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WP3: Dynamic Multi-Sectoral Resilience Modelling and Assessment Framework

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EXECUTIVE SUMMARY

This deliverable provides a comprehensive overview of the Citizen Observatory MINKA, produced during the EU Horizon Europe project ARSINOE.

Building upon the existing Citizen Observatory Natusfera and iNaturalist, MINKA extends its capabilities to encompass a broader range of environmental variables, enhancing its capacity to engage users and address Sustainable Development Goals (SDGs).

MINKA facilitates citizen participation in scientific research by allowing users to contribute observations across various domains, including biodiversity and environmental data such as temperature, air pollution, and water transparency. The platform emphasises collaborative intelligence, co-creation, and community involvement, fostering a culture of shared knowledge and collective action.

Key features of MINKA include an innovative iconographic taxonomy user profile, intuitive user interfaces, and a robust backend infrastructure supporting data management and analysis.

Furthermore, MINKA prioritises data privacy and security, implementing robust measures to safeguard user information and platform integrity. By adhering to stringent data privacy policies and user agreements, MINKA maintains trust and transparency in its operations, fostering a safe and inclusive environment for participants. Through the future integration of Artificial Intelligence (AI) for species identification and ongoing enhancements to quality assurance processes, MINKA strives to ensure the accuracy and reliability of user-contributed data.

Looking ahead, MINKA seeks to explore opportunities for further growth and development, including the implementation of environmental and biodiversity observations in real-case scenarios, optimisation of mapping solutions, and continuous improvement of quality assurance processes. Also MINKA will explore the how to refine communication strategies (to optimize the community of practice), engage in co-design exercises (to integrate new elements into functionalities), and conduct data governance analysis. These initiatives underscore MINKA's commitment to advancing citizen science, empowering communities, and contributing to achieving sustainable development goals.

The MINKA software is available for use via the website minka-sdg.org and the MINKA App can be easily downloaded on both Android and iOS platforms. MINKA software codebase is detailed in section 3.5. of this deliverable.

The MINKA deliverable describes an innovative platform that leverages citizen science to address environmental challenges and promote data-driven decision-making for a sustainable future.

1. WHAT IS CITIZEN SCIENCE?

Citizen science, also known as **participatory science**, is a crucial link between science and society. Combined with emerging technologies, it broadens the research horizons and enhances public involvement. This approach emphasises collaborative intelligence and co-creation, fostering the development of scientific solutions that benefit both researchers and communities.

As defined in the European Green Paper on Citizen Science for Europe, citizen science involves the active engagement of the general public in scientific research activities. Citizens contribute to science through intellectual efforts and knowledge or by providing tools and resources. This multifaceted involvement unfolds in various ways:

- Participants play a pivotal role by supplying experimental data and facilities, posing novel questions, and actively contributing to creating a fresh scientific culture.
- Volunteers, through their participation, gain valuable learning experiences and skills. They develop a profound understanding of scientific work in an engaging and didactic manner, enriching their knowledge in the process.

In this manner, interactions among science, society, and policy are enhanced, fostering a more democratic approach to research rooted in decision-making informed by evidence.

As We Observe Eu project outlines, citizen observatories represent community-based environmental monitoring and information systems encouraging individuals to contribute their observations. The key characteristics of citizen observatories include:

- Active involvement of citizens in both environmental monitoring and governance.
- A two-way flow of data information, facilitating communication between stakeholders.
- Generation of citizen observations directly in the field ('in situ').
- Utilization of modern mobile and web technologies to support and enhance the monitoring process.

The emergence of citizen observatories like MINKA signifies a progressive shift towards an active citizen involvement in environmental monitoring and governance. MINKA stands as a prime example of how modern mobile and web technologies can be utilized to support and enhance the participatory monitoring process while fostering meaningful participation in citizen science initiatives.

2. WHAT IS MINKA?

MINKA is a participatory Citizen Observatory (CO), an infrastructure that facilitates the participation of citizens at multiple levels. MINKA gathers data through geolocalised images uploaded by citizens, and it focuses on observations related to the Sustainable Development Goals (SDG) of UNESCO, being one of the first Citizen Observatories (COs) to report data that addresses the SDGs.

The word MINKA comes from the pre-columbine language Quechua, meaning “receiving mutual help within the community”. This concept is the base of how the dynamic of the platform works. Users can contribute by uploading their own observations, improving the quality of the other users' observations, and validating their data. MINKA can report biodiversity observations, and a pilot has been developed to accept environmental observations.

UNESCO has officially recognised MINKA as one of their SDG Actions (#SDGAction53541). Also, MINKA is one of the tools of the European Union's Mission "Restore our Oceans and Waters by 2030".

MINKA offers two distinct versions: a complete **website version** and a simplified **mobile app** for Android and iOS platforms. The MINKA web platform is currently available in various languages: English, Greek, Catalan, Spanish, Italian, Galician, Basque, German, Portuguese, and French.

MINKA has been created by the Institut de Ciències del Mar (ICM-CSIC) in partnership with Quanta Labs in the framework of the Europeans Projects ARSINOE, ANERIS and Cos4Cloud. MINKA is managed and coordinated by the research group EMBIMOS of the Institut de Ciències del Mar (ICM-CSIC). MINKa also receives funding form the European Projects GUARDEN and ECS to develop Datathons and BioBlitzes.

MINKA emerged after the experience of the EMBIMOS group of the ICM-CSIC working on the Natusfera Citizen Observatory and other citizen science initiatives during the last 10 years. The Citizen Observatory Natusfera was created in 2016 in Spain by CREAF and GBIF.ES, in collaboration with CSIC centres Real Jardín Botánico and Institut de Ciències del Mar. As an outcome of the opportunity to report on Sustainable Development Goals (SDGs) and enhance the platform to foster community engagement, facilitate greater interaction among users, tailor it to local contexts, and enable the reporting of additional variables beyond biodiversity to enhance participation and deepen understanding of ecosystems, the development of the MINKA platform commenced in 2020 under the European Cos4Cloud project, led by ICM-CSIC.

Initially positioned at Technology Readiness Level (TRL) 4 at the beginning of ARSINOE project, (see section ‘Technology Readiness Level (TRL) in MINKA’), MINKA underwent significant advancement during the ARSINOE project, culminating in the implementation in a real-case scenario within the ARSINOE Case

Study 1 (Greening the Athens metropolitan area). Concurrently, MINKA underwent testing in Catalonia as part of the current citizen science activities of the ICM-CSIC. These field tests with real users, conducted with the collaboration of local partners, were instrumental in elevating MINKA's biodiversity component from TRL 4 to 8, marking a substantial leap in its development trajectory under ARSINOE.

Moreover, the ARSINOE initiative fostered a strategic partnership with the ANERIS project in 2023 (see Section 'Functional improvements:'), aiming to integrate environmental variables into MINKA. This collaboration has propelled MINKA environmental component to TRL 6, a significant progress towards its goal of becoming a comprehensive tool for environmental monitoring and research.

2.1. MINKA and the SDGs

The (SDGs) serve as a roadmap for achieving a sustainable future, necessitating reliable and comprehensive data for effective monitoring and progress assessment. Citizen science offers a novel data source that holds promise for SDG reporting and monitoring, yet its full potential remains largely untapped. In a recent study (Fraisl et al, 2020) [(1)], an analysis and review of SDG indicators and citizen science initiatives revealed the current and potential contributions of citizen science to the SDG framework. In particular, the study revealed that citizen science is already making strides in monitoring specific SDG indicators, with significant inputs observed in areas such as Life on Land, Sustainable Cities and Communities, Good Health and Wellbeing, and Clean Water and Sanitation. Leveraging citizen science data to its fullest extent demands demonstrating its value in the global data ecosystem, fostering partnerships, and maximizing investments to amplify its impact on SDG progress. According to this study, to unlock the full potential of citizen science data for the Sustainable Development Goals (SDGs), creating an enabling environment is crucial. This involves:

- Raising awareness and sharing experiences about citizen science's role in SDG monitoring.
- Developing case studies and success stories to showcase innovative uses of citizen science data.
- Ensuring data quality through defined criteria and quality assurance procedures.
- Integrating citizen science into SDG indicator methodologies.
- Promoting consistent data collection standards across citizen science initiatives.
- Supporting open data formats and standards for citizen science data.
- Sustaining citizen science initiatives through innovative funding schemes.

In this context, MINKA serves as a proactive contributor to the SDGs, anchored on pillars of **Observation Registration**, **Community Sharing**, and **Community Interaction**, with a future focus on **Community Empowerment**. MINKA contributes now to SDG 14 (Life on below water) and SDG 15 (Life on land), but it is committed to advancing research and action aligned with the SDGs, underscoring its pivotal role in driving sustainable development efforts. Until now, MINKA have been able to:

- **Raise awareness and sharing experiences about citizen science's role in SDG monitoring:** MINKA has collaborated with educational institutions (see section 'MINKA IN ARSINOE CASE STUDIES') to incorporate citizen science modules into curriculums and raise awareness among students.

Also, MINKA has participated in several conferences and workshops to educate stakeholders about the importance of citizen science.

- **Develop case studies and success stories to showcase innovative uses of citizen science data:** As shown in section 'MINKA IN ARSINOE CASE STUDIES', MINKA is active working in ARSINOE Case Study 1 (Greening the Athens metropolitan area Athens). A pilot has been started too in Case Study 9 (Sardinia) and negotiations are being done to start a pilot in Case Study 6 (Black Sea).
- **Ensure data quality through defined criteria and quality assurance procedures:** MINKA have a rigorous data validation process, involving both expert data curators and community validation mechanisms. This ensures that only high-quality data meeting predefined criteria are accepted for SDG monitoring purposes.
- **Integrate citizen science into SDG indicator methodologies:** MINKA has been recognized by UNESCO as an official SDG Action (#SDGAction53541).
- **Promote consistent data collection standards across citizen science initiatives:** The Insitut de Ciències del Mar (ICM-CSIC) is part of the EU-Citizen.Science where they share best practices and align methodologies with other citizen science observatories and projects.
- **Support open data formats and standards for citizen science data:** MINKA data can be downloaded in an anonymised way.
- **Sustaining citizen science initiatives through innovative funding schemes:** MINKA have not developed yet sustainable plans beyond public financing, but MINKA is exploring the viability of other funding sources.

2.2. How does MINKA work?

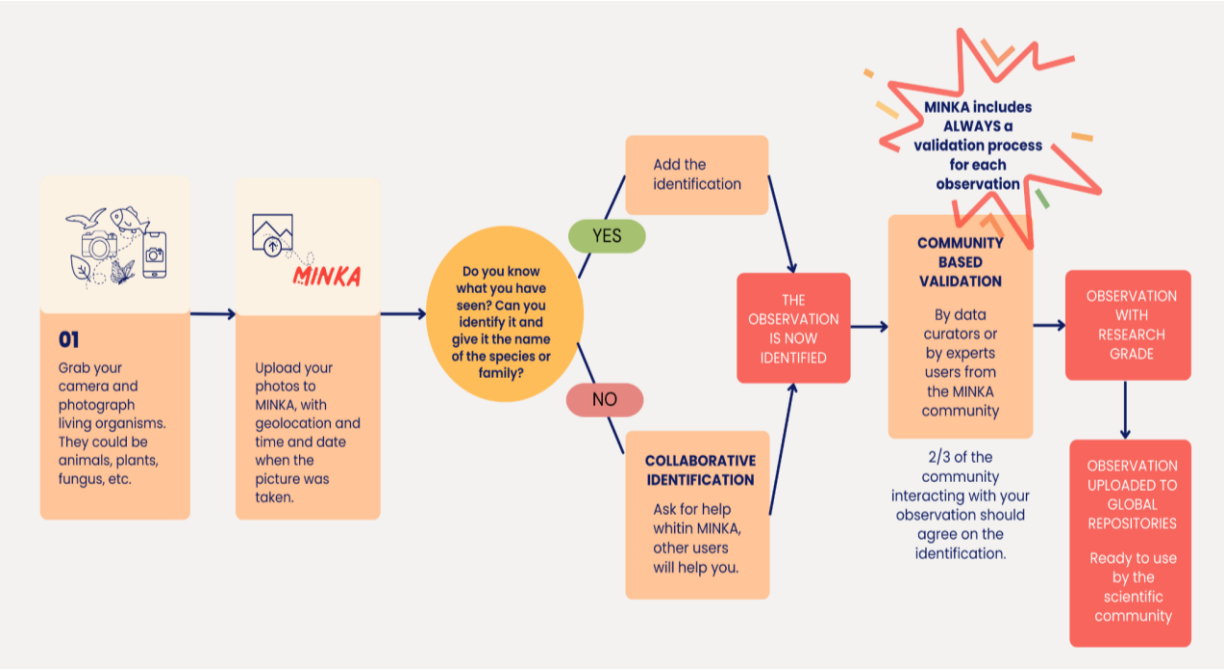
Figure 1 MINKA overview

The fundamental functionalities of MINKA are outlined in the following points.

- **Record Keeping:** Users can document their observations and store the data in the cloud. This ensures that their observations are not only recorded but are also easily accessible for reference.
- **Community Connection:** MINKA facilitates user interaction within its community. Members can collaborate to validate or enhance each other's observations, discover new projects, and engage in various community activities.
- **Learning Opportunities:** Users can expand their knowledge on biodiversity, species identification, sustainability, and environmental topics by engaging in conversations with fellow MINKA community members.
- **Scientific Contribution:** Uploaded observations undergo validation by the community, leveraging the expertise of other members. Once a specified number of validations are achieved, the observations attain Research-Grade status and are uploaded to global repositories, available for use in research studies.
- **Observation Organization:** Users can initiate projects aligned with their interests and invite the MINKA community to participate in developing sustainability-focused initiatives. Users can also contribute to other projects of interest by uploading observations or actively participating in project discussions.

The typical progression of an observation in MINKA is delineated in Figure 2, from the moment the photograph is captured to its eventual attainment of research-grade status, making it eligible for upload to global repositories.

Figure 2 A MINKA biodiversity observation journey



This process is vital for maintaining the accuracy, reliability, and integrity of the observations and knowledge within the platform. Engaging the community in the validation process allows for a collective evaluation and verification of different elements. This collaborative effort enhances the platform's robustness and fosters a more trustworthy environment by ensuring that a diverse group of contributors thoroughly examines and confirms observations.

Figure 3 offers a comprehensive insight into the mechanics of "Community Validation" within MINKA. This process serves as a pivotal step in guaranteeing the precision, dependability, and authenticity of observations and insights on the platform. Through community involvement in the validation procedure, we can collectively assess and confirm diverse elements, thereby enhancing the platform's resilience and credibility.

Figure 3 Community validation in MINKA

2.3. MINKA web and MINKA App

The MINKA web version has all available functionalities, providing users with a complete toolkit for engaging with the MINKA platform. From creating and managing projects to exploring observations and interacting with the community, the website offers a seamless and feature-rich experience accessible through any web browser.

In contrast, the mobile App version is designed for users who prefer to engage with MINKA on the go. The App focuses on allowing the upload of observations directly from the mobile camera. By simplifying

the interface and prioritizing ease of use, the App offers a convenient solution for users who wish to contribute observations while in the field or away from their desktop.

This dual approach ensures that users have the flexibility to choose the platform that best suits their needs and preferences, whether they prefer the comprehensive capabilities of the website or the convenience of the mobile App for on-the-go contributions.

2.4. Technology Readiness Level (TRL) in MINKA

The Technology Readiness Level (TRL) provide a standardised method for assessing the maturity of a technology or innovation. NASA initially developed Technology Readiness Levels (TRL) in the 1970s as a systematic way to assess the maturity of technologies during the development process. The TRL scale ranges from TRL 1 to TRL 9, with each level representing a specific stage of technological readiness and development.

- **TRL 1 - Basic Principles Observed:** At this stage, scientific research translates into applied research and development. The concept is identified, and scientific research is initiated to understand its feasibility.
- **TRL 2 - Technology Concept Formulated:** The concept is developed in this phase, and basic principles are recognised. The technology's potential applications are identified, but no experimental validation has occurred.
- **TRL 3 - Experimental Proof of Concept:** Active research and development efforts are underway during this stage. Proof of concept experiments are conducted to validate the feasibility of the technology.
- **TRL 4 - Technology Validated in Lab:** At TRL 4, the technology is validated in a laboratory environment. This involves testing and experimenting with the technology to demonstrate its functionality and performance under controlled conditions.
- **TRL 5 - Technology Validated in Relevant Environment:** In this phase, the technology is validated in a relevant environment, simulating real-world conditions. This step is crucial to assess the technology's readiness for further development and eventual deployment.
- **TRL 6 - Technology Demonstrated in Relevant Environment:** At TRL 6, the technology is demonstrated in a relevant operational environment. This involves field-testing the technology to evaluate its performance and effectiveness in practical applications.
- **TRL 7 - System Prototype Demonstration in Operational Environment:** In this stage, a prototype of the system is demonstrated in an operational environment. The technology is refined and optimised based on feedback from real-world testing.
- **TRL 8 - Actual System Completed and Qualified:** At TRL 8, the technology is considered complete and qualified for operational use. The system undergoes final testing and validation to ensure compliance with performance and safety requirements.
- **TRL 9 - Actual System Proven in Operational Environment:** TRL 9 represents the highest level of technological maturity. The technology has been successfully demonstrated in an operational environment and is regularly used.

In the context of MINKA, we have achieved **TRL8 for biodiversity observations**, indicating that the platform's capabilities for collecting and analysing biodiversity data have been successfully demonstrated in real-world scenarios. However, for **environmental observations**, MINKA currently stands at **TRL6**. While the environmental observation component is still in a pilot phase and has not yet been fully validated in real-case scenarios, we are scheduled to conduct beta testing with selected users in May 2024. This testing phase will allow us to gather feedback and validate the effectiveness of MINKA's environmental observation capabilities in real-world environments. See section 'Functional improvements:' for more information on the environmental component of MINKA.

2.5. Logo and Visual Identity for MINKA

As part of the efforts to enhance the MINKA Citizen Observatory, we have developed a fresh logo and visual identity (Figures 4 and 5) to reflect the platform's evolution and expanded capabilities. This new branding modernises MINKA's image and aligns with its mission to promote citizen participation in environmental observation and conservation efforts. Alongside the new logo, we have introduced a refreshed look and feel for the website and updated promotional materials.

Figure 4 MINKA logo

MINKA

Figure 5 Example of the MINKA visual identity guideline

3. MINKA WEB FUNCTIONAL AND TECHNICAL DESCRIPTION

3.1. MINKA features and improvements

MINKA is a newly evolved version of the old Natusfera Citizen Observatory. Stemming from a fork of the iNaturalist platform, MINKA marks a significant evolution towards a more community-oriented and versatile citizen science platform.

Originally developed as a platform for documenting biodiversity observations, iNaturalist provided an excellent starting point for MINKA's development. However, MINKA's unique focus on community engagement and the Sustainable Development Goals (SDGs) of UNESCO necessitated several enhancements and modifications performed in ARSINOE. By building upon iNaturalist's infrastructure, MINKA benefits from a solid technological backbone while offering tailored functionalities to meet the demands of the MINKA community.

One notable improvement in MINKA is the expanded scope of observations beyond biodiversity alone. Recognising the interconnectedness of environmental factors, MINKA introduces the capability to upload environmental variables alongside traditional biodiversity observations. This expansion allows participants to contribute a broader range of data, enriching the platform's potential for scientific research and environmental monitoring.

Prior to ARSINOE, within the framework of the Cos4Cloud project, ICM-CSIC conducted several co-design workshops to gather targeted feedback on new features and user experience enhancements for the platform. Additionally, training sessions for teachers were conducted, allowing ICM-CSIC to collect valuable feedback and suggestions for improving MINKA for educational purposes. This knowledge was carried forward into the ARSINOE project.

This section explores the key features and improvements introduced in MINKA during ARSINOE, showcasing its potential as a versatile and community-driven citizen science platform. Some of these improvements were based on feedback gathered during the previous Cos4Cloud project, while others were collected through beta testing of MINKA during ARSINOE. MINKA relied on the experience and feedback of prominent communities utilizing citizen science platforms for their own local citizen science projects in Catalonia, Spain. These communities agreed to act as beta-testers and chose to utilize MINKA for their citizen science projects, even migrating from other Citizen Observatories data and user profiles through formal legal agreements with the users and respecting the data privacy policy of the previous Citizen Observatories. Specifically, these communities oversee the projects UrbamarBio, BioPrat, and Biodiversitat de Torrelles de Llobregat within MINKA. They extensively tested the MINKA platform to identify bugs and suggest functional and community engagement improvements. The feedback was collected individually and analysed by the MINKA core team, comprised of a group of senior researchers and technicians from Quanta Labs and ICM-CSIC with background in software development, data

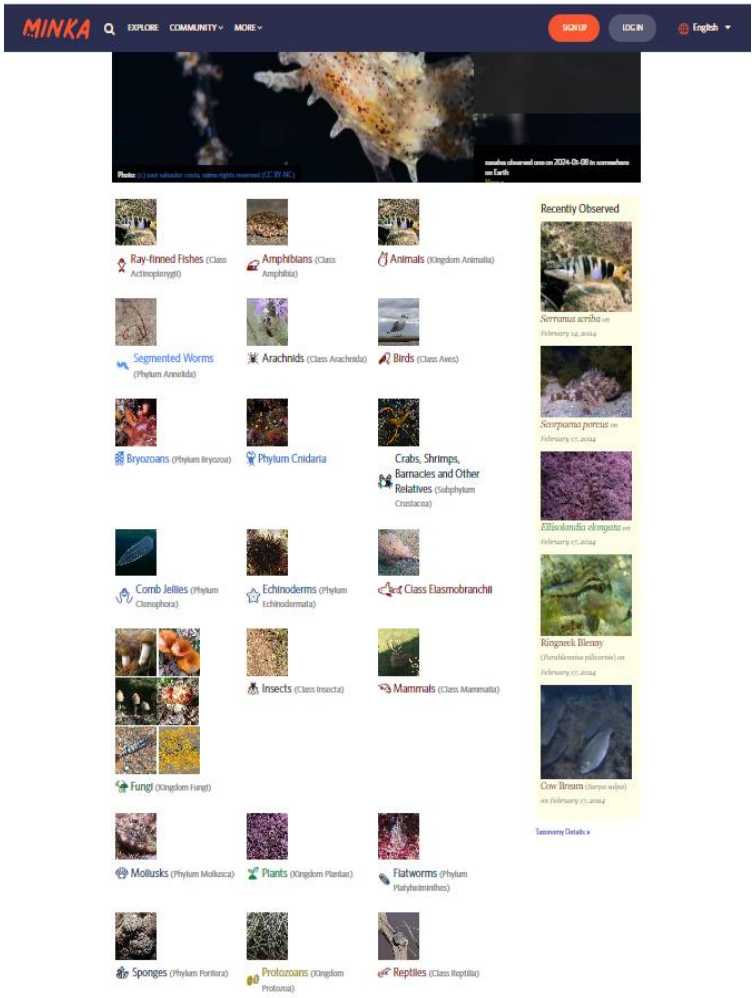
governance, data curation, and community engagement in citizen science projects. The feedback collected by the communities during Cos4Cloud and ARSINOE was transformed by the MINKA core team into specific issues to stablish a roadmap for improvements and new features implementations.

3.1.1. Functional improvements:

The following list summarises the key functionalities and improvements in MINKA:

1. **Marine Species Reporting:** MINKA now supports the dedicated reporting of marine species with a specific taxonomy, including various marine categories. Expressly, we have incorporated Annelida, Bryozoa, Cnidaria, Crustacea, Ctenophora, Echinodermata, Elasmobranchii, Platyhelminthes, Porifera, and Elasmobranchii (Figure 6). A new set of icons to search by category has been developed to include the new taxa (Figure 7).

Figure 6 Taxa covered by MINKA



2. **Iconographic Taxonomy User Profile:** MINKA introduces an innovative user profile with visual representations of taxonomy, allowing users to explore and engage with their preferred species of interest (Figure 8). Three profile options are available (Figure 9): marine-focused, land-focused, and general for user customisation.

Figure 7 New category icons in MINKA

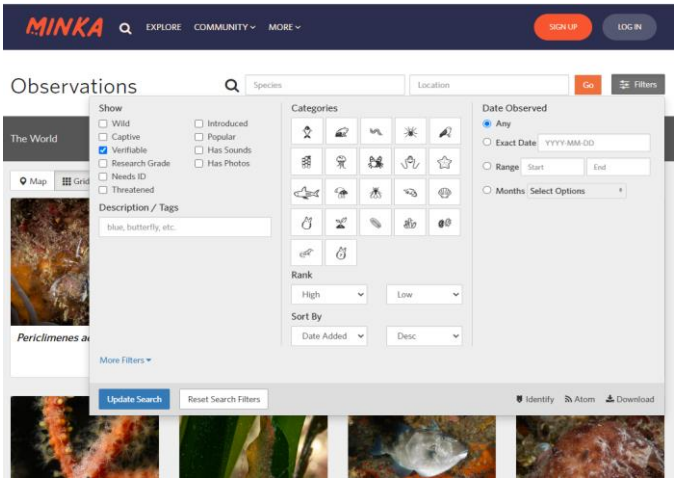


Figure 8 Taxonomy profile selection in the User Settings page of MINKA

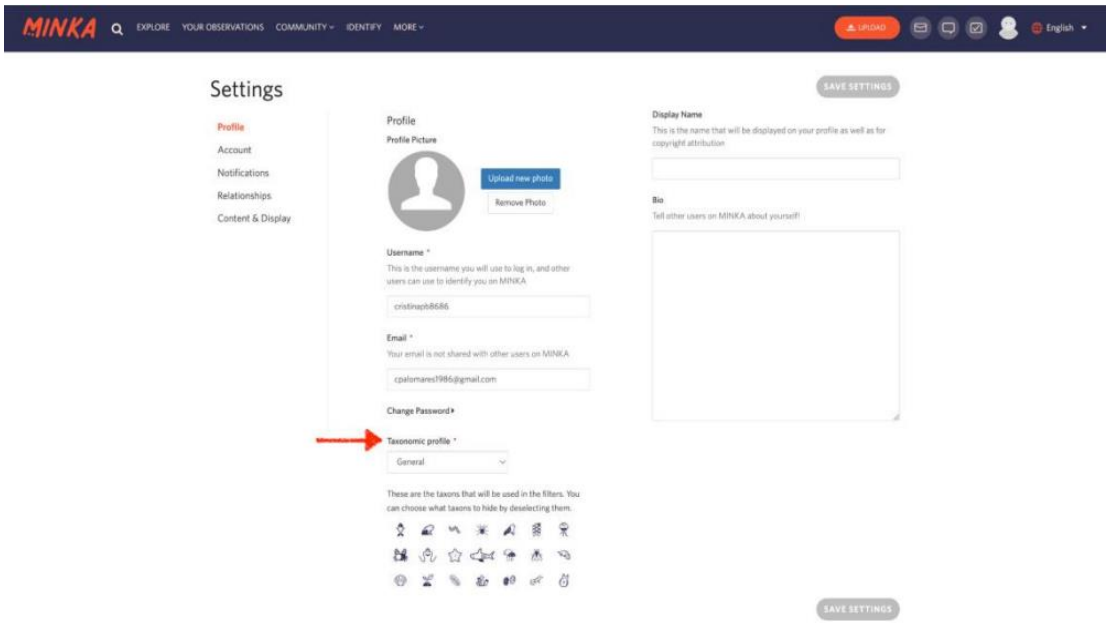
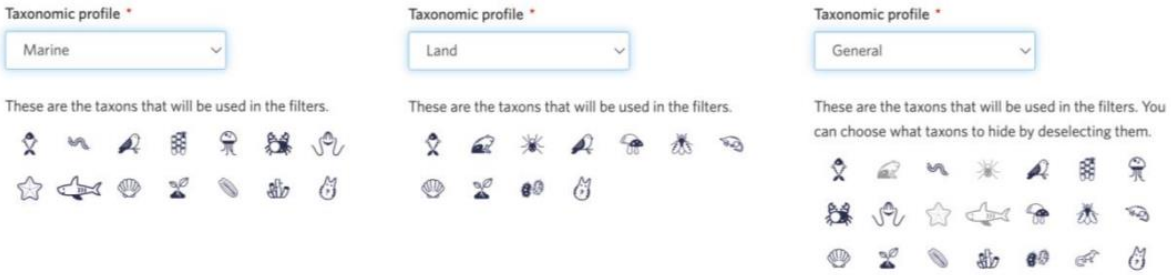


Figure 9 Taxonomy profile selection in the User Settings page of MINKA



1. **Improved design:** The header and footer have been re-designed following the MINKA visual identity guide to make them more modern and easier to use (see Figures 10 and 11). Some minor design problems such as making sure that all the colours matched and that the text didn't overlap, were also fixed.

Figure 10 New MINKA Header (logged in and logged out)

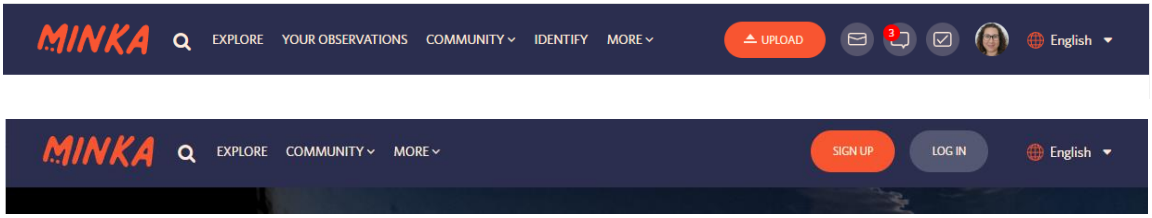


Figure 11 New MINKA Footer

2. **Bug Fixing:** The current version of MINKA includes fixes to various bugs discovered during testing, including:
    a. Missing translations and text typos,
    b. Error when deleting and exporting,
    c. Profile icon disappears when narrowing the window,
    d. {site} tag not shown in the interface,
    e. "*Loading suggestions*" is displayed when there is no text.
    f. Different issues with map zones.

3. **Environmental variable reporting:** MINKA is expanding its capabilities to address additional Sustainable Development Goals (SDGs) by facilitating the reporting of environmental data observations, such as temperature or rainfall.

    Approaching the reporting of environmental variables requires carefully considering the diverse environmental factors and their varied reporting methods. In our initial phase, we focused on environmental variables that closely align with reporting and validation procedures for biodiversity variables. This strategic decision enables us to leverage existing views and workflows associated with biodiversity reporting, thereby maximising code reuse and streamlining the user experience (UX) for reporting environmental variables. With this in mind, our objectives are threefold:

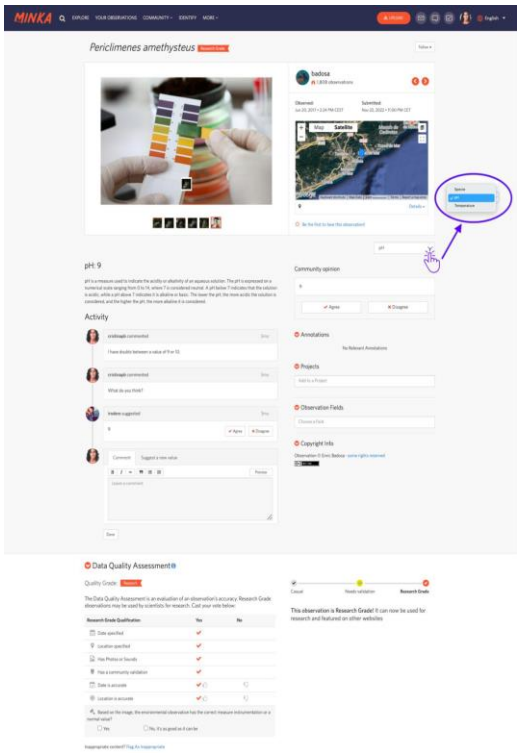
    a. **Maximising Code Reuse and User Participation:** By utilising similar interfaces to those used for biodiversity reporting, we aim to minimise the need for extensive UX analysis while capitalising on the familiarity of current users with the platform's workflows. This approach facilitates the participation of current users in reporting environmental variables, thereby enhancing community engagement and the potential for environmental data to be submitted by existing users.

    b. **Ensuring Backward Compatibility:** We are committed to ensuring backward compatibility to accommodate users who may not wish to access the new environmental variable services. Users can easily deactivate environmental variable services, preserving the familiar appearance and functionality of MINKA for those who prefer to focus solely on biodiversity monitoring.

        Working with similar interfaces will facilitate the participation of current users, already familiar with the current workflow in the case of biodiversity, if they are interested in also providing information on the new environmental variables that we propose and that are reported in a very similar way to the biodiversity observations. With this premise, we hope to develop different functional aspects such as communication strategies (to maximise the community of practice), co-design exercises (to incorporate new elements into the functionalities) and data governance analysis.

c. **Development of Environmental Variables Prototypes:** The project has already made progress on developing a prototype for environmental variables. An initial prototype (Figure 12) enabled the incorporation of various environmental variables alongside biodiversity observations within MINKA. For instance, an observation may now include information about biodiversity and optional values for environmental variables, such as pH and temperature. Most of the data on environmental variables was initially managed separately through an API, as outlined in Subsection 'MINKA Web System Architecture'. However, a second pilot version has been developed to create environmental observations independent of biodiversity observations.

Figure 12 First prototype of integration of environmental variables on the MINKA web



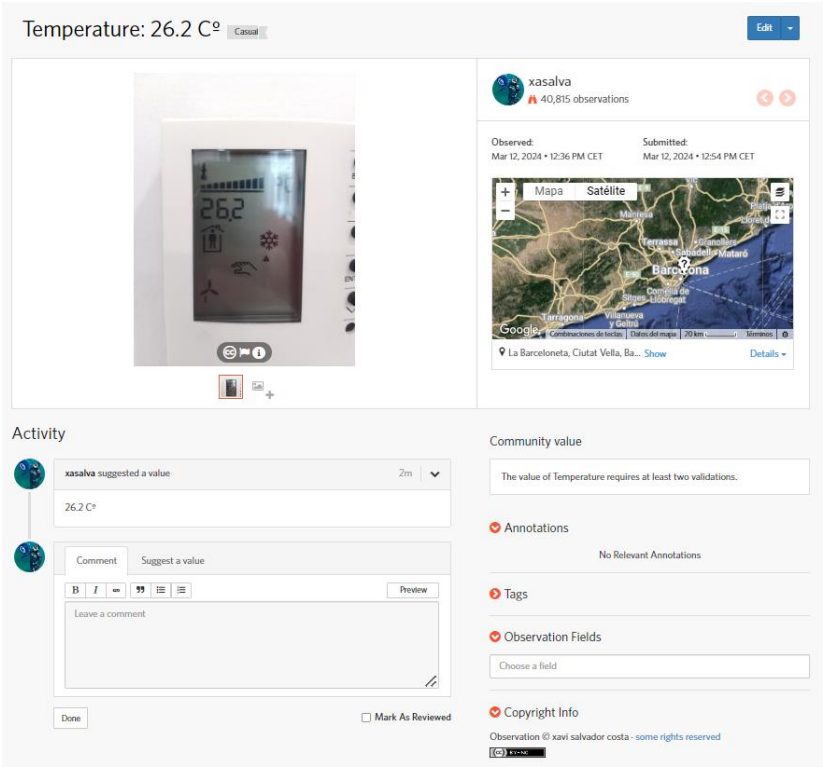
For the development of environmental parameters within MINKA, a collaborative effort was established with the ANERIS project, ANERIS started in 2023 and it is actively working on operational marine services for citizen science. In November 2023, ARSINOE and ANERIS jointly organised a co-design workshop in Barcelona to advance this initiative. During this session, organised by the Institut de Ciències del Mar (ICM-CSIC), a partner of both projects, representatives from ANERIS, including Marsbased, Quanta Labs, Dribba, and Science for Change, collaborated with ICM-CSIC experts from the ARSINOE project to highlight the key goals when introducing environmental parameters in MINKA and propose the best solution.

Throughout the collaborative session, we identified key challenges encompassing technical aspects, data governance, user engagement, data accuracy, and usability. We proposed a tailored solution to integrate environmental variables effectively into the platform, which resulted in the second environmental pilot version of the environmental parameters presented in this deliverable.

Efforts have been directed towards developing a second prototype to integrate this functionality, and efforts are still ongoing at the time of this deliverable submission. This updated prototype will allow for creating environmental observations as standalone entities within MINKA, maintaining the familiar look and feel of biodiversity observations (Figure 13). Despite their shared interface, environmental observations are treated as distinct entities internally, as detailed in Subsection **'**Database Schema Enhancements'. Future investigations will explore the potential benefits of directly relating both environmental and biodiversity observations within MINKA.

Since the second prototype has not been yet to production, ANNEX 1: Prototype 2 for environmental variables in MINKA shows screenshots of the prototype, including a lector where users can choose what kind of observations want visualise and the new data quality assessment. Currently prototype 2 has been field-tested in March 2024 with temperature and rainfall by ICM-CSIC researchers.

Figure 13 Second prototype of integration of environmental variables on the MINKA web



3.1.2. Non-functional improvements:

This section outlines the key non-functional improvements addressed in MINKA during the duration of the ARSINOE project, from its beginning until March 2024.

1. **Improved User Experience:** Significant enhancements have been made to improve the user experience in MINKA and make it more user-friendly and enjoyable.

   Pre

   a. ***Notification functionality*** has been improved, now having three distinct fields for different types of updates instead of one. This makes it easier for users to differentiate between

      i. *Private messages* received from other users (envelope icon in the header)

      ii. *Notifications of interest* regarding comments on observations. Users can see notifications for observations they're interested in, whether they are their own observations or ones they've helped identify. They can also see the tags for other users or new observations related to the taxa or projects they're following.

      iii. *Identifications* updates on their observation or observations they have contributed to identify.

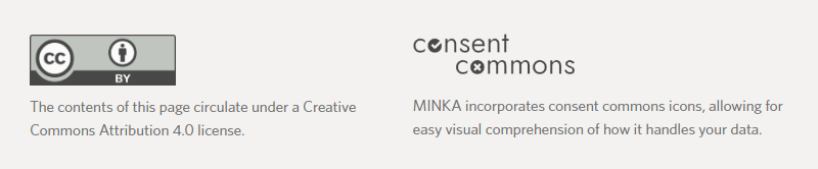
   Also, notifications are now grouped by user, reducing redundancy, and users can scroll through and order them as needed. For example, now, if a user has uploaded 50 observations, they will not receive one notification for each upload, just a single notification saying they have uploaded 50 notifications.

Finally, users can browse the notifications and arrange them in order.

b. ***New support pages***, including vital information such as "About us", "Community Guidelines", “Governance”, and "Terms of use", have been added or fixed.
c. ***Configurable alert messages by the MINKA admin*** for public notifications have been introduced for better user awareness.
d. ***Delete unused old media platforms***, like CloudSound and Flickr, have been removed.
e. ***Project ID*** is now displayed on the project page, ensuring users can access this information.

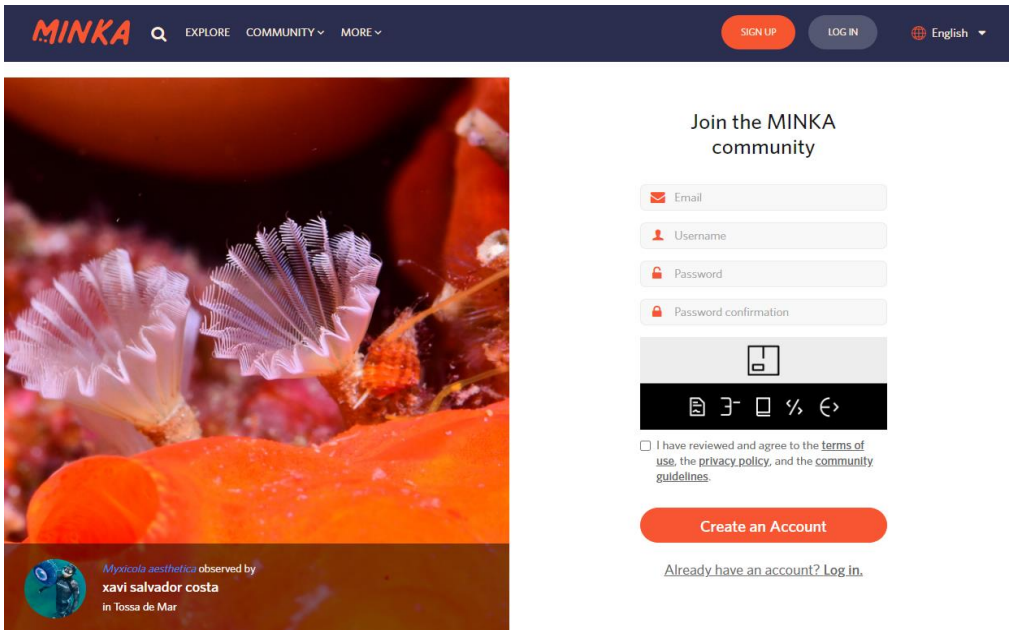
2. **New Cookies and Privacy Policy Management:** These changes have been implemented both in the website version of MINKA and the App version.
   a. MINKA now adheres to Consent Commons to visually present its privacy policy to users (Figure 14).

Figure 14 MINKA Consent commons information in the footer of the web



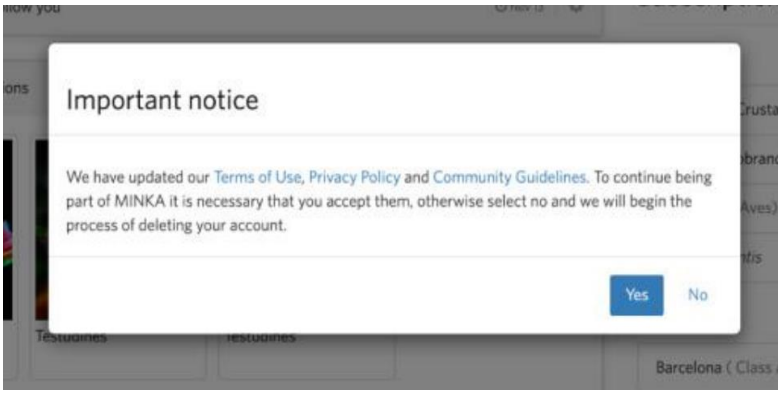
   b. The privacy policy has been updated, and corresponding changes have been applied throughout MINKA, including the sign-up page (Figure 15), the privacy user settings page, and a new privacy policy page.

Figure 15 New sign-in page in the MINKA web with the updated privacy policy



c. A new pop-up (Figure 16) informs users of policy changes, allowing them to accept or refuse.

Figure 16 Pop-up to accept the new privacy policies



d. A new cookies management system (Figures 17 and 18) and integration of Matomo as a new cookie on MINKA have been implemented. Matomo is being used to track website analytics.

Figure 17 New cookies pop-up

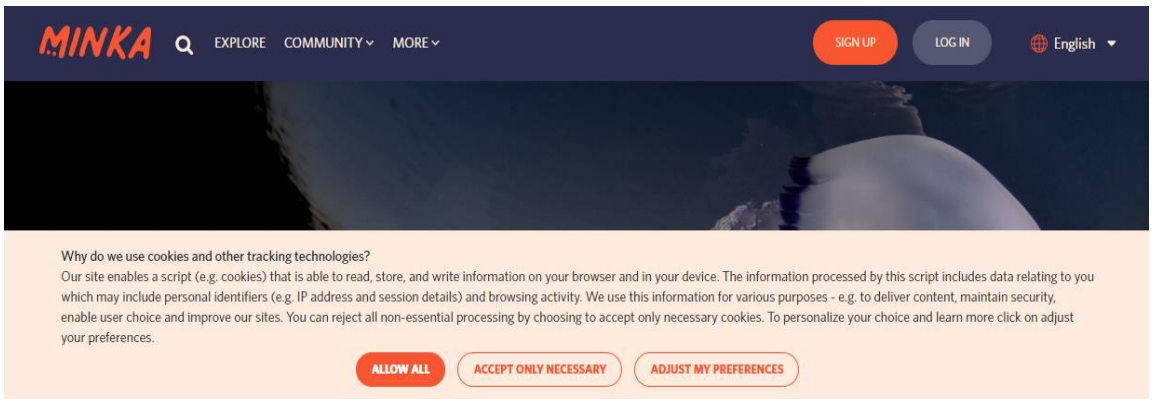
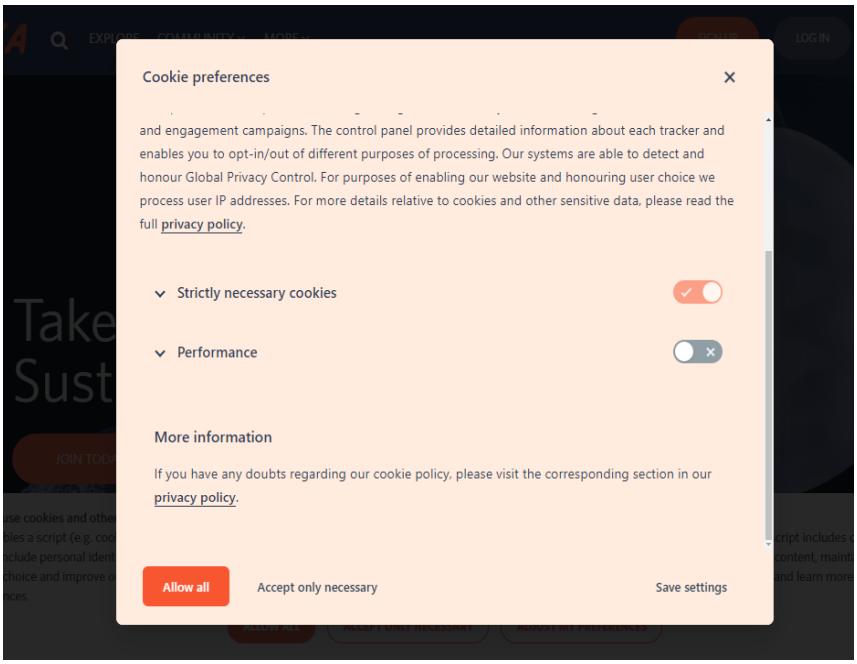


Figure 18 New cookies preferences



3. **Deployment Improvement:**
   a. Deploying MINKA has been made more accessible and error-free with several enhancements.
   b. A new Staging environment has been added to differentiate between testing and production.
   c. Docker files have been updated to address issues encountered during the initial production release.

3.2. MINKA Web System Architecture

In this section, we present the overall structure of the expanded MINKA website, highlighting its main components and their interactions.

The MINKA website follows a monolithic architecture, featuring a single web application providing primary functionality. Additionally, an API application assists the main application by handling resource-intensive tasks, such as user notification management and sharing MINKA data with external parties.

MINKA includes additional software components, such as a search engine, specialised database extensions for geolocation, various caching mechanisms, and a background jobs queue system to enhance functionality.

To create the first prototype for uploading environmental variables (see Section ‘Functional improvements:’), a new module called 'minka-api-vars' was added to manage these variables. A bridge was created to integrate this module seamlessly with the MINKA web application, and a functional proof of concept was deployed in the MINKA staging environment.

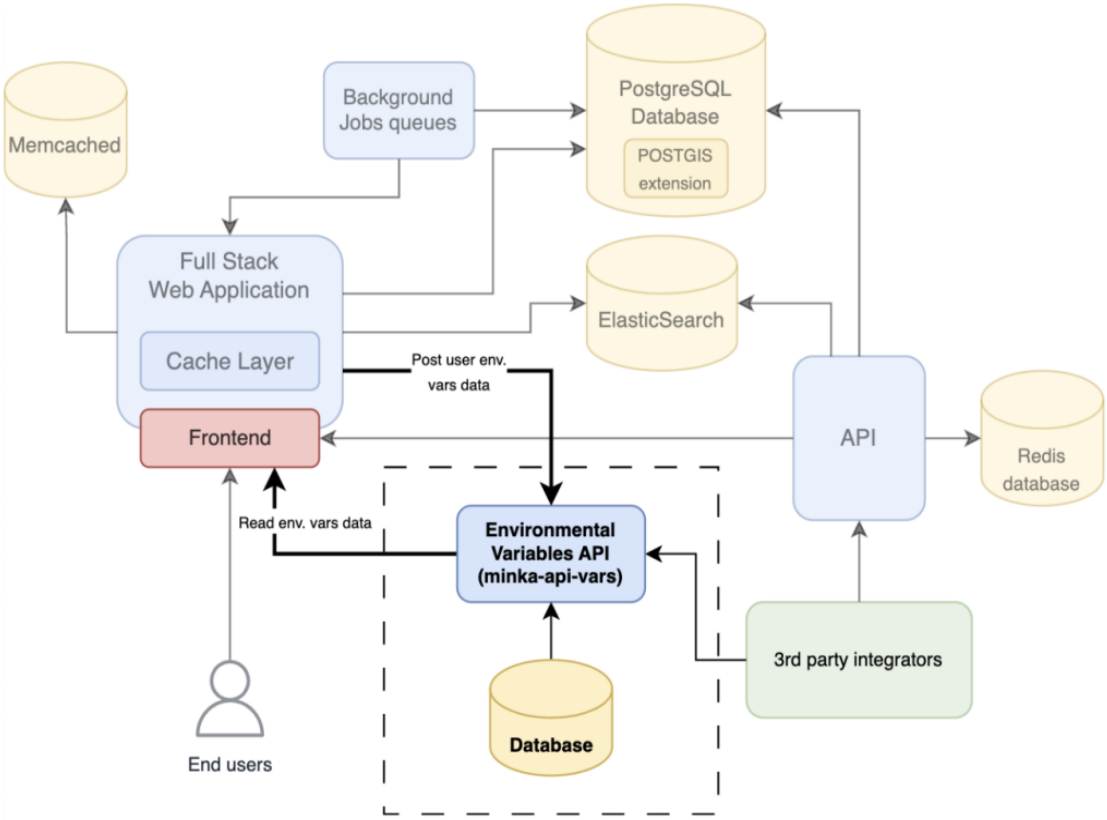
3.2.1. Main system components

Figure 19 shows the key components of the architecture, emphasising the new components created.

MINKA comprises the following components:

- **Full Stack Web Application:** Powered by a *Ruby on Rails* application, this central component manages data and interactions within the MINKA architecture.
- **Frontend:** Part of the Full Stack Web application, the front end is directly served by the *Ruby on Rail*s routing system, utilising various technologies (see Section 'Codebase').
- **API:** Implemented using NodeJS, the API serves third-party integrators and the MINKA website frontend. It underwent modifications to handle user notifications, user profile data, and searches within the system.
- **Search Engine:** ElasticSearch indexes data entities like observations, identifications, places, projects, users, taxons, terms, and notifications. These indexes support efficient search functionality, ensure timely notifications, and contribute to platform statistics. ElasticSearch enables scalability to handle growing user and observation volumes.
- **PostgreSQL Database (with PostGIS):** MINKA stores data in a PostgreSQL database enhanced with geographical functionality through PostGIS. Database table modifications were made to support the described features.
- **Background Jobs Queues:** Managed by the Ruby on Rails framework and supported by the PostgreSQL database, background job queues handle heavy processing asynchronously. No changes were made to this component for this deliverable.
- **Memcached:** Memcached serves as a caching mechanism in MINKA, optimising performance by storing the results of costly processing operations. No changes were made to this component for this deliverable.

Figure 19 MINKA architecture components



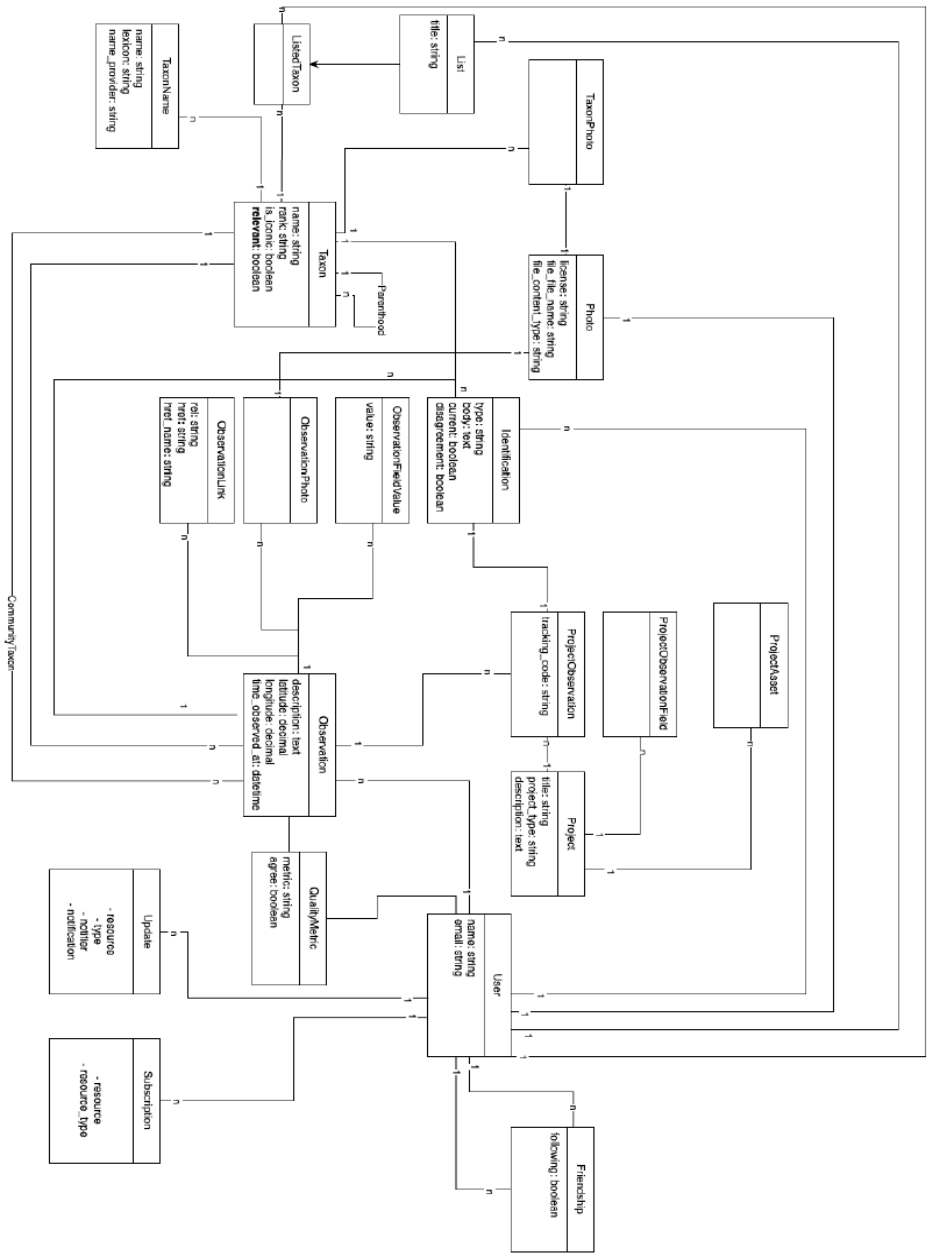
3.3. Database design

In Figure 20, we present the entity-relationship diagram showcasing the primary database entities within the MINKA platform. The diagram includes only the most pertinent attributes of each entity, with certain non-core entities omitted for clarity, such as invitations, taxon colours, or wiki pages. Additionally, unrelated entities that do not contribute to a better understanding of the features described in this deliverable, such as those associated with taxa changes, have been excluded. Below, we offer an overview of the key entities featured in the model:

- **Observation:** This fundamental entity represents each individual species uploaded to the platform by users. When creating an observation, users can associate it with a taxon or observation photo, among other attributes. Observations can also be linked to other entities to provide additional information, such as observation links or observation fields.

- **Taxon:** The taxon entity corresponds to a hierarchical representation of species, complete with names, descriptions, and rankings. While the diagram presents a simplified view, the platform encompasses a comprehensive system for managing taxon sources, names, changes, versions, reviews, links, ranges, and schemas.

Figure 20 MINKA entity-relationship diagram excerpt



- **User:** This entity represents all registered users on the platform, each with distinct roles (e.g., admin, curator, owner, regular user) determined by the Roles entity (not depicted in the diagram). Users can establish friendship associations with other users and subscribe to various entities through the Subscription entity.
- **Identification:** Users can validate the taxon of an observation through the identification entity. This validation can confirm the current taxon or propose an alternative. Each observation

possesses a community taxon, aggregating all identification models to determine the consensus taxon.

- **QualityMetric:** This entity assesses the quality of an Observation by allowing users to assign predefined metrics such as wilderness, location, date, and more.
- **Project:** Observations are associated with projects created within the platform, represented by the Project entity.
- **List:** This entity signifies a compilation of taxa compiled by users to track species they've encountered, are interested in, or wish to observe. Lists can also represent taxa occurring in specific locations within the platform.
- **Update/Subscription:** These are polymorphic entities capable of relating to various entities within the application. They enable user subscriptions to different entities and track changes. While not all possible associations are depicted in the diagram for clarity, examples include Observations, Users, and Projects.

3.3.1. Database Schema Enhancements

Numerous adjustments have been implemented within the database schema to enhance functionality and address evolving requirements. Essential modifications include:

1. **Introduction of Specific Iconographic Taxonomy for Marine Species:** A new pertinent field has been integrated into the Taxon database model to facilitate the customisation of highlighted taxa within the user interface (UI). Data migrations have been undertaken to designate specific taxa as relevant and to modify the iconic field for marine species taxa.
2. **Implementation of Iconographic Taxonomy User Profile:** To accommodate user preferences regarding taxonomy profiles, two additional fields have been added to the User model:
    - profile_taxon_name: This field specifies the type of taxonomic profile selected by the user.
    - profile_taxon_ids: In the event of a custom profile selection, this field allows users to store their preferred taxon IDs as an array of integers within the User model.
3. **Integration of New Cookies and Policy Management:** To offer improved control and transparency over cookie management and policy compliance, the following fields have been introduced:
    - policy_accepted_at: This field records the timestamp when the user accepted the policy.
    - policy_status: This field indicates the current status of the policy, denoting whether it has been accepted, declined, or is pending user action. It facilitates easy monitoring and enforcement of policy compliance.

4. **Development of a Second Prototype for Environmental Observations:** In support of existing observation features such as Biodiversity Observations and introducing a new observation type termed Environmental Observation, the Observation model has been extended utilising Single Table Inheritance (STI) methodology. Key changes include:
    - *Biodiversity Observation*: Taxon associations have been transferred from the parent Observation to the Biodiversity Observation. Associations with identifications related to species and data validations specific to species details are now linked with the Biodiversity Observation child model.
    - *Environmental Observation*: The new Environmental Observation model shares most features with the existing Observation. However, it is specifically linked to an Environmental Variable, which determines the variable name, measurement unit, and specific validations for the observation. A new value field has been incorporated into the Observation to track the measurement, utilised by the Environmental Observation model.

    A new model has been established to track value measurement suggestions from the MINKA community. Similar to the existing Identification model, it focuses on environmental variable measurements rather than species identification.

3.4. User Interface Design

The user interface (UI) design is crucial for a positive and smooth experience on MINKA. This section explains the design principles, highlights user experience considerations and showcases wireframes.

The UI design of MINKA's new features follows core principles for a user-friendly interface:

- **Consistency:** Ensuring a uniform interface across the web app for easy navigation.
- **Simplicity:** Prioritizing a clean design, avoiding clutter and unnecessary complexity.
- **Responsiveness:** Adapting seamlessly to various devices and screen sizes. Note: Mobile users can use the MINKA app for an optimised mobile experience.
- **User-Centricity:** Focusing on user needs and preferences, backed by user research and feedback throughout the design process.

Beyond design principles, we have carefully considered user experience (UX) to improve MINKA's overall usability. These considerations encompass:

- **Visual Hierarchy:** Utilizing a clear visual hierarchy, ensuring key elements stand out and important information is easily noticeable.
- **Intuitive Interactions**: Prioritising intuitiveness, we focus on logical and easy-to-understand user interactions and workflows, making tasks effortless.
- **Error Handling:** Our design provides clear and helpful error messages when users encounter issues or make mistakes to incorporate effective error-handling mechanisms.
- **Feedback and Progress Indicators:** Implement visual cues like loading indicators and progress bars to inform users about system actions and processes when necessary.

3.4.1. User interface wireframes

We have developed wireframes to illustrate key aspects of our user interface design, providing an overview of the app's layout, components, and interactions. Here are some examples:

- **Homepage Wireframe:** This wireframe is designed to attract new users with appealing visuals and clear messaging. It highlights MINKA's unique features, benefits, and value proposition, presenting key features in a scannable manner for quick understanding. The goal is to captivate and convert new users, ensuring a positive user journey within the web app.
- **Footer Wireframe:** The footer wireframe includes essential details about the organisation or project, such as '*Coordinated by*' and '*Financed by*' information. License logos for Creative Commons and Consent Commons and links to pages like *Governance*, *Community Guidelines*, and *Contact Us* are included. Social media links facilitate easy navigation to the web app's social media profiles.
- **Environmental Variables Feature Wireframe:** Figures 12 and 13 display the wireframe for the first prototype of the environmental variables reporting. The design integrates environmental observations into biodiversity observations, maintaining MINKA's aesthetics.

3.5. Codebase

The MINKA codebase was developed from a fork of iNaturalist, an open-source social network for naturalists.

The entirety of the code is housed in two Git-based repositories on GitHub:

- **Minka SDG**, which encompasses the Ruby on Rails Full Stack application along with all frontend code.
- **Minka SDGAPI** contains the NodeJS API that extends functionality to the front end and is available for integration by third-party entities.

All code pertinent to the features outlined in this deliverable can be found within these repositories. The code commits reference-specific tasks undertaken during development to track changes implemented. Currently, the repositories are set to private access, but they are intended to transition to open-source status. This will enable others to contribute and foster a community of developers around the platform.

3.5.1. Front end

The MINKA front end comprises distinct modules utilising various technologies to support their functionality. Key technologies and modules include:

- **AngularJS** is utilised in the Explore module for observation and species search, filtering, and visualisation. It controls forms, components, navigation and integrates with Google Maps. The module was modified to incorporate new taxonomic profiles and the iconographic taxonomy for marine species.

- **ReactJS** is employed in multiple independent modules, each composed of React components managed by Redux for state. These modules, compiled using Webpack, include the life lists module for species tracking and searching, the stats module for user-specific statistics, and the user profile edition module, all modified for new taxonomic profiles.

- **Ruby on Rails' view layer** is used in simpler layouts like the admin panel, observation detail pages, user dashboard, and authentication. All features outlined in this deliverable necessitated modifications in the Ruby on Rails frontend views, written in both erb and haml templating systems. JavaScript code in this layer, excluding AngularJS and React components, is based on JQuery and the Ruby on Rails UJS library.

3.5.2. Backend

The backend components of the MINKA application consist of the Ruby on Rails full-stack application and the Node.js API, detailed in Section 'MINKA Web System Architecture'. Both applications underwent modifications to support the features outlined in this deliverable.

- **The Ruby on Rails application** adopts the MVC (Model-View-Controller) design pattern, relying heavily on Active Record models with multiple data accessors and callbacks for model creation and modification. While lacking additional design patterns initially, this deliverable introduced the use of presenters to reuse presentational logic from models, with plans for further pattern integration like the Command pattern. The codebase maintains a plain structure familiar to Ruby on Rails developers and is not divided into functional modules.

- **The Node.js API**, built on Express.js, follows the MVC pattern and utilises PostgreSQL and Elasticsearch as data sources for the model layer. Unlike the Ruby on Rails backend, it eschews a full-featured ORM in favour of Squel, a Node.js SQL query builder, for PostgreSQL access, simplifying code and improving efficiency. For Elasticsearch integration, the API employs the official Elasticsearch Node.js client, directly sending JSON-based requests. API endpoints are documented using the Open API standard, accessible at https://minka-sdg.org:4000/v1/docs/.

  Moreover, the Node.js API includes a tile server to enhance the performance of map components in the MINKA frontend. These tiles, generated from Elasticsearch data, offer efficient loading of place and observation information, and are documented as Observation Tiles and Polygon Tiles in the API documentation.

3.6. Quality Assurance and Testing

To maintain consistent quality standards and ensure MINKA's proper functioning, we've implemented robust quality assurance processes across the development lifecycle. These processes involve:

1. Code Reviews:

- Conducted for every new pull request, code reviews are crucial for ensuring quality, maintainability, and adherence to coding standards.

- Experienced developers or designated team members systematically examine source code, focusing on logic, readability, efficiency, and best practices.
- Feedback and suggestions for improvement are provided to enhance overall code quality, minimise bugs, and foster collaboration among team members.

2. Functional Testing:

- This testing ensures the solution meets specified requirements and functions as intended.
- Manual functional testing occurs at different stages:
  - The person overseeing code reviews performs the first round of functional testing for each pull request.
  - Once a pull request is approved, it undergoes functional testing in a staging environment replicating the production environment.
- Before deploying a release to the production environment, it undergoes testing in a staging environment. In this phase, we test the bug fixes, improvements, and new features included in the release and conduct regression testing. Regression tests are specifically designed to:
  - Verify Unimpacted Features: Ensure that features not directly affected by the release continue to function as expected.
  - Prevent Issue Recurrence: Confirm that previously resolved issues do not reoccur, maintaining the overall system's stability.

3.7. Security and Data Privacy

This section focuses on how MINKA keeps user information safe and secure. We'll also discuss the rules and agreements that explain how user information is used on the MINKA platform.

3.7.1. Security

MINKA adheres to engineering best practices by incorporating encrypted communications, robust authentication and authorisation methods, and isolating the back end using firewall rules.

The application's deployment relies on Docker, providing a resilient architecture focusing on high availability and security. Using containers ensures that only necessary connection sockets are exposed, minimising the risk of exploitation by malicious users.

For data security, regular backups of the database are conducted. These backups are securely stored offsite in a cloud infrastructure, accessible only to a select few administrators with the appropriate permissions.

3.7.2. Terms of Use

The Terms of Use for the MINKA platform establish a binding agreement that governs user interactions and outlines the legal framework for platform operation. These terms delineate eligibility criteria for platform use, acceptable and unacceptable uses, and the permissions users grant to MINKA. Additionally,

detailed protocols are provided for deactivating accounts and requesting information removal, ensuring adherence to data privacy laws and regulations.

3.7.3. Privacy Policy

The Privacy Policy of MINKA elucidates the measures in place to protect users' data. It provides insights into data storage methodologies, specifying both geographical and virtual locations where data is held. The policy details with whom the platform may share user data, the circumstances under which sharing occurs, and the legal requirements guiding such sharing. User rights are clarified, encompassing access, rectification, erasure, and data portability. The policy addresses consent management, outlining how MINKA obtains, records, and respects user consent, along with protocols for consent withdrawal. Additionally, it categorises collected data types, explaining the purpose and legal basis for each category.

3.7.4. Cookie Settings

MINKA has implemented a cookie management system that adheres to the ePrivacy Directive and GDPR. This system gives users precise control over their cookie preferences, enabling consent for mandatory cookies, customisation of optional settings, and opting out where permissible. Users can conveniently revisit and adjust these settings through their profiles, reflecting MINKA's commitment to ongoing consent and preference management.

3.7.5. Consent Commons Framework

MINKA has introduced the Consent Commons Framework, a pioneering approach to simplifying personal data management. This feature utilises intuitive visual icons to convey complex data practices in an accessible manner. Each icon clarifies specific aspects, such as the purpose of data collection, data sharing with third parties, user rights (including data portability and erasure), international data transfers, and data storage practices. This initiative underscores MINKA's commitment to transparency and empowering users in data privacy.

3.7.6. Data Licensing Options

MINKA offers diverse data licensing options for images, datasets, and audio files. These options include seven forms of Creative Commons licences, including Public Domain, such as Attribution, Attribution Non-Commercial, Attribution Non-commercial share alike, Attribution Non-commercial No-derivates, and Attribution Share-alike. These options cater to content creators' specific needs and preferences, empowering users to make informed decisions about how their content is used and shared. This approach enhances respect for intellectual property and creative rights within the MINKA community.

3.8. Documentation

This section introduces the available documentation for MINKA, catering to both developers and administrators.

- **Technical Specifications for Developers:** Internal deployment documentation for MINKA has been created to guide its operation. This evolving document provides a step-by-step process for installing and configuring MINKA in a development environment.
- **API Documentation for External Integration:** API endpoints are documented using the Open API standard, accessible at https://minka-sdg.org:4000/v1/docs. This comprehensive documentation facilitates external integration efforts.
- **Admin Configurations:** MINKA offers documentation on configuring different home page fields, including sections like "How it works," "Sustainable Goals," and "App Stores." Administrators can utilise these resources to customise the appearance and content of the home page.

3.9. Future Directions and Opportunities for MINKA Web

MINKA has exciting prospects for growth and advancement in the future. These directions were discussed with ARSINOE Case Study leaders 1 and 2, as well as identified during co-design workshops performed in the Cos4Cloud project previous the beginning of ARSINOE. We highlight key areas where MINKA can expand its impact and benefits:

3.9.1. Integration of Environmental and Biodiversity Observations:

MINKA's integration of environmental variables will be tested with end-users in real-case scenarios during the ARSINOE project.

3.9.2. Utilisation of Artificial Intelligence for Species Identification:

MINKA plans to leverage Artificial Intelligence (AI) technology to improve species identification. By integrating AI algorithms like Pl@ntNet, MINKA can automate species recognition through image analysis, ensuring accurate and standardised species data for users.

3.9.3. Transition to Cost-effective Mapping Solutions:

To reduce costs and ensure long-term sustainability, MINKA seeks to replace the Google Maps API with a free alternative. This transition will maintain mapping functionality while minimising expenses, reflecting MINKA's commitment to efficient resource management.

3.9.4. Enhanced Quality Assurance Process:

MINKA aims to strengthen its quality assurance process by implementing unit tests, integration tests, and automated functional tests. This approach will help identify and address potential issues before they impact users, ensuring a stable and reliable platform.

3.9.5. Improve UX

By engaging an experienced UX consultant, MINKA aims to facilitate a co-design process involving real users to effectively implement the aforementioned improvements, with a specific focus on integrating new environmental variables. Additionally, MINKA will explore opportunities to enhance platform engagement to foster increased interaction among both existing and new users.

These future initiatives demonstrate MINKA's commitment to continuous improvement and user satisfaction, aligning with its goal of promoting citizen participation and data-driven decision-making for sustainable development.

4. MINKA APP FUNCTIONAL DESCRIPTION

For the development of the MINKA app on both iOS and Android platforms, we opted to commence from scratch with new code. We choose to use FLUTTER as a development kit. This decision stems from its versatility, enabling us to cater to various devices, including Android and iOS. Additionally, FLUTTER allows us to explore potential applications across different operating systems, such as Windows, OSX, and Linux, alongside the possibility of developing a web application.

4.1. MINKA App Features

The current version of the MINKA App represents a simplified version of its web counterpart, primarily aimed at facilitating the rapid submission of multiple observations via smartphones. This app serves as a preliminary step towards enhancing MINKA's adaptability and versatility in the future. However, it's crucial to acknowledge that while efforts are underway to adapt the code for future scalability, the process is still ongoing and does not fully reflect the application's potential for expansion.

The MINKA App offers the following functionalities:

- **User authentication and onboarding:** Users can securely create accounts and access the platform, with the acceptance of privacy policies ensuring the protection of user data.
- **Quick access to project information:** Users can efficiently navigate through their active and recent projects and explore all available projects on MINKA. They can also review general observations using map and list formats, distinguishing between their content and that of other users.
- **User profile management:** Each user has a dedicated profile where they can manage their sharing preferences and other settings common in mobile applications of this nature.
- **Creation of observations:** The app's core feature enables users to create new geolocated observations with detailed information, contributing directly to citizen science initiatives.
- **Consultation of observations:** The collaborative nature of MINKA allows users to interact with observations generated by themselves or others within the platform, fostering engagement and knowledge sharing among the community.

Currently, the MINKA App can report biodiversity observations. At the time of finishing this report, efforts were made to adapt the MINKA App to report environmental observations (see Section 'Future Directions and Opportunities for the MINKA App').

4.1.1. UI and UX in the MINKA App

MINKA App development has prioritised user feedback when shaping its user interface (UI) and user experience (UX) design strategies. The app was tested by a small group of MINKA users from the MINKA web, and their feedback has helped us improve the UI and UX design.

- **User-Centric Design Approach:** UI/UX enhancements commence with a user-centric design philosophy.

- **Iterative Design and Feedback Mechanisms:** We have adopted continuous iterative design cycles, enabling us to swiftly prototype, test, and refine our UI/UX. This iterative process has resulted in developing a more intuitive navigation structure, streamlining complex workflows, and optimising the app's overall layout for enhanced usability.
- **Streamlined Data Entry and Reporting:** Significant revisions have been made to the data entry and reporting interfaces to streamline the process of logging observations. We have simplified form elements, improved auto-complete functions, and restructured data entry fields to reduce errors and expedite data submission.
- **Performance Enhancement:** Recognizing the importance of performance in user satisfaction, we have optimised the application's performance to ensure swift loading times and seamless transitions between different app sections. This optimisation minimises frustration and enhances the overall user experience.
- **Improved Onboarding Experience:** Emphasizing the importance of a seamless and informative onboarding process, we aim to develop a more comprehensive system to welcome and guide new users through the functionalities of the MINKA App. This enhanced onboarding experience will aim to swiftly familiarise users with the core features and capabilities of the app, enabling them to contribute to biodiversity reporting and analysis with confidence and ease.

Figure 21 Examples of the MINKA App interface

4.1.2. Legal aspects and privacy policy

As explained in the section 'Legal aspects and privacy policy', the MINKA app has evolved its privacy policies and terms and conditions to align with those established by the MINKA web.

In alignment with the MINKA Web, the MINKA App has implemented similar legal and privacy measures to ensure user protection and data transparency. The Terms of Use have been adapted from MINKA

Web's guidelines, outlining eligibility criteria, usage guidelines, and user permissions. Updates include clear instructions for account deactivation and personal data removal, complying with privacy laws.

Similarly, the Privacy Policy of the MINKA App mirrors the protective measures of the MINKA Web, detailing data storage practices and user data handling specifics. It outlines user rights concerning their data, such as access, amendment, deletion, or transfer of personal information, and explains consent management procedures comprehensively.

The MINKA App has integrated the Consent Commons framework to enhance users' understanding of data privacy, employing visual data practices. This initiative reflects MINKA's commitment to transparent data privacy practices and user empowerment.

Furthermore, inspired by MINKA Web's approach to intellectual property rights, the MINKA App offers various Creative Commons licensing options for user-generated content. These licenses, ranging from Public Domain Dedication to Attribution models, enable users to specify how their contributions are utilized within the community, fostering a culture of collaboration and respect for intellectual property rights.

4.1.3. Incorporation of Continuous Integration

Integrating Continuous Integration and Continuous Deployment (CI/CD) practices into the development lifecycle is essential for boosting productivity and expediting time to market. Utilizing Xcode Cloud for iOS and Fastlane for Android allows us to test and deploy procedures, ensuring swift and efficient delivery of new features, updates, and bug fixes.

Xcode Cloud for iOS, an integrated continuous integration and delivery service within Xcode, is tailored for Apple platforms. It automates application compilation, testing, and distribution of iOS applications, triggering an automated build emphasising every commit. Tests utilise a clean, encapsulated environment on Apple's servers, guaranteeing a release-ready main branch. Moreover, it facilitates simultaneous testing across multiple devices and configurations, pinpointing device-specific issues. Once testing is complete, Xcode Cloud automatically distributes the build to testers, stakeholders, or the App Store.

Fastlane for Android is an open-source platform designed to simplify Android deployments by automating tasks like generating screenshots and handling signing issues. It integrates seamlessly with Android's build tooling to compile and package releases while managing metadata and deployment to the Google Play Store. Automated testing ensures that each release meets quality standards. Fastlane's actions can be triggered on specific branch commits, ensuring the stability of the master branch and early detection and resolution of issues.

Implementing CI/CD with Xcode Cloud and Fastlane offers several advantages:

- **Increased Productivity:** Developers spend less time on repetitive tasks, allowing them to focus on creating value through new features and code improvements.
- **Higher Quality:** Automated organisation of issues early, ensuring consistent code quality.

- **Faster Release Cycles:** Streamlined workflows enable more frequent releases, enabling rapid responses to market demands and user feedback.
- **Improved Team Collaboration:** Automated processes facilitate more frequent integration of team members' work with less effort, minimizing conflicts and ensuring a deployable codebase.
- **Scalability:** The CI/CD setup scales with the project, handling increased loads and more complex workflows without significant overhead.

4.2. The MINKA App System Architecture

MINKA App stands as an innovative solution for biodiversity reporting, showcasing a sophisticated technological architecture that emphasizes its advanced capabilities. Utilizing the robust Flutter framework, MINKA App epitomizes modern app development by leveraging cross-platform compatibility to deliver a seamless user experience.

4.2.1. Key Features of the MINKA App:

Cross-Platform Efficiency: Powered by Flutter, MINKA App can effortlessly generate natively compiled applications for mobile, web, and desktop environments from a unified codebase. This versatility allows MINKA App to extend its reach across different platforms without the need for extensive redevelopment, ensuring consistency in functionality and design across various devices.

- **Rich UI Capabilities:** With Flutter's comprehensive set of UI components, MINKA App can create custom, visually appealing interfaces that align perfectly with its goal of providing an engaging and intuitive user experience. This enables MINKA App to foster user engagement in marine life reporting effectively.
- **Enhanced Performance and Simplicity:** MINKA App utilizes GetX for efficient state management, navigation, and dependency injection, resulting in improved performance and a smoother user experience. This lightweight yet potent solution streamlines code organization and facilitates efficient state management.
- **Reactive Programming:** With support for reactive programming, MINKA App can update its UI in real-time in response to data changes, ensuring dynamic displays of updated environmental data, user interactions, and real-time notifications within the app.

4.2.2. Flutter as the Core of MINKA App:

Flutter serves as the foundation of MINKA App's development and maintenance endeavours, offering a range of unique features and capabilities ideal for building a robust, cross-platform application. Key benefits of Flutter for MINKA App include:

- **Single Codebase:** Developers can write a single codebase for deployment on multiple platforms, significantly reducing development and maintenance costs.
- **Rapid Development with Hot Reload:** Flutter's 'hot reload' feature accelerates the development process by enabling instant visualisation of code changes without full app recompilation.
- **Rich Set of Pre-Designed Widgets:** Flutter provides a comprehensive library of pre-designed widgets, simplifying UI development efforts.
- **Performance:** Flutter compiles to native ARM code, ensuring high performance crucial for scaling the app and integrating complex features.
- **Ease of Integration:** Flutter seamlessly integrates into existing applications, allowing for gradual scaling and flexibility in expanding the app's capabilities.
- **Streamlined Testing Process:** Testing is simplified with Flutter's single codebase approach, ensuring scalability without exponentially increasing testing efforts.
- **Responsive Framework:** Flutter's responsive framework enables dynamic UI adaptation to diverse screen sizes and orientations, ensuring consistent user experiences across devices.
- **Strong Community Support:** Backed by Google and a vibrant community, Flutter receives regular updates and offers ample resources for ongoing development and maintenance efforts.

4.3. Future Directions and Opportunities for the MINKA App

As the MINKA App continues to evolve, several key areas have been identified for future development. Some of these improvements were directly detected by the MINKA technical team, formed by ICM-CSIC and Quanta Labs, and others were raised by MINKA test users. These enhancements aim to refine the app's functionality and user experience, ensuring that it remains at the forefront of biodiversity reporting and environmental data collection.

Areas of Focus for Future Development:

4.3.1. Enhanced Testing Protocols

- Robust Testing Framework: Strengthening the existing testing framework with comprehensive automated tests covering a broader range of scenarios.
- Performance and Load Testing: Enhancing performance and load testing to efficiently handle increased user traffic and data processing demands.
- User-Centric Testing Approaches: Prioritizing user-centric testing methods, such as beta testing with a diverse user group, to address real-world usage issues effectively.

4.3.2. Reporting of Environmental Variables

- Expanded Data Collection: Adapting the MINKA App to report a broader range of environmental variables, including water quality metrics, air temperature, and pollution levels.
- Integration with External Sensors and Devices: Exploring integration with external environmental sensors for automated data collection.
- Data Visualization Tools: Enhancing the app with advanced data visualisation tools for better interpretation and understanding of environmental data.

4.3.3. Improved Offline Capabilities

- Advanced Data Syncing: Enhancing offline capabilities with sophisticated data syncing mechanisms for seamless integration upon reconnecting to the internet.
- Expanded Offline Functionality: Adding more features in offline mode, such as advanced data entry and access to previously downloaded data.
- Reliability in Remote Areas: Enhancing reliability and usability in remote areas with limited or no connectivity for uninterrupted marine life observation.

4.3.4. UI/UX Improvements Based on User Feedback

- Continuous UI/UX Refinement: Continuously refining the UI/UX based on user feedback, including simplifying navigation and improving aesthetic appeal.
- Feedback Mechanisms: Strengthening feedback mechanisms within the app to gather insightful and actionable user feedback.
- Personalization Features: Introducing more customisation options for users to tailor the app according to their preferences and usage patterns.

5. BUILDING THE MINKA COMMUNITY

Engaging volunteers is a fundamental aspect and a critical determinant of success in citizen science initiatives like the MINKA Citizen Observatory. Effective volunteer recruitment strategies are pivotal in ensuring a robust and active community of participants, essential for achieving the objectives of citizen science projects.

Citizen science emerges as an efficient strategy to address knowledge challenges in environmental evidence-based policies, which often require vast amounts of data. However, the success of citizen science projects hinges on the recruitment and sustained engagement of volunteers. Maximising the number of observations necessitates maximising participation rates, underscoring the importance of recruitment and engagement strategies.

The MINKA platform recognises the significance of fostering long-term engagement with volunteers for data collection and promoting scientific literacy, community empowerment, and environmental stewardship. By cultivating a vibrant and active community of participants, MINKA aims to leverage citizen science as a powerful tool for advancing the Sustainable Development Goals, driving positive change, and enhancing environmental decision-making processes. This section aims to elucidate the importance of engagement in the MINKA platform, highlighting strategies for effective volunteer training, recruitment and long-term participation.

5.1. Training materials

This section provides an overview of the training materials developed for the MINKA Citizen Observatory, aimed at enhancing user experience and ensuring efficient engagement with the platform. These user guides serve as comprehensive resources to assist users in navigating various aspects of the MINKA infrastructure, empowering them to contribute meaningfully within MINKA. Below is a brief outline of each user guide. The visual user guides (infographics) and the MINKA App video-tutorials were developed by ARSINOE project. Meanwhile, the rest of the user guides were developed under the ANERIS project, but are collected here since they have been used by ARSINOE Case Studies.

- **MINKA Platform Infrastructure User Guide:** This guide offers detailed instructions on utilising the MINKA web platform, providing users with a comprehensive overview of its features, functionalities, and navigation pathways.
  - Link to the guide (English)

- **MINKA APP - User Guide:** Designed for mobile users, this guide facilitates seamless navigation of the MINKA application, empowering users to contribute observations and access relevant information on the go.
  - Link to the guide (English)

- **MINKA Identify User Guide:** This guide assists users in identifying observations submitted by other participants within the MINKA platform. It provides insights into the identification process, enabling users to categorise and validate observations effectively, thereby enhancing data accuracy and reliability.
  - Link to the guide (English)

- **MINKA Translation User Guide:** In line with the collaborative nature of the MINKA platform, this guide facilitates the translation of the MINKA website and application into multiple languages. Users will find detailed instructions on participating in the translation process, promoting inclusivity and accessibility across diverse linguistic communities.
  - Link to the guide (English)

- **MINKA Projects User Guide:** Tailored for users interested in creating projects within the MINKA platform, this guide offers step-by-step instructions on project setup, management, and collaboration.
  - Link to the guide (English)

- **Visual Guides (Infographics):** Visual guides in the form of infographics have been developed to provide users with concise, visually engaging instructions on key actions within the MINKA platform. These infographics offer step-by-step guidance on essential tasks such as signing up for MINKA, creating new projects, uploading observations, catering to diverse learning preferences and facilitating ease of use. Each infographic distills complex processes into digestible visual sequences, enhancing user comprehension and promoting efficient interaction with the platform. Furthermore, to ensure inclusivity and accessibility across linguistic communities, these visual guides have been translated into multiple languages. Translations are available in English, Spanish, Catalan, and Greek.
  - Link to the infographic (English)
  - Link to the infographic (Greek)

- **MINKA App Video-tutorials:** A set of eight video tutorials on the use of the MINKA App, from how to create an account to modify an observation.
  - Link to the videos (English)

Development of a New Section on the MINKA Website

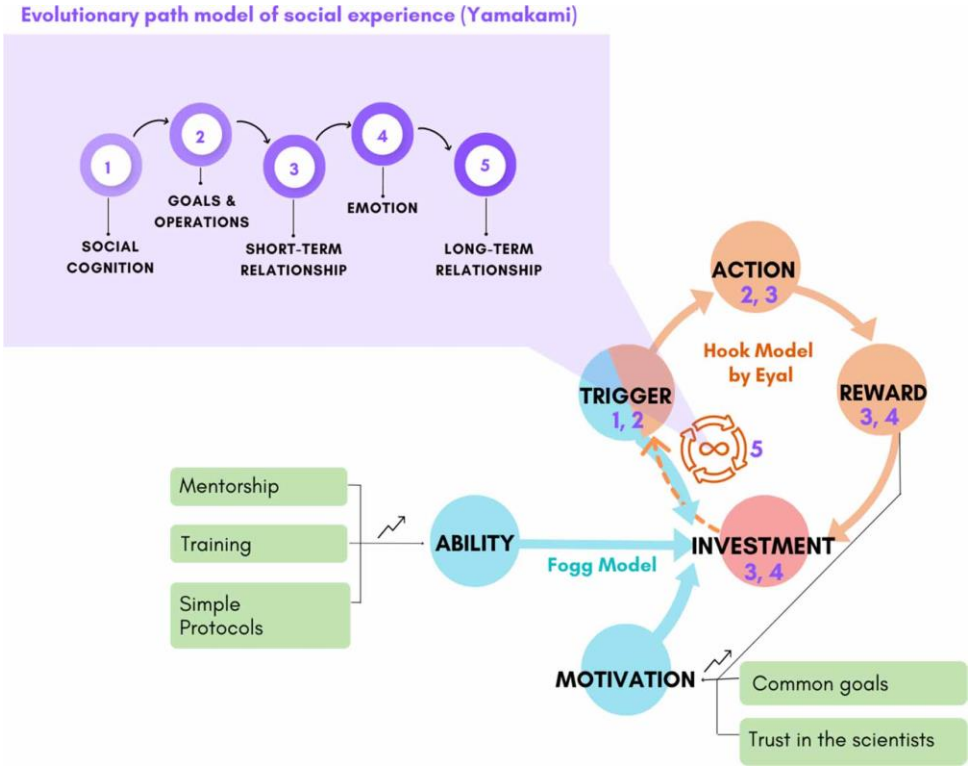
Efforts are currently underway to enhance user accessibility and streamline access to the array of resources available within the MINKA Citizen Observatory (CO). As part of these ongoing initiatives, a new section on the MINKA website is being developed to house all user guides, visual infographics, and supplementary materials. This section will serve as a centralised repository, offering users convenient

access to information to maximise their engagement with the platform and facilitate meaningful contributions to citizen science endeavours.

5.2. Engagement of the community: Janus Engagement Framework

The sustained engagement of volunteers is crucial for the success and longevity of citizen science projects like MINKA. To foster long-term involvement, the Janus Engagement Framework [2] (Figure 22), developed by the EMBIMOS group from the Institut de Ciències del Mar (ICM-CSIC) within the framework of ARSINOE, offers valuable insights. This framework integrates theoretical engagement models, technology user experiences, and strategies for maintaining motivation and enhancing volunteers' abilities and was tested in a real-case study, the citizen science project UrbamarBio. This case study, UrbamarBio, consists of the long-term high-resolution spatio-temporal participatory monitoring of coastal biodiversity in 20 urban beaches in three Spanish cities (Barcelona, Badalona and Sant Adrià del Besòs). The Janus framework were tested between 2016 to 2021, were volunteers reported observations (photographs) of coastal and marine living organisms on the Citizen Observatory Natusfera until 2020 and MINKA in 2021.

Figure 22 Janus Engagement Framework



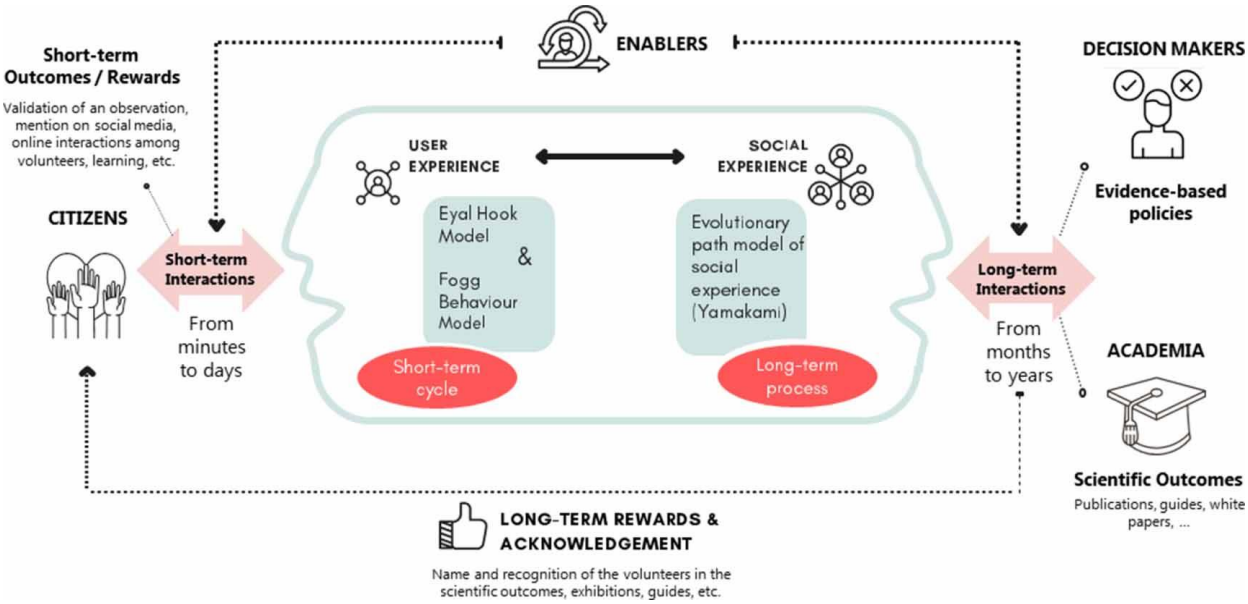
- **Behavioural Models:** The Fogg Behaviour Model (FBM) emphasises motivation, triggers, and ability as key factors driving community participation. Volunteers must be sufficiently motivated,

triggered appropriately, and have the ability to engage easily. Simplifying observation protocols can enhance volunteers' ability and increase participation rates.

- **Habit Formation:** The Eyal Hook Model (EHM) outlines a four-phase process for habit formation involving triggers, actions, variable rewards, and investments. By incorporating these elements, citizen science projects like MINKA can create engagement habits among volunteers, leading to sustained participation over time.

- **Layered Social Experience:** The layered model of social experience developed by Yamakami emphasises the importance of emotional connections and trust in fostering long-term relationships between users and platforms. By designing experiences that prioritise social interaction, feedback, rewards, and emotional satisfaction, citizen science platforms can cultivate a sense of belonging and commitment among volunteers.

Figure 23 Short and long-term interactions Janus framework: rewards as an example.



- **Multi-Temporal Approach:** By recognising the dual nature of engagement, the Janus framework adopts a multi-temporal approach that addresses both short-term and long-term engagement needs. Short-term rewards, triggers, and engagement actions keep volunteers motivated, while long-term scientific outputs and policy impacts serve as enduring rewards for sustained participation. Figure 23 shows the dual nature of engagement using reward as an example. User experience-focused models (Eyal and Fogg model) and social experience-focused model (YM) both generate short and long-term rewards. Academia produces scientific outputs that can be translated into long-term rewards and acknowledgements for the volunteers. Decision-makers use data obtained from volunteers to create evidence-based policies, which act as long-term rewards for the volunteers.

By integrating these elements into the design and management of the MINKA platform, we can create a dynamic ecosystem that fosters long-term engagement among volunteers. This approach not only enhances the quality and quantity of data collected but also promotes a sense of ownership, satisfaction, and impact among participants, ultimately advancing the goals of citizen science and sustainable development.

5.3. Janus engagement framework in practice

To take the Janus Engagement framework from theory to practice, citizen science practitioners need to identify who will perform the short-term and long-term engagement actions. With this purpose, and according to the engagement framework, four essential engagement roles were identified (figure 24): (a) **generating effective triggers**, (b) **motivating people**, (c) **reducing potential participation barriers (increasing ability)** and (d) **generating rewards for volunteers**.

Figure 24 shows on the left the four engagement roles that are essential for achieving an effective engagement strategy according to the Janus framework. The second box on the right of Figure 24 represents the Quintuple Helix of innovation used to implement the Janus framework in the case study UrbamarBio. The different roles are represented in the Quintuple Helix as the primary interaction between three actors: (a) academia, which provides knowledge, data curation and a Citizen Observatory, (b1) industry enablers and (b2) government enablers. The industry enablers represent the industry involved in non-formal education activities and that provide access to a pre-existing community, expertise in public engagement at a local level, and the capacity to overcome typical logistics barriers of citizen science projects. The government enablers are those who provide the legal and socio-economic frameworks to develop participatory activities (such as special permits for outdoor activities or event facilities close to the area). Both academia and the enablers are influenced by the (c) citizens, including schools and non-governmental organization (NGOs). Finally, the (d) context, known as local biodiversity and cultural heritage, is the driver for participatory environmental and social projects.

Three-Step Implementation Guide:

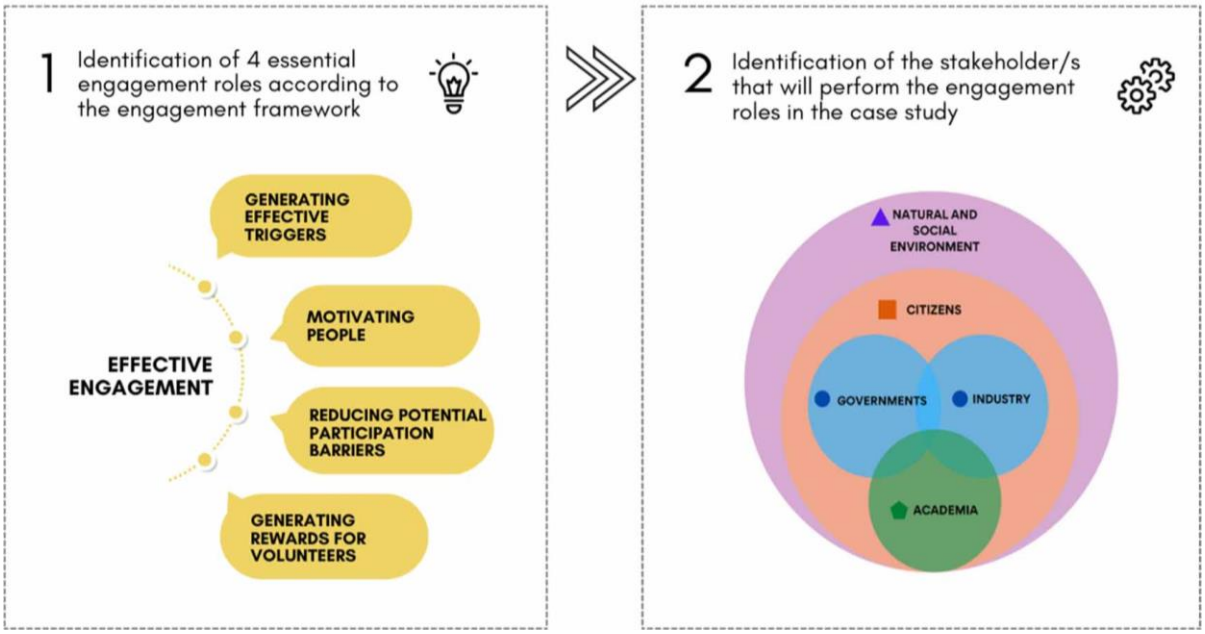
- ***Barriers Identification:*** Identify barriers to engagement within the project context. This may include logistical challenges, lack of motivation among participants, or limited accessibility to project resources. If the community is ready to participate and there are no relevant barriers to overcome, objectives can be determined to improve engagement.

- ***Stakeholder-Engagement Role Mapping:*** Map stakeholders to specific engagement roles based on their expertise and capacity to specific engagement roles. While some projects may involve a single stakeholder performing all roles, others may require collaboration among multiple entities with diverse expertise. The Quintuple Helix of innovation (Figure 24) serves as a valuable model for identifying key stakeholders, including academia, industry enablers, government enablers,

citizens, and the context (e.g., local biodiversity and cultural heritage). For example, academia may generate effective triggers and provide knowledge resources, while industry enablers may focus on motivating participants and reducing barriers through logistical support.

- ***Solution-Matrix Construction:*** Develop a solution matrix outlining strategies to overcome identified barriers (or achieving aimed goals), incorporating elements of the engagement framework. Solutions should address the stakeholders' needs and align with the project objectives. The matrix should specify the role of participants, enablers, and academia in implementing each solution.

Figure 24 Implementation of the engagement framework: mapping of stakeholders.



By following this three-step implementation (Figure 25) guide and leveraging the Janus engagement framework, citizen science projects within the MINKA platform can effectively engage volunteers, overcome barriers to participation, and foster long-term commitment and impact. This approach ensures that both short-term and long-term engagement actions are performed, contributing to the success and sustainability of the project.

Figure 25 Implementation guide. An example guide of how to implement the proposed engagement framework in UrbamarBio.

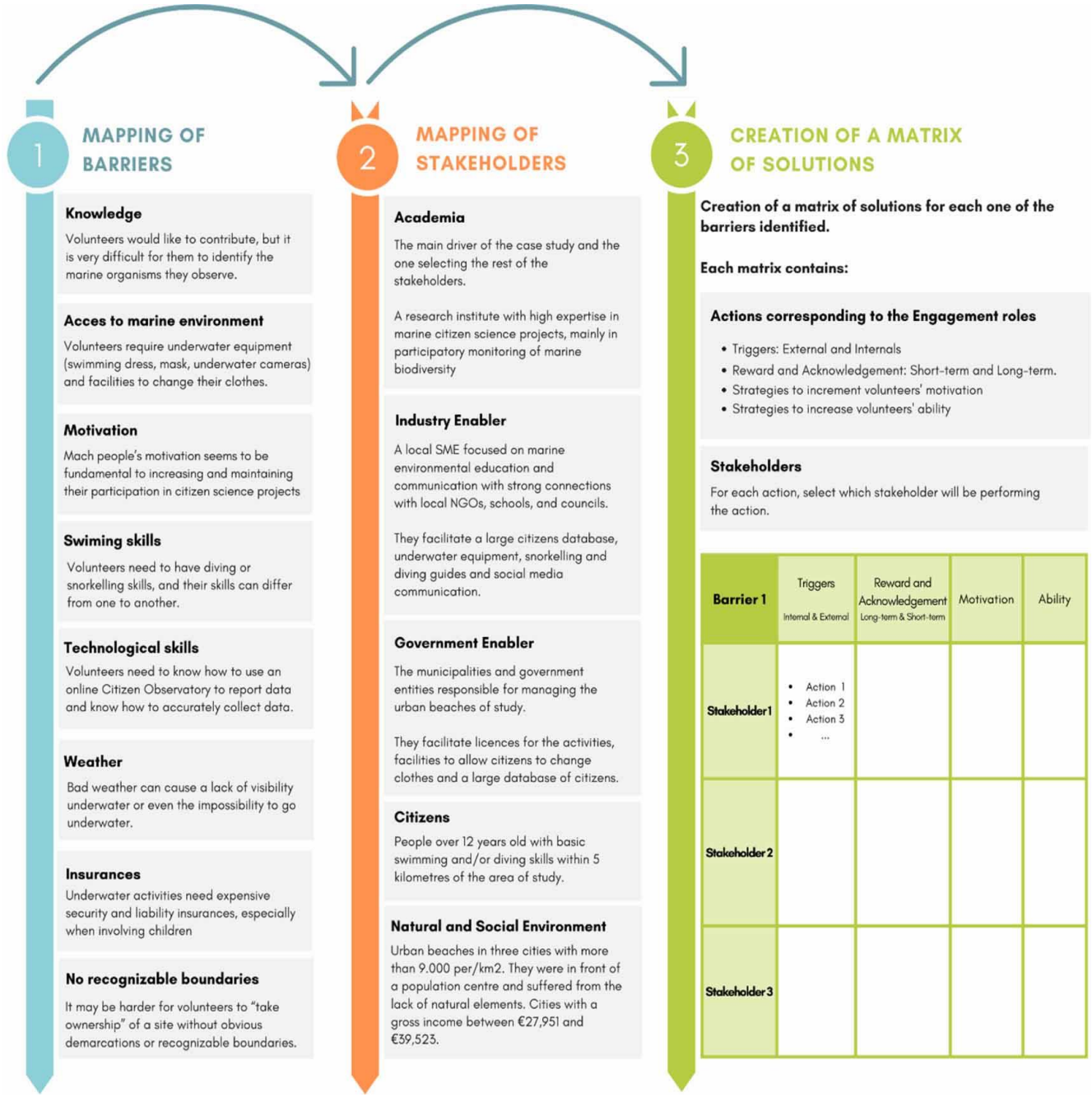
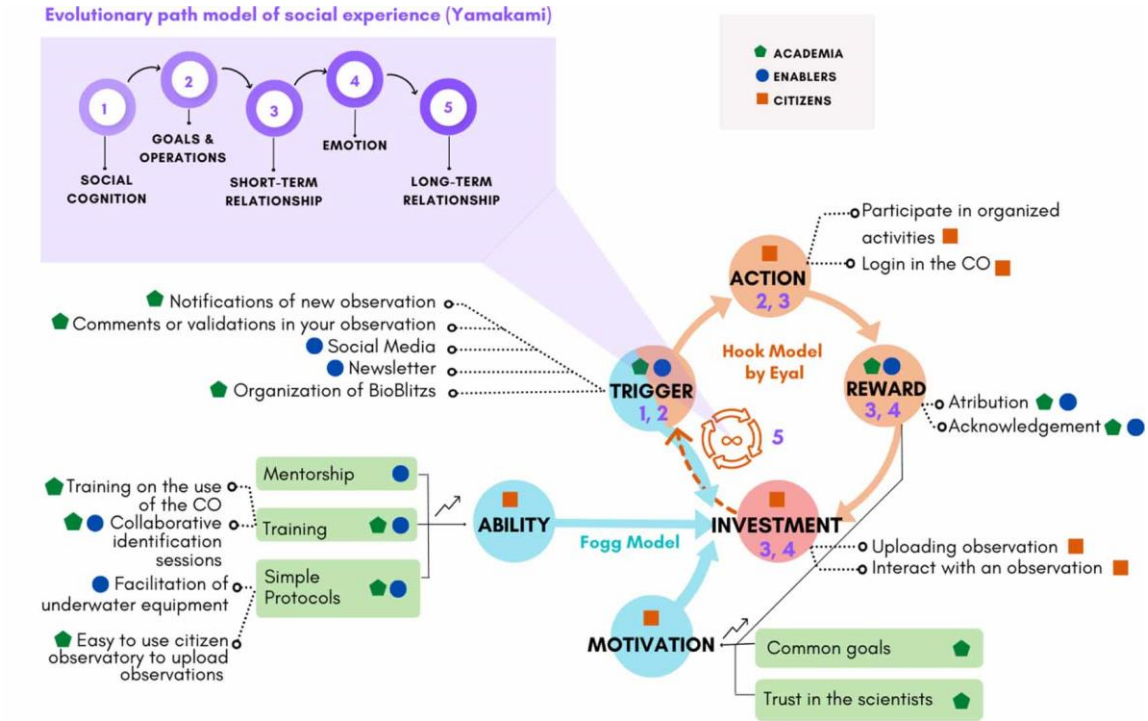

1
MAPPING OF BARRIERS
Knowledge
Volunteers would like to contribute, but it is very difficult for them to identify the marine organisms they observe.
Acces to marine environment
Volunteers require underwater equipment (swimming dress, mask, underwater cameras) and facilities to change their clothes.
Motivation
Mach people's motivation seems to be fundamental to increasing and maintaining their participation in citizen science projects
Swiming skills
Volunteers need to have diving or snorkelling skills, and their skills can differ from one to another.
Technological skills
Volunteers need to know how to use an online Citizen Observatory to report data and know how to accurately collect data.
Weather
Bad weather can cause a lack of visibility underwater or even the impossibility to go underwater.
Insurances
Underwater activities need expensive security and liability insurances, especially when involving children
No recognizable boundaries
It may be harder for volunteers to "take ownership" of a site without obvious demarcations or recognizable boundaries.
2
MAPPING OF STAKEHOLDERS
Academia
The main driver of the case study and the one selecting the rest of the stakeholders.
A research institute with high expertise in marine citizen science projects, mainly in participatory monitoring of marine biodiversity
Industry Enabler
A local SME focused on marine environmental education and communication with strong connections with local NGOs, schools, and councils.
They facilitate a large citizens database, underwater equipment, snorkelling and diving guides and social media communication.
Government Enabler
The municipalities and government entities responsible for managing the urban beaches of study.
They facilitate licences for the activities, facilities to allow citizens to change clothes and a large database of citizens.
Citizens
People over 12 years old with basic swimming and/or diving skills within 5 kilometres of the area of study.
Natural and Social Environment
Urban beaches in three cities with more than 9.000 per/km2. They were in front of a population centre and suffered from the lack of natural elements. Cities with a gross income between €27,951 and €39,523.
3
CREATION OF A MATRIX OF SOLUTIONS
Creation of a matrix of solutions for each one of the barriers identified.
Each matrix contains:
Actions corresponding to the Engagement roles
Triggers: External and Internals
Reward and Acknowledgement: Short-term and Long-term.
Strategies to increment volunteers' motivation
Strategies to increase volunteers' ability
Stakeholders
For each action, select which stakeholder will be performing the action.
Barrier 1
Triggers
Internal & External
Reward and Acknowledgement
Long-term & Short-term
Motivation
Ability
Stakeholder 1
Action 1
Action 2
Action 3
...
Stakeholder 2
Stakeholder 3

Figure 26 Janus engagement framework with examples of implementation in UrbamarBio. Each proposed engagement and recruitment strategy is annotated with the stakeholder who should carry out the activity.



6. MINKA IN ARSINOE CASE STUDIES

MINKA is currently being utilized in Case Study 1 of the ARSINOE project (Greening the Athens metropolitan area), and there are plans to extend its use to Case Study 6 in Sardinia and Case Study 9 in the Black Sea region.

In Athens, MINKA has primarily been employed in educational settings under the coordination of Case Study leaders and local ARSINOE partners to identify the necessary stakeholders for community engagement. The involvement of local partners is essential for identifying stakeholders who will fulfil roles outlined in the Janus Framework. In Case Study 1, teachers underwent training on MINKA usage, including both the MINKA web platform and App. Also, the MINKA web and App has been translated to Greek, as well as various training materials. AS a result, more than 3.700 observations of the Athens area have been uploaded to MINKA and more than 700 species have been identified (Figure 27).

In Case Study 6 in Sardinia, a test pilot was conducted in March 2024, where teachers from the Elmas Agrarian School were trained in MINKA usage. This initial pilot has laid the groundwork for collaboration planning in this case study to collect data on macroinvertebrates and plants in the surrounding areas of the agricultural school.

Additionally, Case Study 9 in the Black Sea region intends to utilize the environmental component of MINKA, although this collaboration has not yet materialized as the component is not ready for real-case testing.

Figure 27 Observations in MINKA within the Athens area.

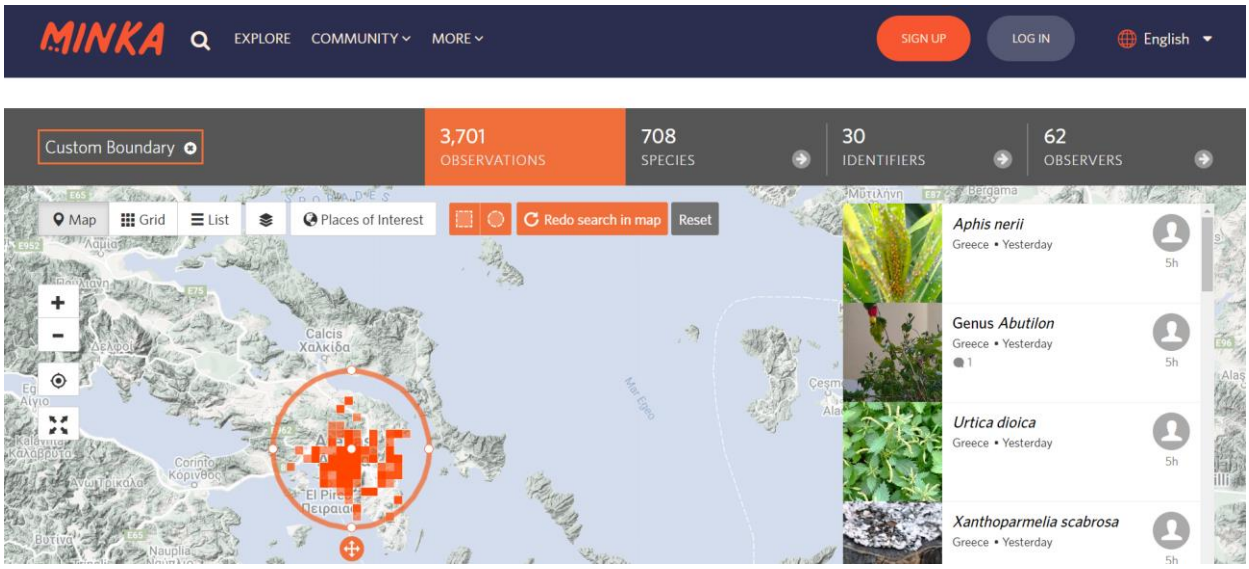
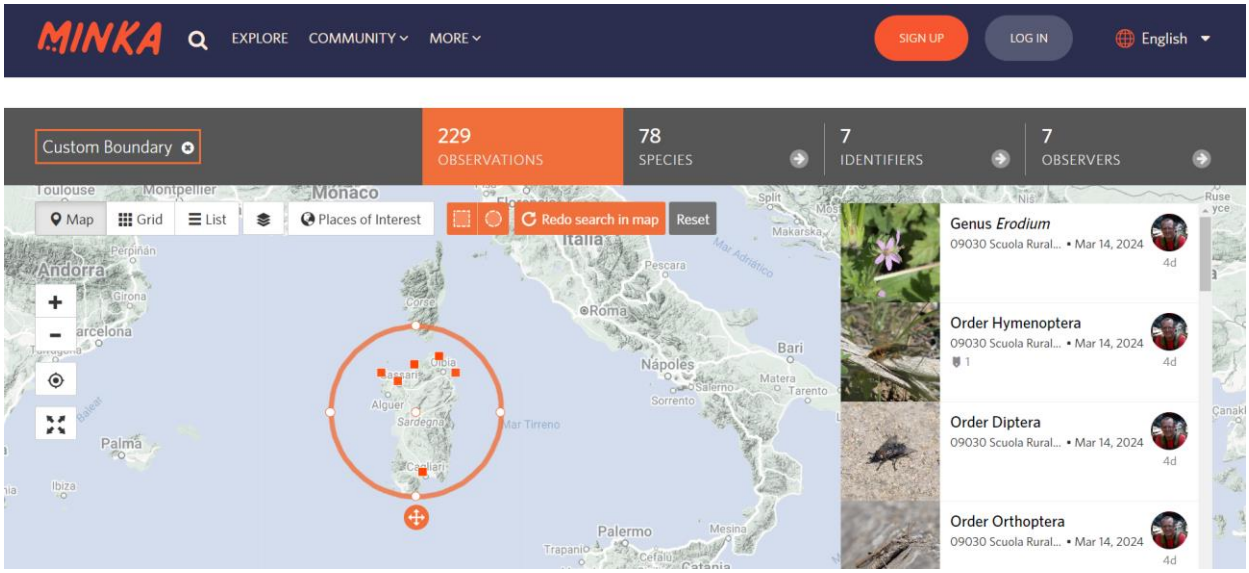


Figure 28 Observations in MINKA within the Sardinia area.



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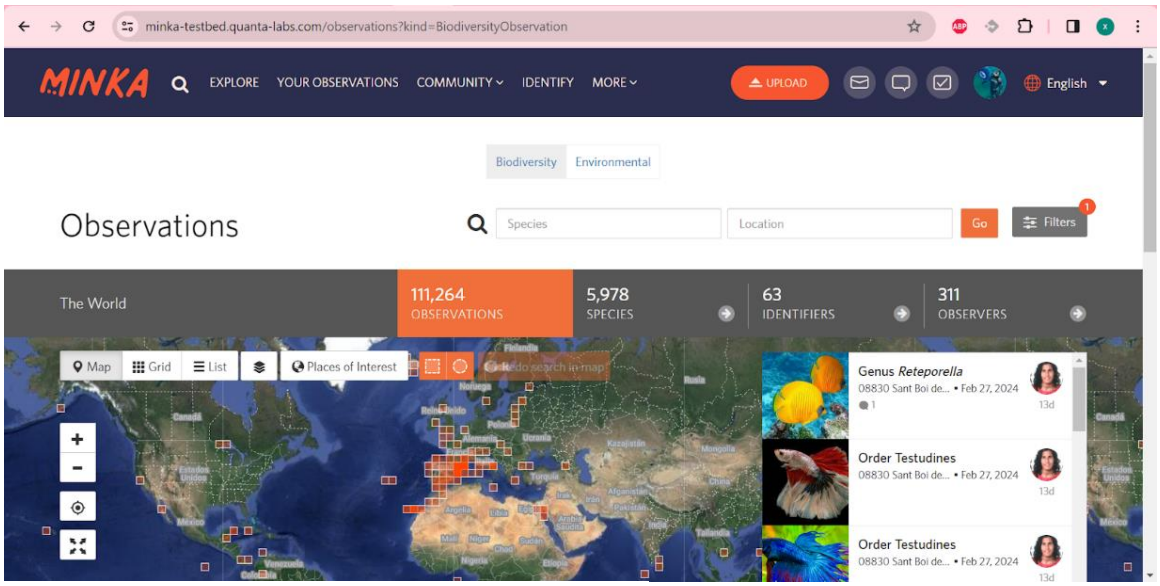
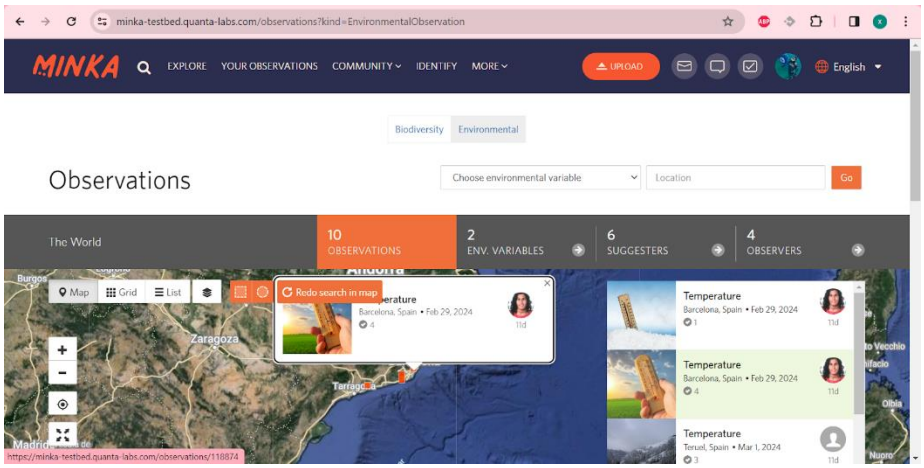
2. Liñán S, Salvador X, Álvarez A, Comaposada A, Sanchez L, Aparicio N, et al. A new theoretical engagement framework for citizen science projects: using a multi-temporal approach to address long-term public engagement challenges. Environ Res Lett. 2022 Oct 1;17(10):105006.

ANNEX 1: Prototype 2 for environmental variables in MINKA

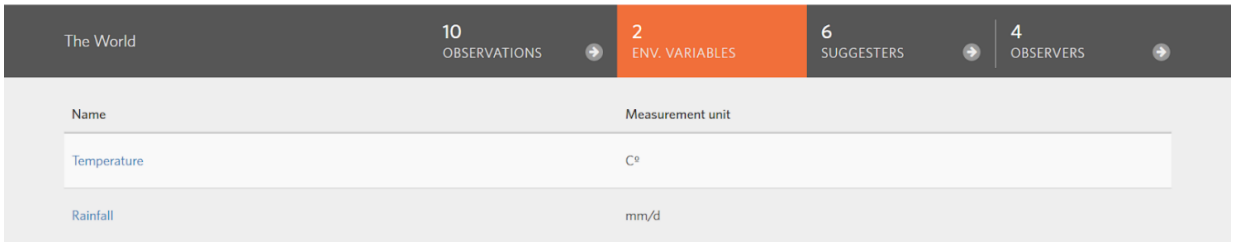
1. **Explore menu:** Users can select what kind of observations they want to observe.



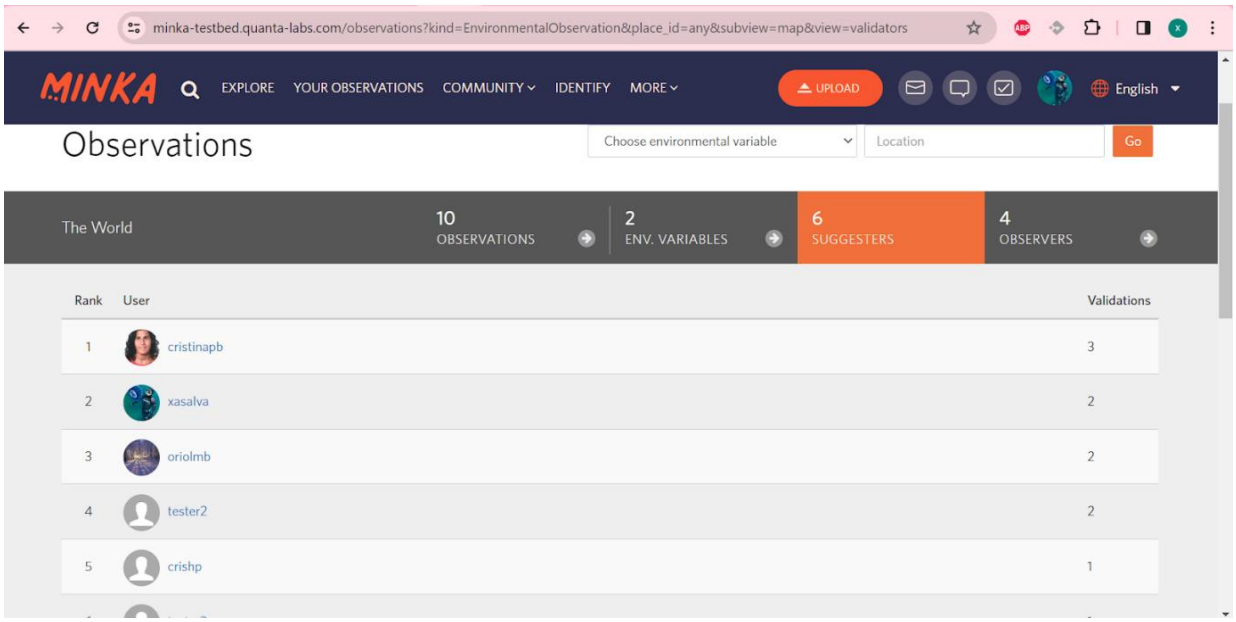
2. **Environmental explore menu:**



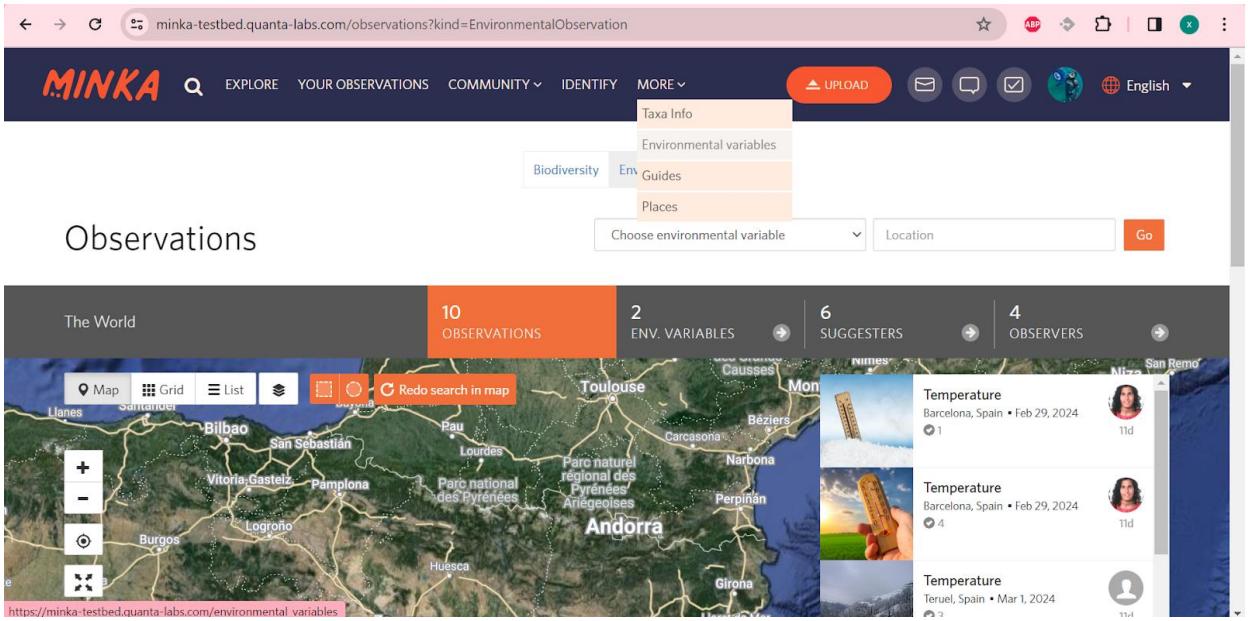
3. Prototype 2 has been tested for **temperature and rainfall.**

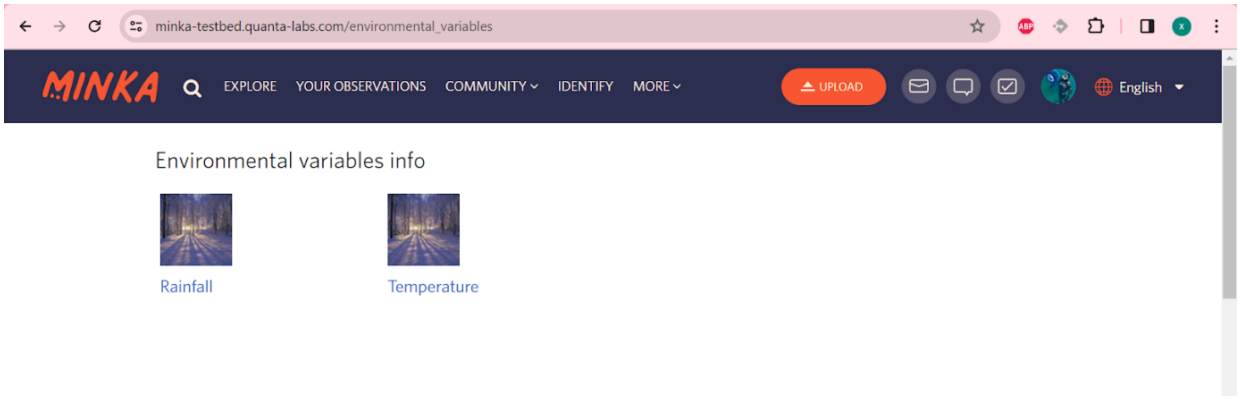


4. In the biodiversity component of MINKA, the field highlighted in orange in the following figure is called "validators". For the environmental component this field has been changed to "**suggesters**". This name may change after the UX study of the environmental component of MINKA.

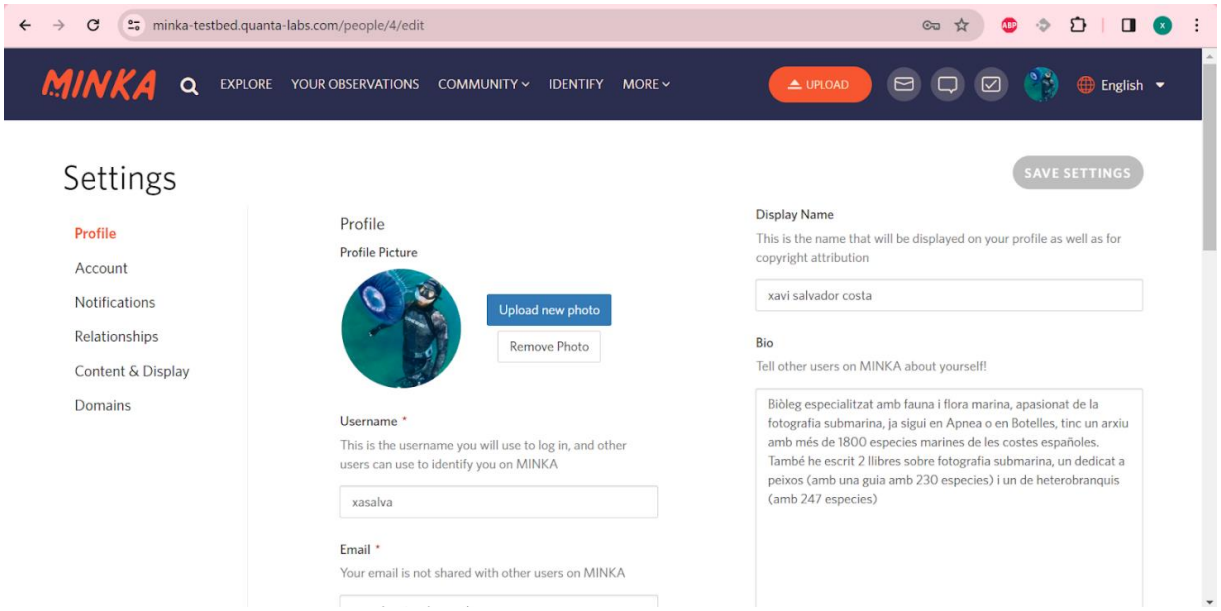


5. The field **Environmental variables** has been added to search what kind of environmental variables exist in MINKA. At this moment, only 2 are available and the creation of a new variables are controlled by the user admin of MINKA.

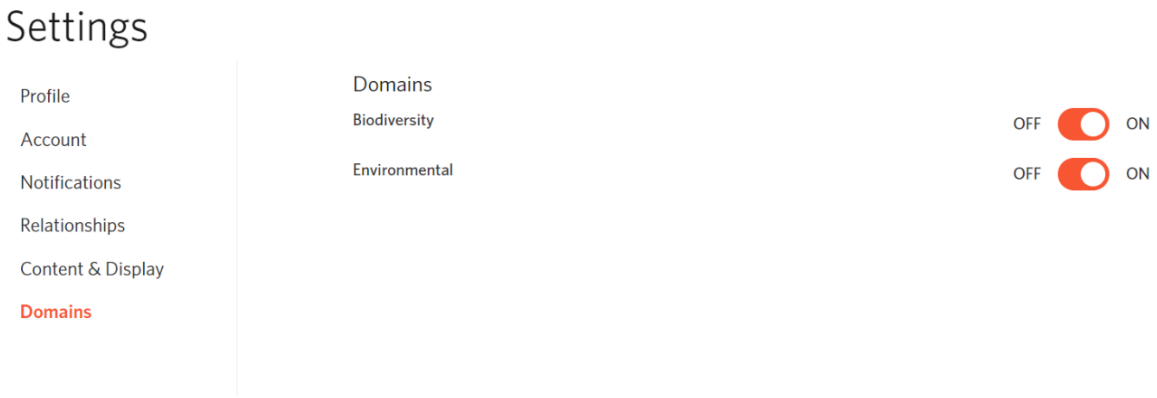




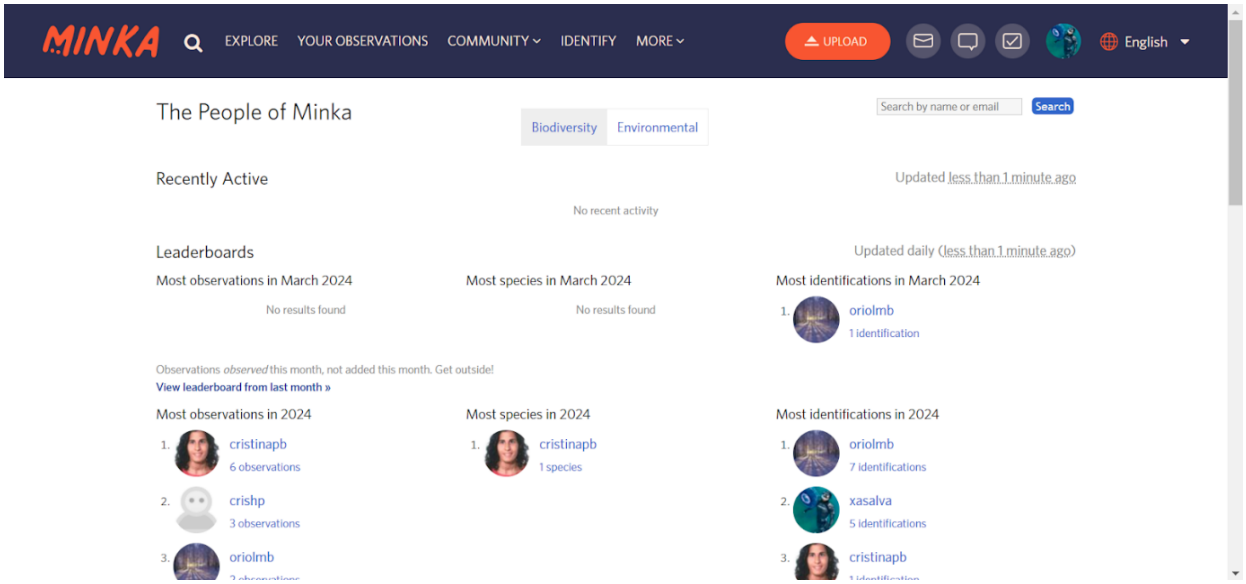
6. In the user settings, a new domain option has been implemented to allow user to chose if they want to see **biodiversity variables, environmental ones or both in their profile**.

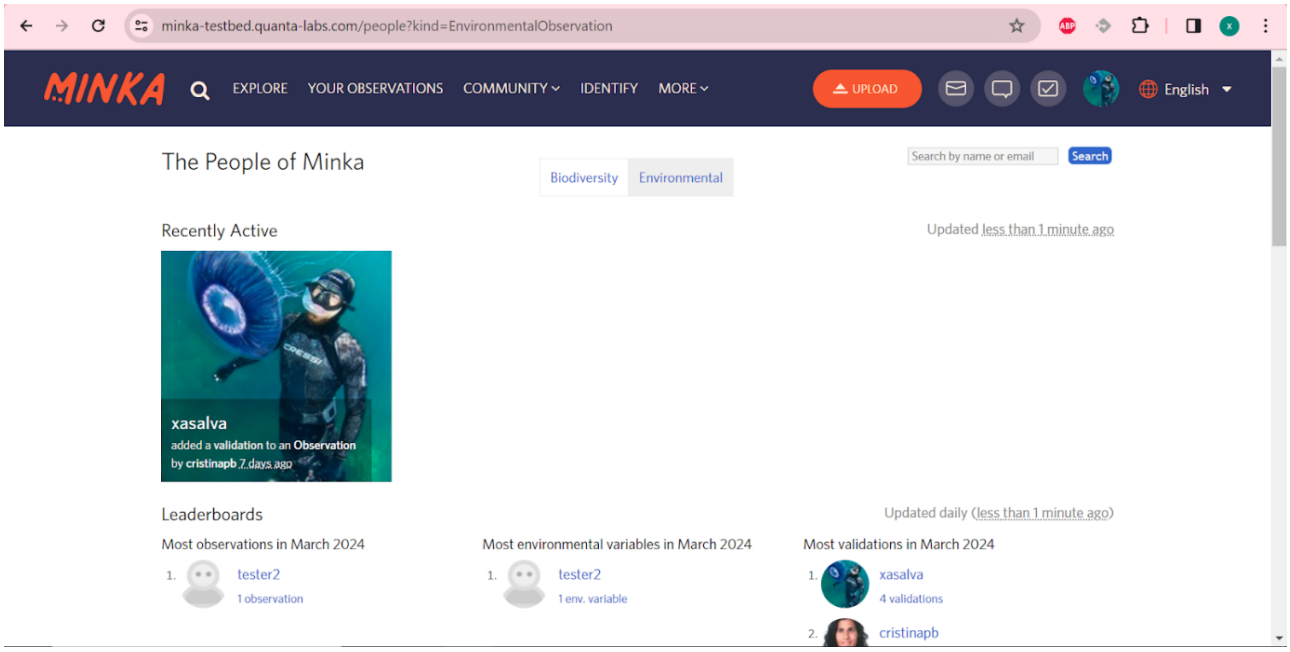


7. It's possible to activate one of the domains or both at the same time. This prevents a disruptive change in the platform in terms of usability and interaction with the existing community.

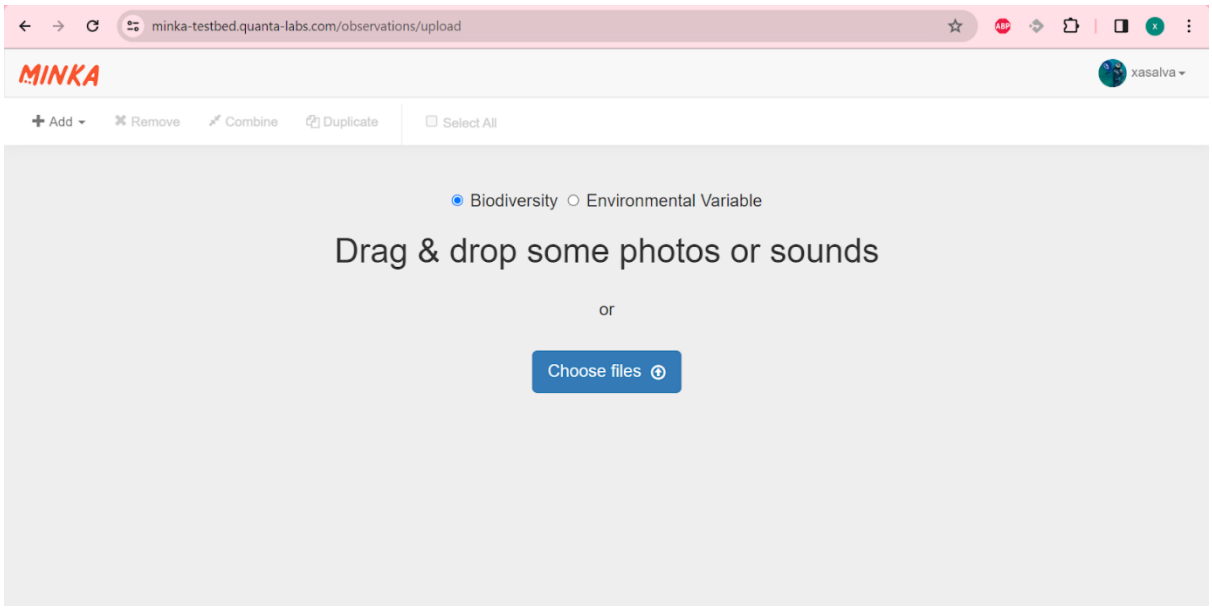


8. Some changes have been effectuated in the people menu, with the possibility of see interactions in terms of biodiversity or environment variables. The following figures shows the menu for biodiversity observations and the menu for environmental observations.

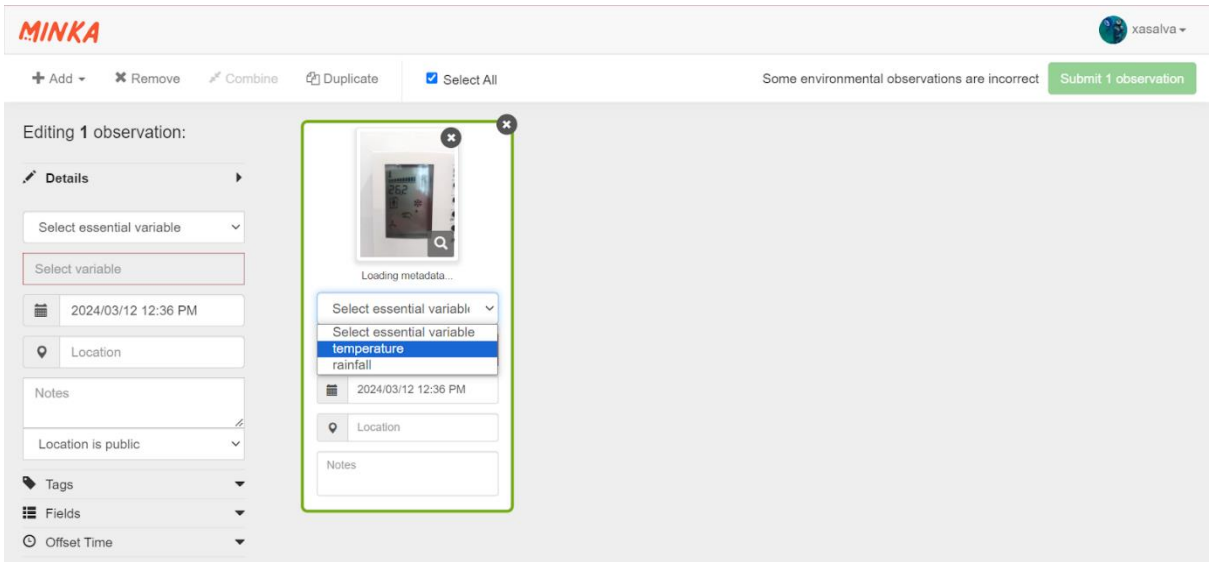




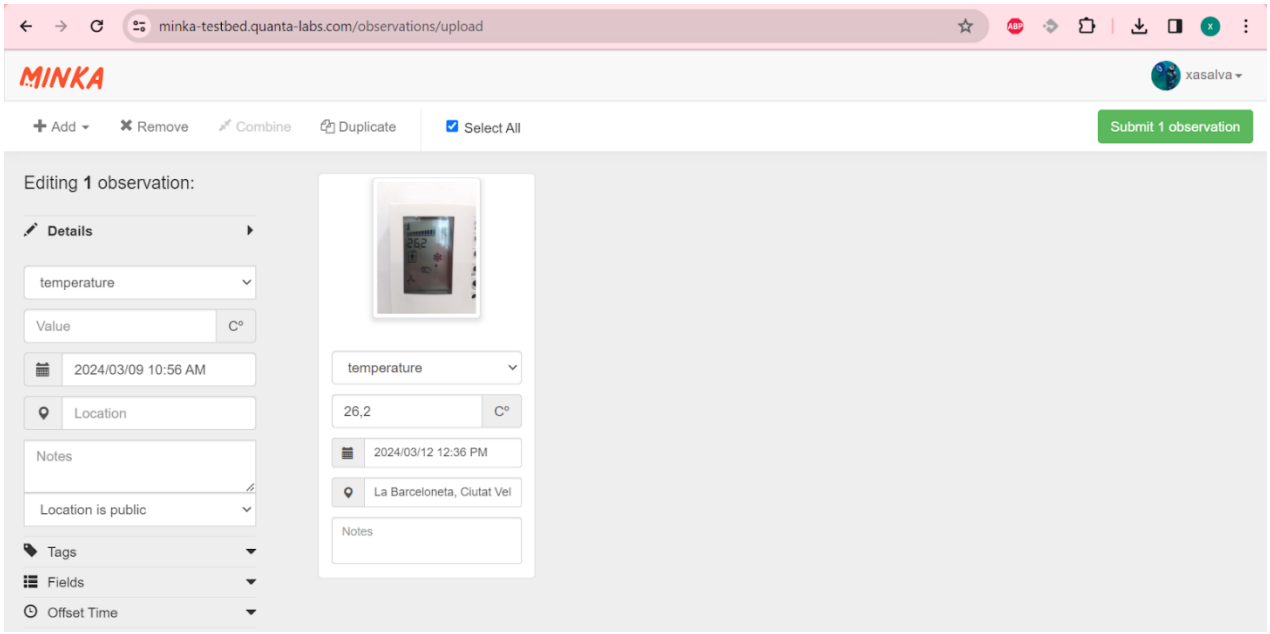
9. **Upload observation menu:** it allows users to upload biodiversity or environmental variables observations.



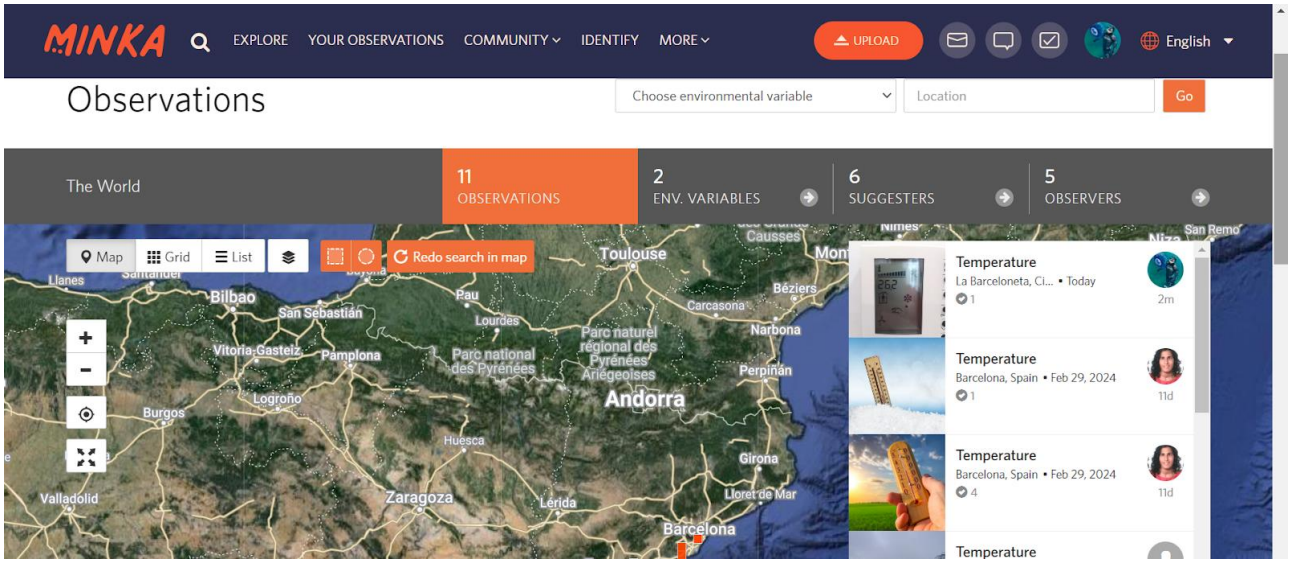
10. **Uploading an environmental variable**. The first step to is select the variable, in this example, temperature.



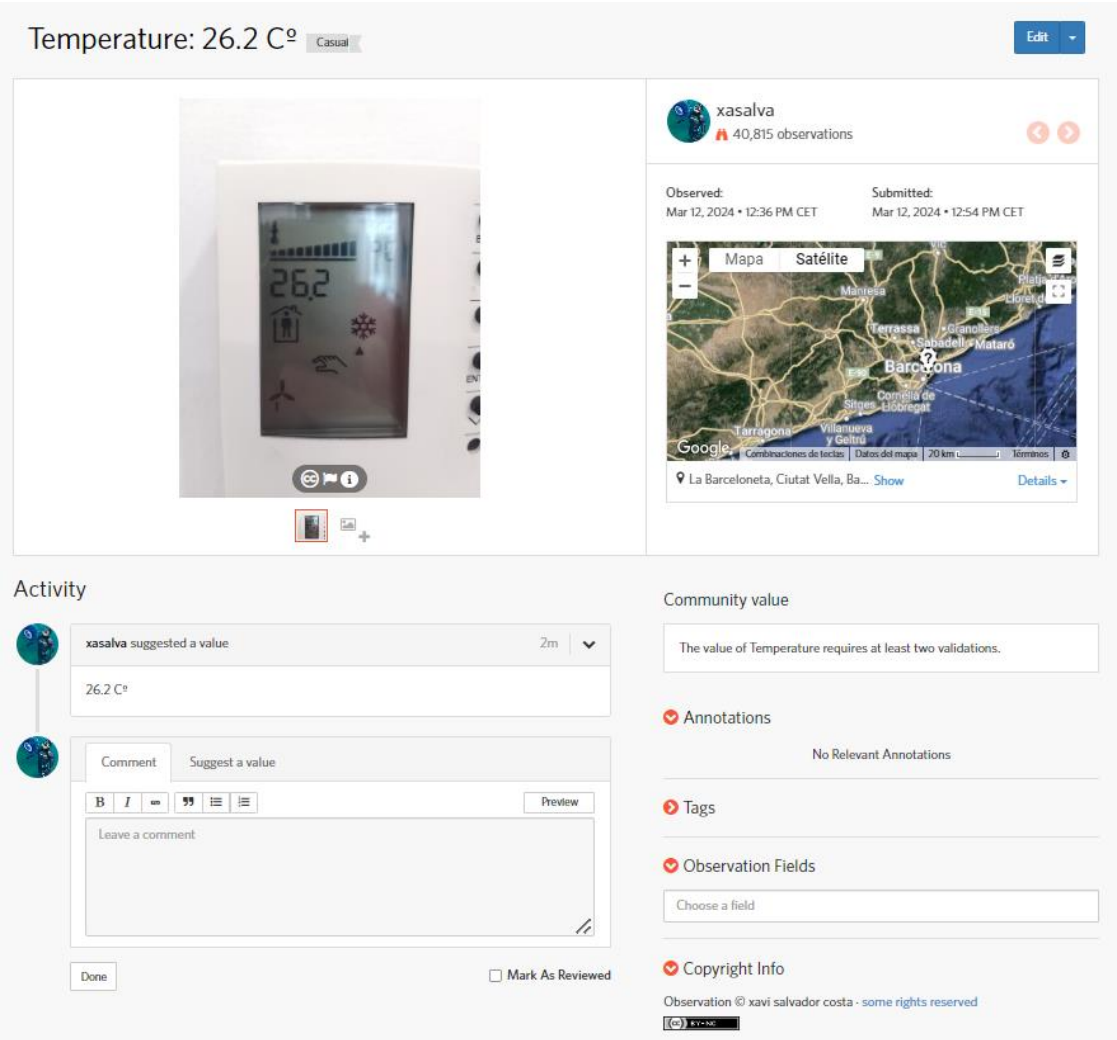
11. **Users can apply the same variable to a group of observations**, selecting each one and choosing the variable that you need at the left column.



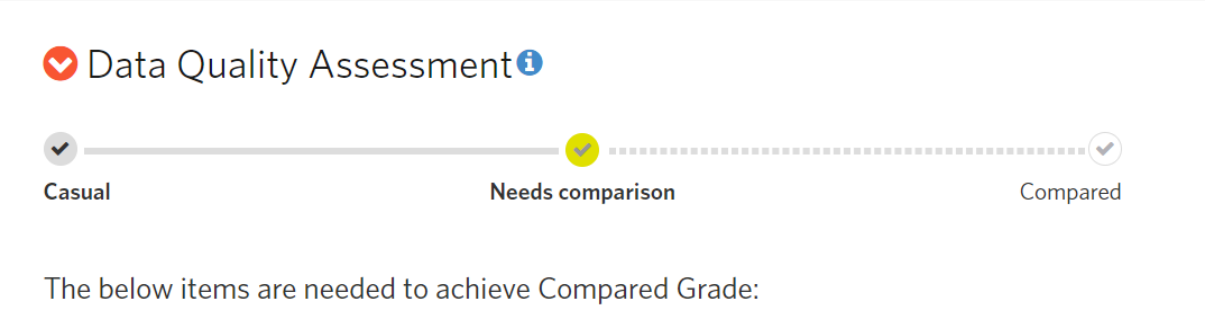
12. **Observation uploaded:**



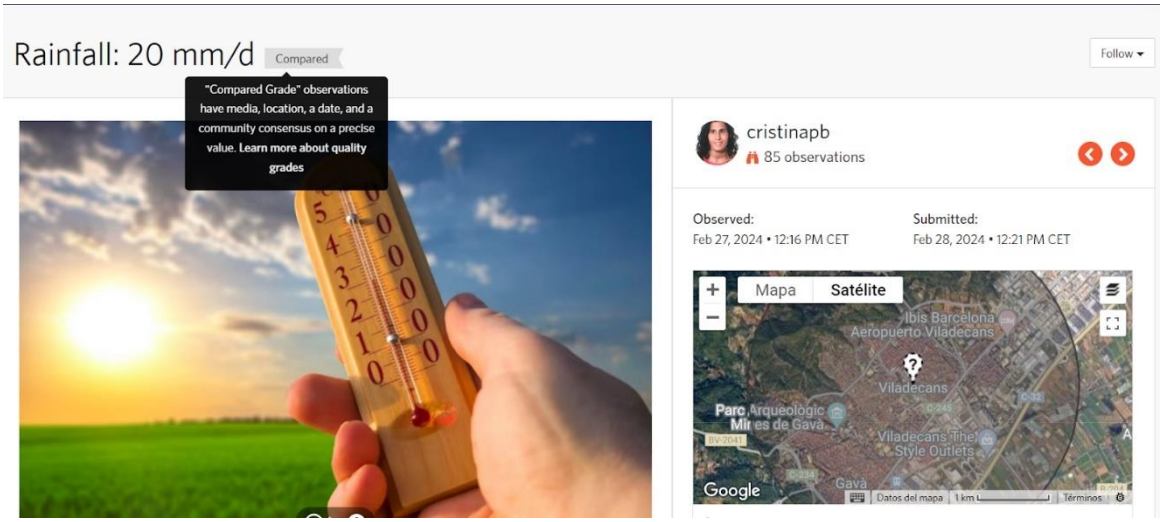
13. **Observation visualisation:**



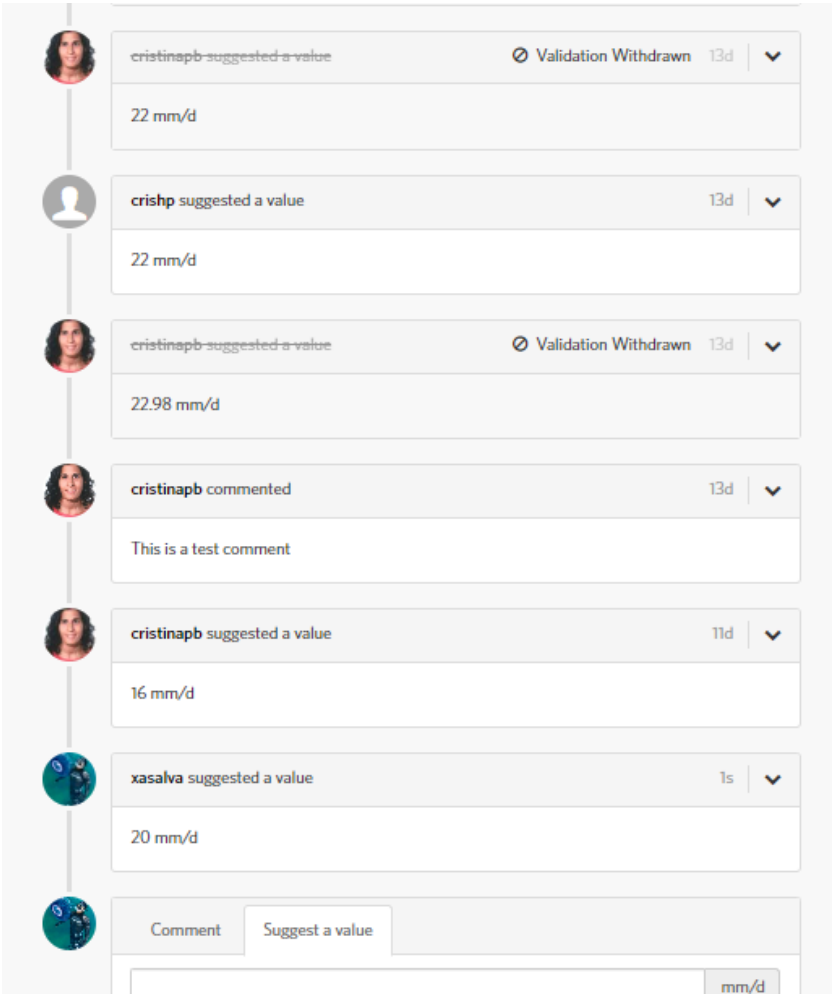
14. **New data quality assessment**



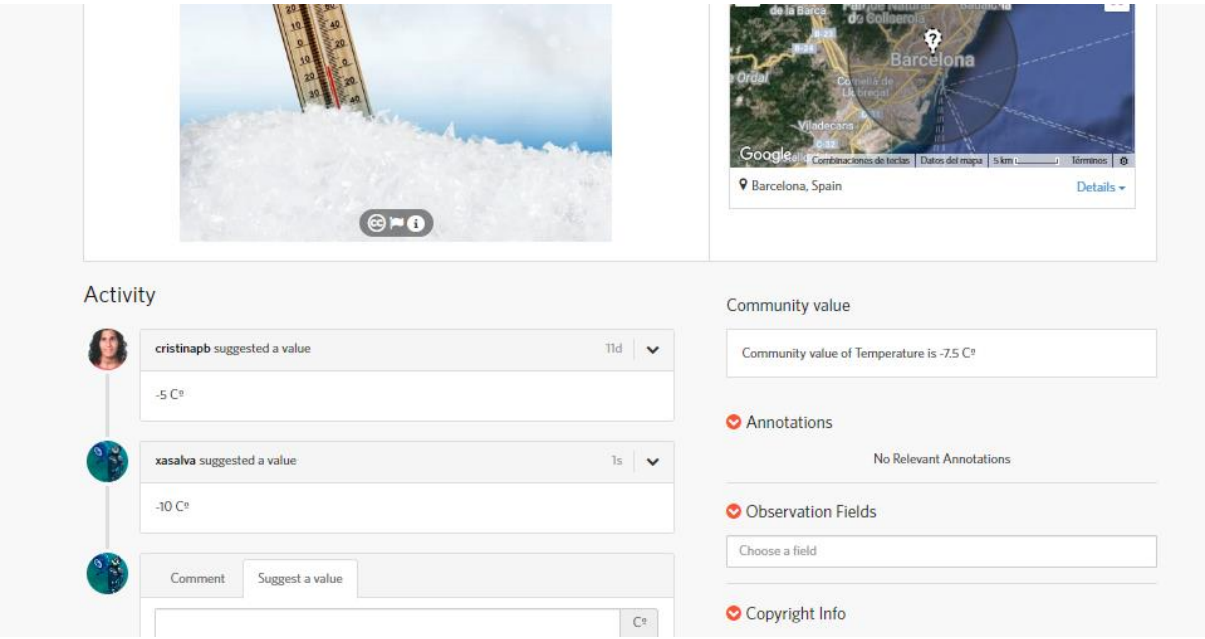
15. Simulated observation with the quality grade compared.



16. Interactions in an environment observation



17. **The community value it's the average of all the values proposed by the community.**



Systems Innovation Approach (SIA) addresses the growing complexity, interdependencies and interconnectedness of modern societies and economies, focusing on the functions of the cross-sectoral system as a whole and on the variety of actors. The Climate Innovation Window (CIW) is the EU reference innovations marketplace for climate adaptation technologies. ARSINOE shapes the pathways to resilience by bringing together SIA and CIW, to build an ecosystem for climate change adaptation solutions. Within the ARSINOE ecosystem, pathways to solutions are co-created and co-designed by stakeholders, who can then select either existing CIW technologies, or technologies by new providers (or a combination) to form an innovation package. This package may be designed for implementation to a specific region, but its building blocks are transferable and re-usable; they can be re-adapted and updated. In this way, the user (region) gets an innovation package consisting of validated technologies (expanding the market for CIW); new technologies implemented in the specific local innovation package get the opportunity to be validated and become CIW members, while the society (citizens, stakeholders) benefits as a whole. ARSINOE applies a three-tier, approach: (a) using SIA it integrates multi-faceted technological, digital, business, governance and environmental aspects with social innovation for the development of adaptation pathways to climate change for specific regions; (b) it links with CIW to form innovation packages by matching innovators with end-users/regions; (c) it fosters the ecosystem sustainability and growth with cross-fertilization and replication across regions and scales, at European level and beyond, using specific business models, exploitation and outreach actions. The ARSINOE approach is show-cased in nine widely varied demonstrators, as a proof-of-concept with regards to its applicability, replicability, potential and efficacy.

ARSINOE
CLIMATE-RESILIENT REGIONS THROUGH SYSTEMIC SOLUTIONS AND INNOVATIONS

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