosystem Services, geomorphological risks, air quality, climate change, and critical zones.

The platform's evolution includes a continuous update plan, with new themes being progressively integrated. The ultimate goal is to consolidate the ITINERIS platform as the primary touchpoint between the scientific community and the general public. By adopting language that is accessible yet rigorous, the platform aims to promote and disseminate a scientific culture that enables citizens to understand the environmental challenges of our time and the technological solutions spearheaded by Italian and European research.

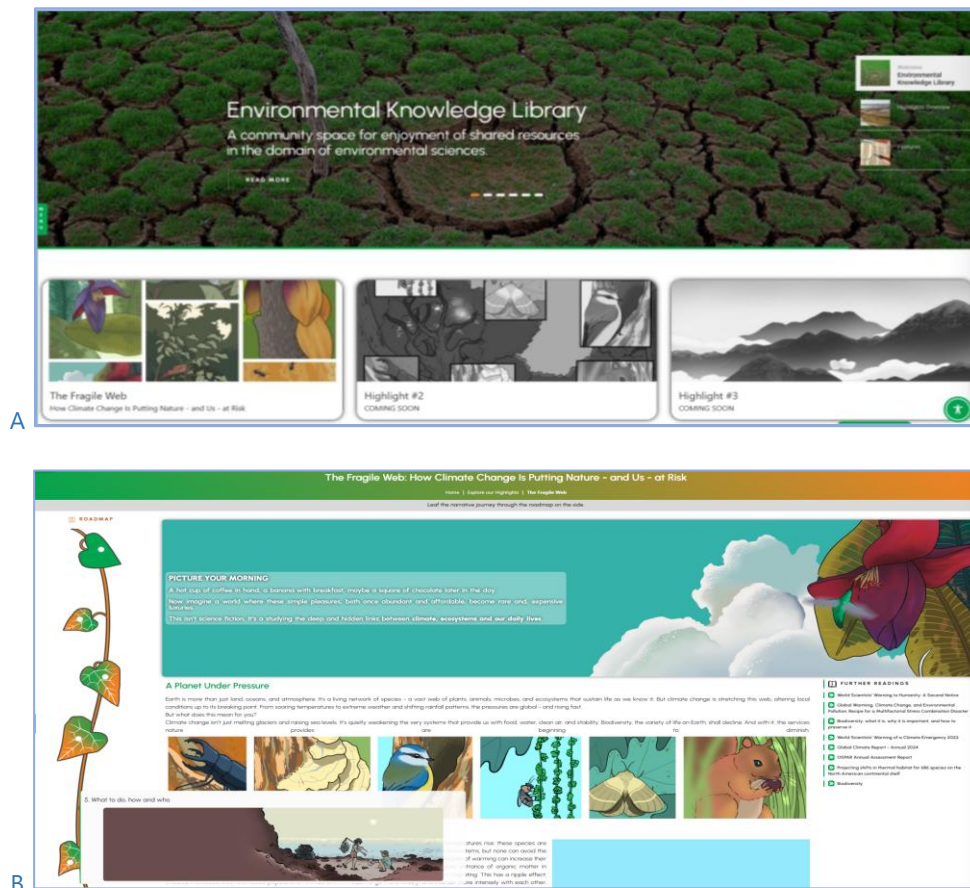


Figure 4.2 Highlights area. a) Highlights overview page showcasing the latest storylines; b) Example of a storyline draft featuring a Roadmap on the left and deep-dive resources (articles, charts, publications, etc.) on the right.

## 4.1 Personal User Area

Registered users and editors can manage their profiles through the Personal User Area. This hub is accessible from the top-right dropdown menu on the homepage. This menu is the gateway to the personal area, where it is possible to manage the profile, view the uploaded resources, check suggested content, and review the notification history of the resources. The dropdown menu also offers a direct path to “Resource Management Area”, where, it is possible to download the templates for creating new content and upload resources (Fig. 4.3a). For users with administrator privileges, this menu provides the critical function of “approving resources”, useful for the platform’s resources review process (Fig. 4.3b).

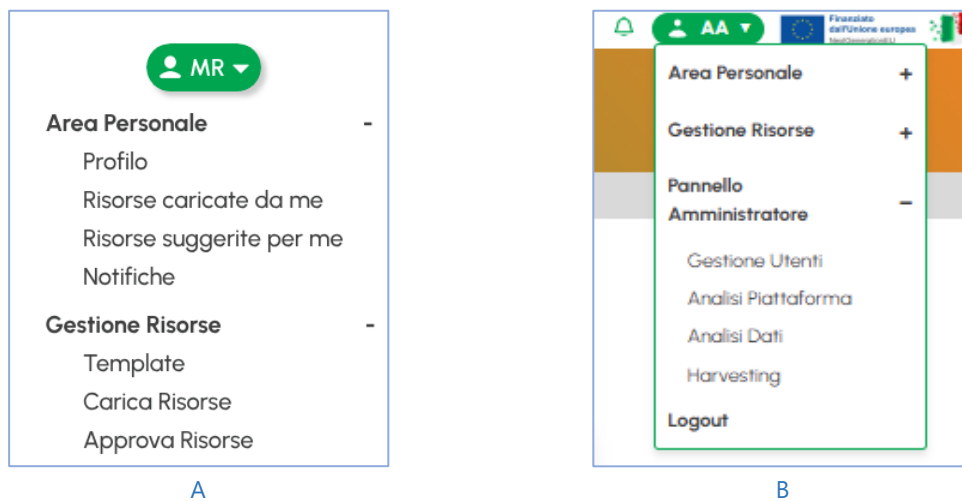


Figure 4.3. Side menu providing access to the Personal Area and Resource Management for a) standard Users and b) Administrators. The latter includes a link to upload resource templates and a platform management panel organized by action type.

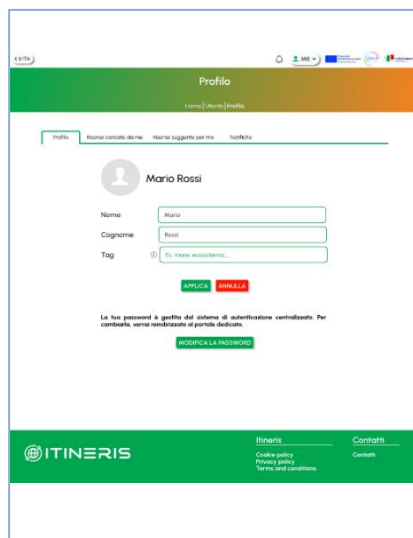
Accessing to the Personal Area, it is presented a comprehensive suite of tools to manage information and resources.

**Profile:** The "Profile" section (Fig. 4.4a) is where it possible to enter personal details and, most importantly, express the scientific interests. By adding relevant tags (i.e. keywords) for subjects and topics, users help the platform provide a more personalized experience. It is possible to select as many as possible tags among the standard list provided and approved by the platform’s administrators.

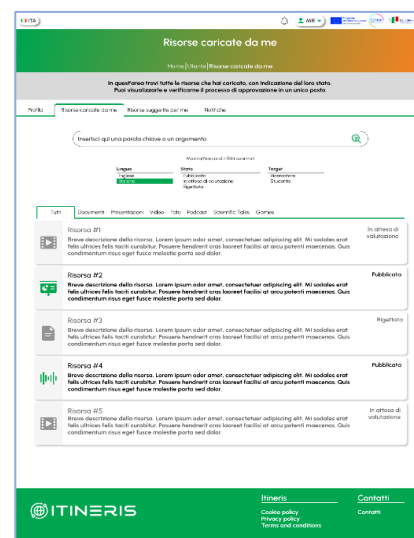
**My Uploaded Resources:** This section serves as a personal archive and control centre for users with the correct right access. In the "My Uploaded Resources" tab (Fig. 4.4b), if a user is and Editor, Approver or Administrator, it is possible and easily view all the content previously uploaded. It is possible to view these resources in a single list or by a more organized, tab-based view, separating them by formats: documents, presentations, videos, photos, podcasts, scientific talks, and serious games. A search bar with advanced filters, including language, publication status, and target categories, ensures to quickly find what users are looking for.

**Suggested Resources:** The "Suggested Resources for Me" section is the heart of the personalized experience within the Semantic Training Platform. This feature transforms the platform from a simple static repository to an intelligent system capable of anticipating user needs. tab (Fig 4.4c). The integrated tagging system allows for direct interaction with the user's profile, leveraging the tags from user's profile to recommend content. This area follow the structure already presented in "My Uploaded Resources" but with a list of resources that align with user's interests, making it easier to discover new and relevant materials. It has a dynamic update systems, in fact, whenever a user changes their interests or adds new tags, the list of suggested resources is automatically updated to reflect the new preferences.

**Resource Status:** Finally, a dedicated tab provides a clear overview of the editorial status of your uploaded resources (Fig. 4.4d). Resources are labelled as either "Draft", "Awaiting evaluation," "Published," or "Rejected." This clear, real-time feedback loop gives an immediate understanding of where your content is in the review process. One advantage is that authors don't have to manually contact administrators to check the status of their work; they simply consult the dedicated tab for an updated overview. Every status change is recorded, effectively reducing the risk of content being stuck in the review process without the author's knowledge. Furthermore, in the event of a rejection, the presence of specific notes directly linked to the resource's status facilitates quick resolution of issues, allowing for the requested changes to be made and the resource to be resubmitted for publication.

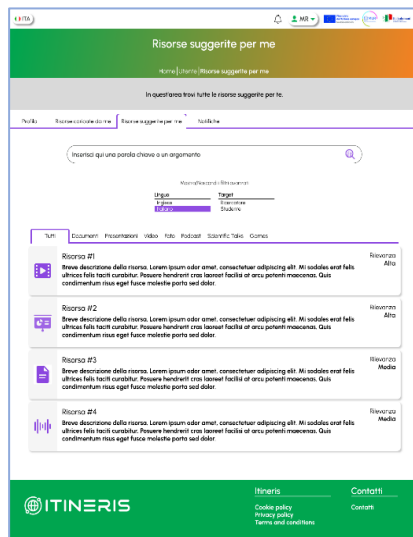


A

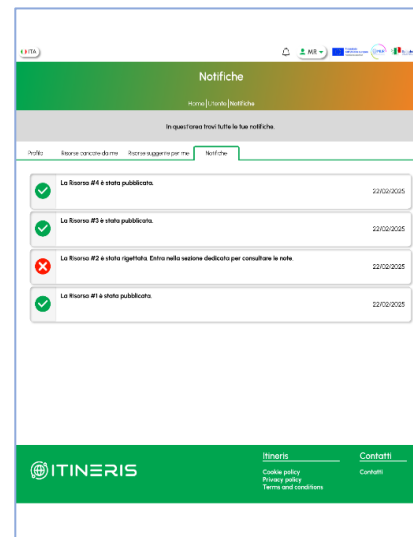


B

Figure 4.4. Sections of the Personal Area: a) User profile Tab; b) Tab with the uploaded resources that lists all the resources the user has uploaded.



C



D

Figure 4.4. Sections of the Personal Area: c) Tab with a list of resources recommended to the user based on their interests; d) Tab with Notification History of the uploaded resources.

It's important to highlight the structured lifecycle of every resource; it is a process designed to ensure the quality and consistency of all published content. The following list illustrates a resource's journey through several distinct phases:

- Draft: The resource is a work in progress by the author and has not yet been submitted;
- Created / Uploaded: The resource have been created or uploaded to the platform;
- Processing/ Metadating: The resource should be provided with the relative mandatory metadata information in order to be ready to begin the review process;
- Approval: The resource and the relative metadata is in the queue of resources, waiting to be reviewed by an administrator;
- Published: The resource has been approved by an administrator and is now active. It is accessible to the public and discoverable through the platform's search sections.
- Rejected: The resource was reviewed by an administrator and did not meet the publication standards. It is not made public and it possible to modify it so that can be resubmitted after appropriate changes.
- Search: Resources can be searched within the platform's database by tags and keywords.
- Download: Each user can decide whether to make their resources available and managed in the My Library section, and whether they can be downloaded by other users by checking the appropriate box.

This robust workflow provides a clear, step-by-step process for all users contributors, ensuring that only high-quality, relevant resources are made available to the wider audience (Fig 4.5). This structured approach also offers authors transparent feedback on the status of their submissions.



Figure 4.5. Logical workflow for the training resource upload process by an Editor user.

Figure 4.6 illustrates the architecture of the platform, highlighting its main functional modules and integrations with external systems. At the centre, the core of the platform is shown, supporting the entire lifecycle of digital training resources (DTOs). Content production is facilitated by predefined templates, while content delivery is supported by navigation features and gamification components. Data management is carried out through a structured pipeline that includes the acquisition of content and metadata, publication, semantic indexing, and finally advanced search; the external systems and platforms with which the solution is integrated are shown below.

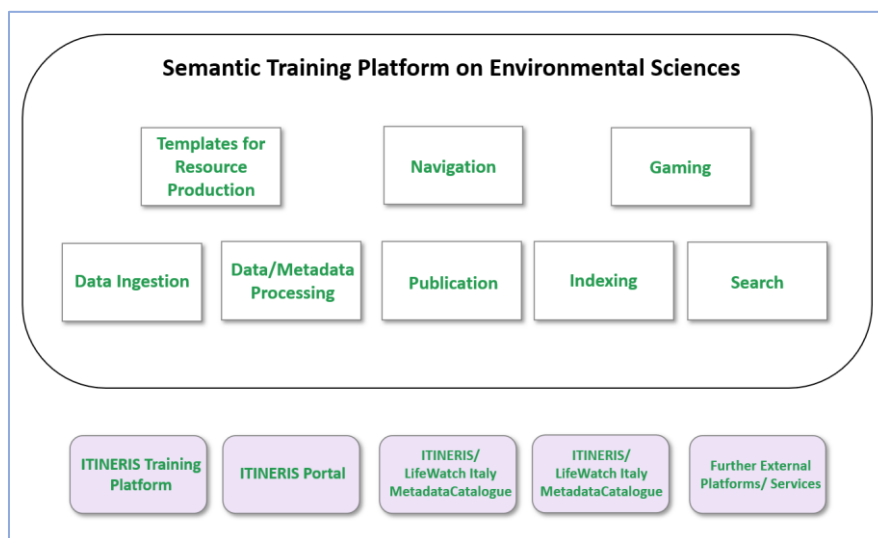


Figure 4.6. Summary diagram of the main functional modules and integrations with external systems. The figure illustrates the platform architecture, highlighting its main functional modules and integrations with external systems. It shows below the external systems and platforms with which the solutions are integrated.

## 4.2 Resource management Area

Here is presented the platform's resource ingestion module, designed to simplifying the process of uploading new resources; this can be done manually, by following the steps already described above, or automatically. In fact, the module enables the systematic acquisition of content uploaded by users (Editor or Administrator), managing not only the physical transfer of files but also their technical validation and the initial extraction of metadata.

The module transforms raw documents into structured data, allowing the semantic engine to index them correctly. In this way, each resource is integrated into the platform's Knowledge Base, becoming immediately available for advanced search and intelligent association with training pathways.

- Documents (.pdf)
- Presentations (.ppt)
- Videos (.mp4)
- Images (.jpg, .png)
- Podcasts
- TedX

As shown in figure 4.7, the interface is set to upload a document, but other resource types are also available for the uploading. The user is prompted to drag and drop the document file and an accompanying thumbnail and it will also be implemented the link insertion feature for external personal resources.

The core of the section is the metadata entry form for each resource's type, that covers a key role for platform's resources discoverability and for their organization. The metadata scheme includes mandatory fields (easily identified from the red asterisk) like Title and Description, as well as field for Author. Users can also enter relevant Tags and specify the Target audience and Date, ensuring the resource is fully indexed and searchable. This process guarantees that all resources are consistently and accurately organized and well described before their submission for the platform's resources review process.

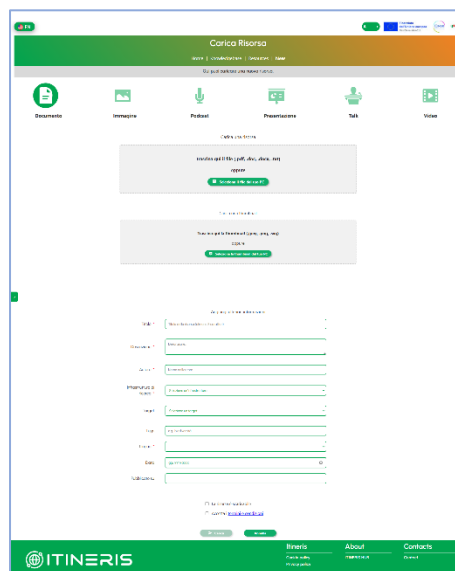


Figure 4.7. Dedicated upload section for submitting a new resources, a document in this example, and providing all the necessary metadata.

The Semantic Training Platform offers a robust and intuitive Resource section for users to explore all the published content. The main resource list provides a clean overview, displaying the title, a brief description, and the publication status for each item. Users can easily browse resources of different format, including documents, videos, images, podcasts,

and scientific talks, using the tabs at the top. In this section, users can also download and share the resources directly, having at the same time a full view of the associated metadata, making the area a central hub for content consumption and dissemination of the platform. Selecting a resource among all the formats (Fig. 4.8a), such as a document (Fig. 4.8b), video (Fig. 4.8c), images (Fig. 4.8d) takes the user into a dedicated detail page with all the resources grouped for the selected format. Furthermore, in this area there are scientific talks designed to translate complex information and data produced by research infrastructures into a series of accessible and engaging stories, making it easier to involve even non-expert users (Fig. 4.9).

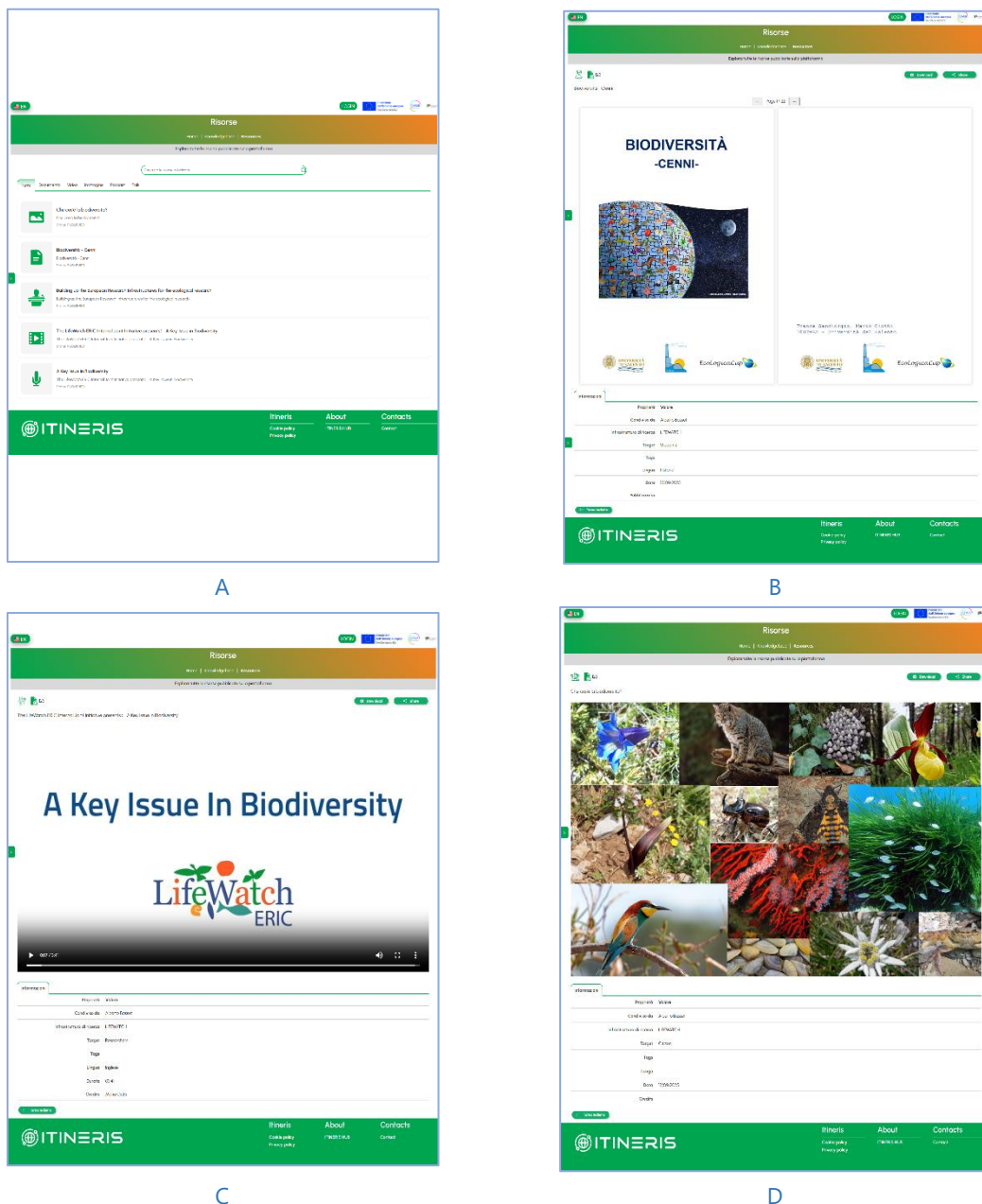
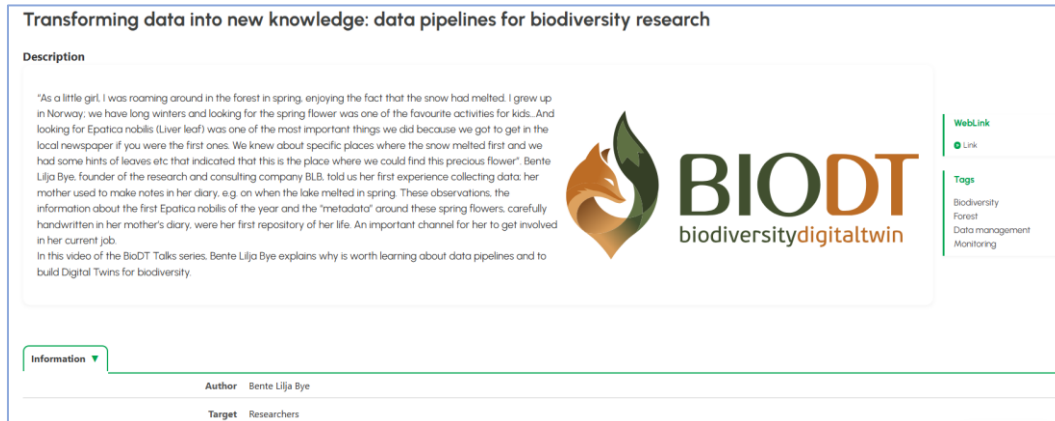


Figure 4.8. Screen displays a list of a) all the grouped resources types provided in the platform. Examples of different resource types: b) documents, c) videos, d) images.



**Transforming data into new knowledge: data pipelines for biodiversity research**

**Description**

"As a little girl, I was roaming around in the forest in spring, enjoying the fact that the snow had melted. I grew up in Norway, we have long winters and looking for the spring flower was one of the favourite activities for kids. And looking for *Epatica nobilis* (Liver leaf) was one of the most important things we did because we got to get in the local newspaper if you were the first ones. We knew about specific places where the snow melted first and we had some hints of leaves etc that indicated that this is the place where we could find this precious flower". Bente Lijja Bye, founder of the research and consulting company BLE, told us her first experience collecting data: her mother used to make notes in her diary, e.g. on when the lake melted in spring. These observations, the information about the first *Epatica nobilis* of the year and the "metadata" around these spring flowers, carefully handwritten in her mother's diary, were her first repository of her life. An important channel for her to get involved in her current job. In this video of the BioDT Talks series, Bente Lijja Bye explains why it is worth learning about data pipelines and to build Digital Twins for biodiversity.

**WebLink**  
Link

**Tags**  
Biodiversity  
Forest  
Data management  
Monitoring

**Information**

**Author** Bente Lijja Bye

**Target** Researchers

Figure 4.9. Examples of resource types uploaded on the platform: scientific talks.

### 4.3 Search and Knowledge Base functionality

The platform's search functionality is another of the key aspects of its structure, it is engineered to satisfy a broad user base ranging from students to RI's researchers and technicians. The approach is structured across three levels of complexity:

**Filter Search:** this search uses resource metadata, allowing users to filter content based on criteria such as author, resource type, or user category (e.g., citizens, researchers, students).

**Keyword Search:** this functionality identifies resources with exact matches to the user's input user's query of Tags and the content or metadata of the resources.

**Semantic Search:** This advanced function uses AI algorithms to understand the meaning and context of a user's query. The system converts textual content, using Natural Language Processing (NLP), and search queries into dense vectors (embeddings) that represent their semantic characteristics. The search algorithm then finds the "k-nearest neighbours" in the vector space, returning results based on conceptual similarity rather than just literal keyword matching.

#### *Knowledge Base*

The Knowledge Base acts as a comprehensive support hub, offering detailed information on platform utilization, including manuals and user guides. It is structured to be both intuitive and easily navigable, with a hierarchical organization that facilitates rapid retrieval of solutions and minimizes the need for direct user assistance. A seamlessly integrated Help Desk service is also available, allowing users to submit support tickets for issues not addressed within the Knowledge Base documentation.

### 4.4 Schools Area

The School Area represents the space within the Semantic Training Platform entirely dedicated to training, education, and scientific dissemination. Accessible both directly from the Home Page and via the side menu, this section has been designed to bring citizens, students and researchers, and closer to the world of biodiversity through a multimodal and engaging approach (Fig. 4.10).

The area is divided into two main macro-sections:

**Educational Games:** an educational section that includes gamification tools such as the BioCross game, designed to allow users to learn biodiversity terminology and concepts "word by word" and other useful resources.

**Training Material:** a collection of documentary resources and in-depth materials aimed at environmental training.

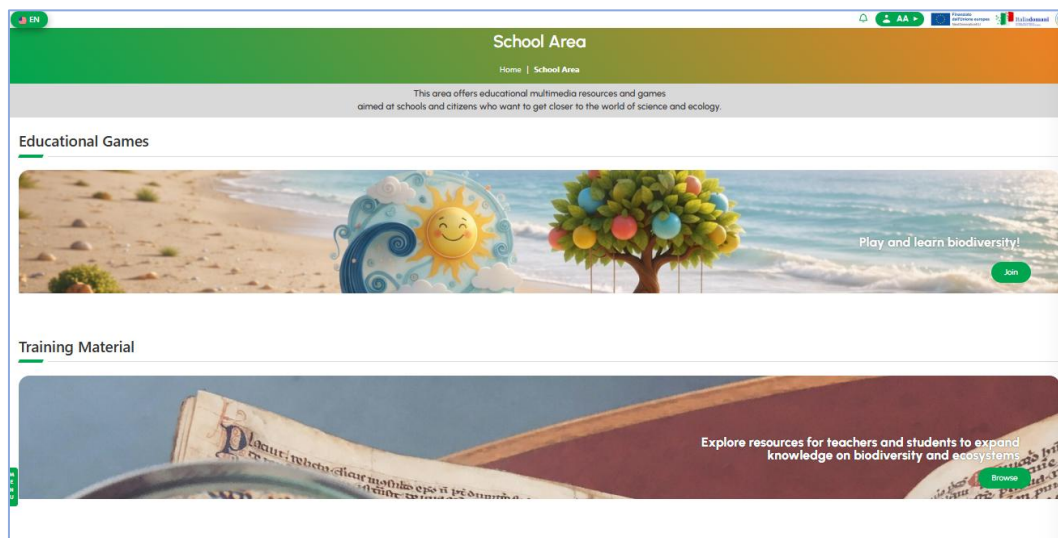


Figure 4.10. Section of the schools area where the education games and training materials are collected.

The School Area transforms the platform into an educational centre, where the complexity of environmental data is made accessible and memorable thanks to a clever balance between theoretical study and playful interaction.

### ***Educational Games***

The gamification strategy of the Semantic Training Platform is designed to transform environmental science learning into an interactive and engaging experience, adopting a “learning by gaming” approach. One of the keystone of this section is the “BioCross Game” (Biodiversity Crossword Game), an educational game accessible to authenticated users from both the Home Page and the “School Area” (Fig. 4.11). The game offers an intellectually engaging challenge, suitable for both solo and group play, designed to test the user’s vocabulary in environmental sciences and their capacity for mental association, making it suitable for online school competitions or stakeholder engagement activities on various environmental science topics.

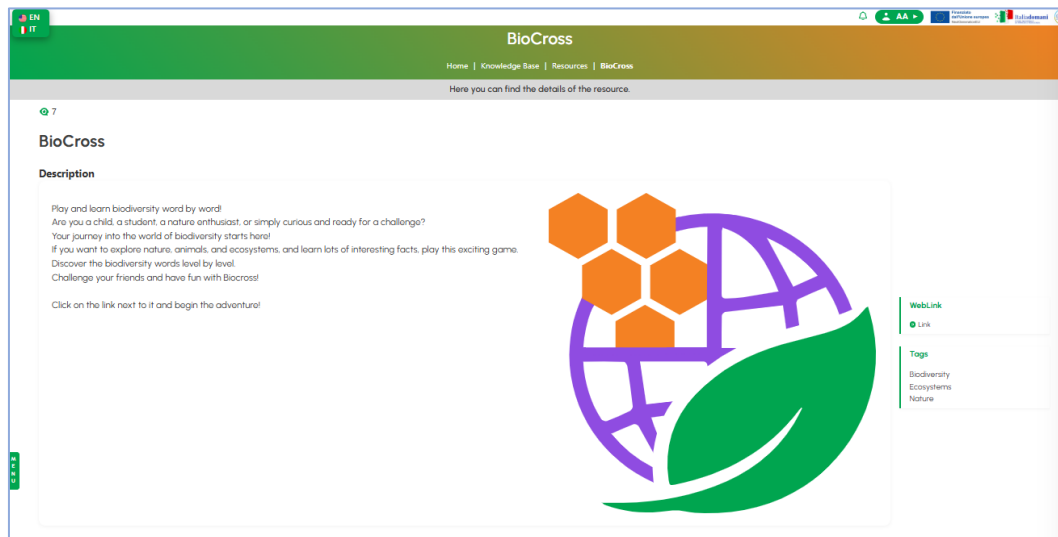


Figure 4.11. BioCross Login Screen. The game description is located on the left, while the direct access link and reference tags are positioned on the right.

**Technical Architecture:** The game is developed as a web application ensuring a high-quality interactive experience, superior graphics, and full compatibility across various devices. The game is structured across three difficulty levels and supports multilingual dictionaries, with specific categories available in both Italian and English. For each level, users can track their progress through the number of completed stages, time spent, and the corresponding partial score (Fig. 4.12). The structure is flexible since players are not required to finish one difficulty level before moving to the next, allowing them the freedom to tackle as many stages as they wish within each difficulty category. Furthermore, thanks to the system's high configurability, the number of levels, stages, and activities is managed entirely by users with administrative privileges. Through an intuitive interface, every parameter can be modified without the need to intervene in the source code.

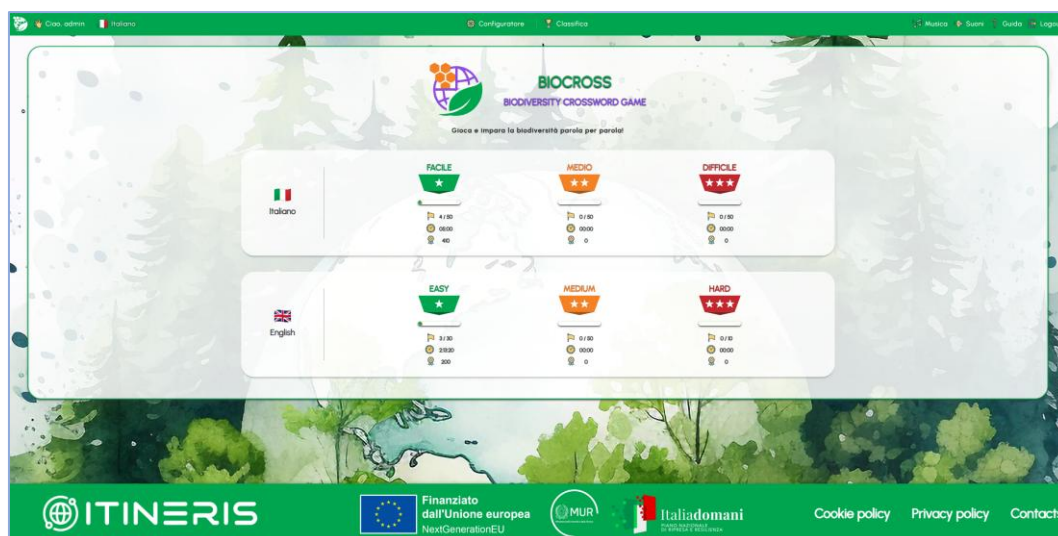
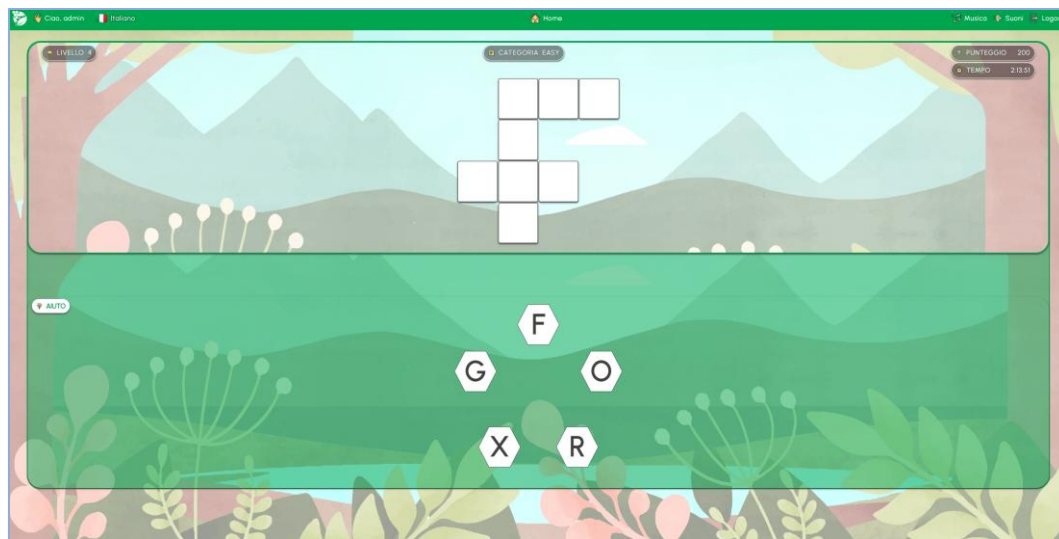


Figure 4.12. Biodiversity Crossword Game Homepage. The three difficulty levels are categorized based on the selected language.

**Game Mechanics:** Players must complete a crossword grid related to biodiversity domains using a letter rotor (Fig. 4.13). Progression is structured through sequential levels since access to each new stage is granted only after successfully completing the previous one. Additionally, at the end of every stage, a fun fact is revealed, related to either the crossword's keywords or the stages overall theme. Stages and difficulty levels contain words for the environmental sub-domains of the ITINERIS project. All words currently in the game have been imported from verified and authoritative dictionaries and glossaries, such as the “eLTER Controlled Vocabulary”.



*Figure 4.13. BioCross gameplay screen: at the top, there is the stage with the grid where the words must be guessed. Below is the rotor showing the letters that need to be rearranged to find the correct words.*

**Scoring:** Each correct word awards points based on its difficulty. Within the system configurator, every term is associated with specific stars and codes that indicate its editorial complexity and point value.

**Support:** Players can request hints to reveal hidden letters in the grid; however, this action incurs a cost in points, which are deducted from the total score accumulated.

**Management and Customization:** A dedicated configuration tool “BioCross Configurator”, administrator users can add words to the dictionaries, modify the existing stages and levels, and define new ones, ensuring the sustainability and continuous updating of educational content. All settings are fully customizable via an user-friendly interface, requiring no source code modifications (Fig.4.14).

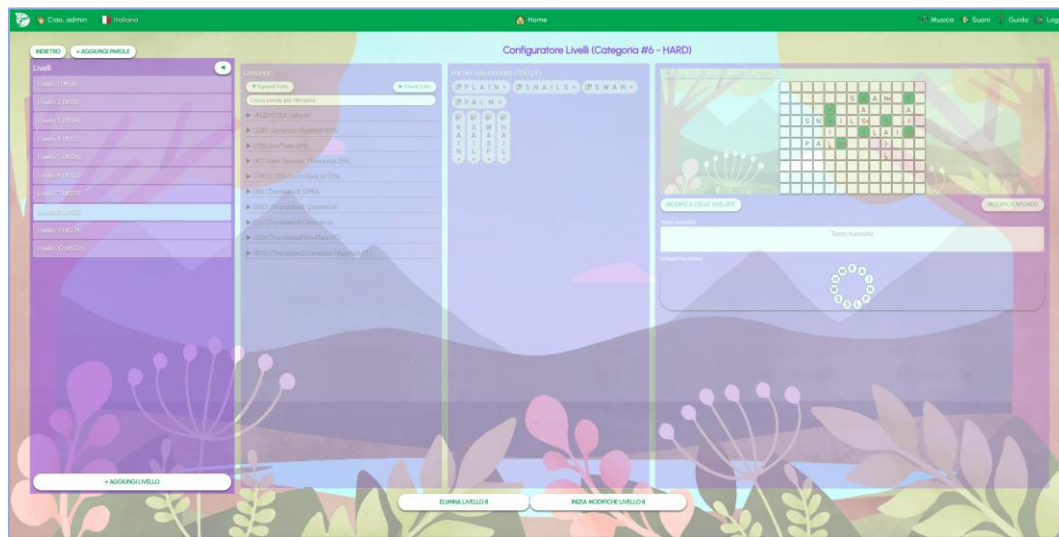


Figure 4.14. The "Level Configurator" interface is organized into distinct columns to streamline the level design process. Starting from the left, the layout features a list of the existing stages, followed by a search engine and a dropdown menu of the glossaries and dictionaries that administrators can use to source their vocabulary. Centrally located is the "selected words" column, which displays all terms chosen for the current level. On the right, the game grid provides a real-time visual preview of how these words intersect on the board. Finally, positioned in the bottom-right corner is the letter circle (the "rotor") that players will interact with to compose words during gameplay. Increasing the rotor size and the word density in the grid directly scales the difficulty level for the player.

**Game Data Analysis:** Game results and participation data are integrated into the platform's Data Analytics systems, allowing for the monitoring of educational effectiveness and user engagement. These insights are particularly valuable for managing competitions with the final leader board ranking determined by the cumulative score across all the stages at every difficulty levels selected for the competition.

### *Training Material*

The section "Training Material" serves as a dedicated educational hub designed to engage younger generations with Environmental Sciences. Its primary objective is to transform complex scientific data into accessible learning tools, promoting awareness of critical contemporary issues such as climate change and biodiversity. Within this area, students can access a variety of multimedia resources, curated from the broader Knowledge Base and pre-filtered specifically for the student demographic. Users can explore the full catalogue or filter resources by format and to further enhance the learning experience, "serious games" from the Education Games section have also been integrated via a dedicated Game format (Fig.4.15).

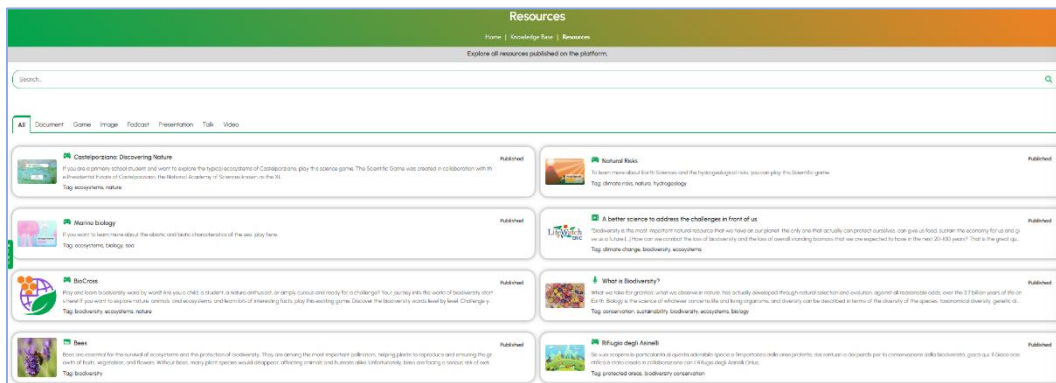


Figure 4.15. Resource page within the structured knowledge library of the Training Material's area, designed to display and provide downloadable educational materials focused on the environment and research, specifically dedicated to students.

In conclusion, the platform's gamification transcends mere entertainment; it serves as a sophisticated educational instrument designed to drive engagement among citizens and students, translating complex scientific data and information available from the research infrastructures into an accessible and stimulating challenge.

## 5. LIST OF ACRONYMS

CNR: National Research Council

CMS: Content management service

DTO: Digital Training Resources

ERIC: European Research Infrastructure Consortium

FAIR: Findable, Accessible, Interoperable, Reusable

IRET: Research Institute on Terrestrial Ecosystems

OU: Operative Unit

NLP: Natural Language Processing UI

PHP: Hypertext Preprocessor

RI: Research Infrastructure

UI: User Interface

UNDP: United Nations Development Programme

UX: User Experience Design

WP: Work Package