NextGEM

Next Generation Integrated Sensing and Analytical System for Monitoring and Assessing Radiofrequency Electromagnetic Field Exposure and Health

D6.6: Development of tools, dashboard and mobile app - Final cycle

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Glossary of terms and abbreviations used

Abbreviation / Term	Description
CSS	Cascading Style Sheets
AMSTAR-2	A Measurement Tool to Assess Systematic Reviews
EHDS	European Health Data Space
EIM	Ecosystem Information Module
EMF	Electromagnetic Field
ERMES	Electric Regularized Maxwell Equations with Singularities
FAIR	Findable, Accessible, Interoperable, Reusable
GA	Grant Agreement
GUI	Graphical User Interface
HTML	Hypertext Markup Language
JSON	JavaScript Object Notation
NIKH	NextGEM Innovation and Knowledge Hub
PI	Principal Investigators
PICO	Population, Intervention, Comparator, Outcome
RA	Risk Assessment
RF-EMF	Radio Frequency Electromagnetic Field
RoB	Risk of Bias
SEO	Search Engine Optimization
UI	User Interface
URL	Uniform Resource Locator
UX	User Experience
VMs	Virtual Machines

Executive Summary

The vision of the NextGEM project is to ensure EU citizens' well-being when employing existing and future EMF-based telecommunication technologies. To address this, an output of the project is the NextGEM Innovation and Knowledge Hub (NIKH), offering a standardised way for all stakeholders of the NextGEM project, including European regulatory authorities, the scientific community, and other interested parties, to store and assess project outcomes and provide access to FAIR (Findable, Accessible, Interoperable, Reusable) data. The unified interface will support the users' interaction and interoperability with various systems via a trusted, web-based solution. It will accumulate, analyse, and present information to the users in a customisable module. By establishing NIKH, NextGEM will provide relevant knowledge that identifies appropriate control measures for EMF exposure in residential, public, and occupational environments.

This is the final version of the deliverable regarding the development of tools, dashboard and mobile app under Task "T6.1: Tools development, Dashboard and Mobile App" and provides an overview of the subsequent development and maturity of the NIKH platform methodology and outlook of the functionality mapping and the preliminary technical design aspects.

This report includes the agreed specifications, the mapping of needs to functionalities, the integration of the data sources through the architectural blocks within the overall infrastructure, and the design and validation of outputs with participating partners. The purpose of this deliverable is to set up the approach for the design and implementation of the NIKH platform based on the needs and requirements described in WP2. The document lays out the staged approach designed to ensure the capturing of the requirements of the components described in WP2. Moreover, it discusses the components needed in terms of data collection, analysis and visualization and presents some initial mock-up designs. The deliverable has been informed by a series of other reports in the project, research conducted, meetings, calls and advice by experts in the relevant field.

1 Introduction

NextGEM aims to provide a framework for the generation of health-relevant scientific knowledge and data on new scenarios of exposure to Electromagnetic Fields (EMF) in multiple frequency bands, and develop and validate tools for evidence-based risk assessment. These project outcomes will be made available through the NextGEM Innovation and Knowledge Hub (NIKH) as a knowledge and collaboration hub for the effects of EMF on health, offering a standardised way for European regulatory authorities, citizens, and the scientific community to store and assess project outcomes, and provide access to FAIR data. This platform will be used as a stepping stone for generating relevant knowledge on EMF exposure, which, as a result, assures the safety of EU citizens by providing a healthy living and working environment.

In alignment and with relevance to the overall project and the approach followed to achieve the objectives, the NIKH platform is a web-based solution which will be the main Graphical User Interface (GUI) and a visualisation environment for the comprehensive management, exchange, and analysis of data related to EMF exposure and any associated potential impacts on health. As such, the scope of this deliverable is to describe the methodology, technologies, functionalities, and design for the implementation of NIKH, along with the status of the GUI and its associated components at the end of NIKH's development cycle. This documentation can be used as a detailed guide for both end-users and project partners, offering insights into the platform's structure, features, and user experience. Furthermore, the deliverable explains the motivation behind design choices, such as the integration with external services, contributing to a more comprehensive understanding of NIKH's GUI.

1.1 Mapping NextGEM Outputs

This section maps NextGEM's Grant Agreement (GA) commitments, both within the formal Task and Deliverable descriptions, against the project's respective outputs and work performed. This is summarised in Table 1.

Table 1: Adherence to NextGEM's GA Tasks and Deliverables Descriptions

TASKS	
Task Number & Title	**Respective extract from formal Task Description**
Task 6.1: Tools development, Dashboard and Mobile App	This task will design and implement the graphical user interface (GUI) of the NIKH by using the requirements and technical specifications from task T2.4 to develop and produce the detailed low- level design of the front-end dashboard and to be approved by the end-users. Selecting the appropriate type of user interface components required, will be used in the implementation of the dashboard. The Knowledge Base will contain a large library of project's activities and outputs: public deliverables, publications, guidelines, policy recommendations, along with articles related to the project concept to provide public authorities and science community a rich content information through a cross-browser and multi-device compatibility. Throughout and beyond NextGEM lifecycle, the users will have the ability to continuously enrich the content of the Knowledge Base, providing a large base and a one-stop info source for all players in the electromagnetic exposure and health ecosystem. Based on the technical specifications from Tasks T2.4, the different features of the application to support citizen self-awareness on EMF exposure will be developed to support the required end-user functionality. Set- up and deployment of the application as a stand-alone module.
DELIVERABLE	
Deliverable: D6.6: Development of tools, dashboard and mobile app - Final cycle (M30) This deliverable will provide the development of the NextGEM tools, including the dashboard and the mobile app for establishing links with the related stakeholders (final cycle).	

1.2 Deliverable overview and report structure

This deliverable outlines the final development cycle of the NIKH platform, presenting updates and refinements that align with the project's objectives and vision. This report highlights the enhancements made to the platform's tools, architecture, user interfaces, and functionality. It also provides insights into the testing, validation, and feedback processes undertaken to prepare the platform for deployment.

Based on the objectives and work carried out under Task 6.1, the document starts with the Executive Summary, followed by the document's introduction in Section 1.

Section 2 focuses on the functional aspects of NIKH, including the design process of NIKH and the platform's architecture, detailing its key components and workflows.

Section 3 elaborates on the Application Portal, providing insights into the information included in NIKH as well as the description of the design steps followed for the external and internal side of the NIKH by introducing the requirements and implementation aspects leading to the development of the NIKH tools, dashboard and mobile app.

Section 4 provides an overview of the External Dashboard, designed as a user-centric interface tailored to different audiences, enabling easy access to NIKH's content, tools and resources.

Section 5 presents the NIKH tools, focusing on their role in enabling registered users to effective data management, analysis, and knowledge dissemination.

Section 6 presents the Mobile App, which provides external stakeholders with an intuitive mobile version of the dashboard.

Finally, Section 7 concludes the deliverable by summarising the outcomes.

1.3 Updates from previous Deliverable "D6.1: Development of tools, dashboard and mobile app - First cycle"

This deliverable builds upon the groundwork laid in "D6.1: Development of tools, dashboard and mobile app - First cycle". The previous deliverable presented the initial development cycle for the NIKH Platform GUI, dashboard, tools and mobile app, focusing on foundational aspects such as requirements gathering, architectural design, and mock-ups. It introduced the concept of a modular and user-centric platform that caters to diverse stakeholder groups, including scientists, authorities, and citizens, while presenting an early version of the GUI across different parts of the website.

The updates presented in this deliverable mark significant progress toward realising the vision of NIKH as a robust and user-friendly solution and include the following:

- **Refined Architecture and Design:** The initial system architecture presented in D6.1 has been further refined, with greater integration of functional components and alignment with FAIR principles. The modular architecture has been enhanced to ensure flexibility, scalability, and robust data management in Section 2.
- **Functional Implementation:** The design direction provided in D6.1 has been implemented into functional components, including the external dashboard and tools. These features have undergone development to align with user requirements and improve usability in Section 3.
- **Security and Privacy Enhancements:** In response to GDPR requirements, additional mechanisms have been implemented for user authentication, data privacy, and consent management, including the deployment of Keycloak for secure login and role management, in Section 3.
- **Enhanced User Interface (UI) and User Experience (UX):** Building upon the mock-ups and feedback from stakeholders, the UI/UX of the NIKH platform has been redesigned for intuitive navigation and accessibility across devices, as demonstrated by all figures presenting screenshots of the website. The platform now provides a seamless experience for both internal and external users in Section 4.
- **Tools and Integrations:** The views of the NIKH tools provided have been updated to capture the refinement achieved since D6.1 in Section 5.
- **Mobile Application Development:** The mobile version of the NIKH platform has now been realised, ensuring compatibility with mobile devices and extending platform functionality for on-the-go users in Section 6.

2 NIKH platform functionality

The NIKH is a platform aiming to address the societal need for comprehensive and secure access to scientific knowledge on Radio Frequency Electromagnetic Field (RF-EMF) exposures and their impact on health. NIKH's both scientific and technological nature provides diverse research activities and experimental studies that facilitate the assessment of causal exposure-outcome associations. The technological nature serves as a means for managing EMF measurements, research data, and risk assessments, effectively communicating these insights to stakeholders. The scientific nature serves as a benchmark for research outputs used as a reliable source for regulatory authorities, the scientific community, and other stakeholders, supporting informed decision-making and contributing to a safe living environment. The identified user groups are classified as external or internal stakeholder, as per Figure 1.

The GUI plays a crucial role in the successful implementation of NIKH. The design and development of the GUI align with the specified requirements and technical specifications of T2.4. The dashboard serves as a visual representation of data derived from EMF measurements, analytical models, bio-experiment results, and risk assessments. It adheres to open standards and FAIR principles [1], ensuring seamless data integration between the backend system and the dashboard. The implementation of the GUI provides a user-friendly interface for users, supporting cross-browser and multi-device compatibility, thus enhancing accessibility for diverse stakeholders. Additionally, the mobile application extends the platform's reach to end-users, including citizens, consumers, and communities. This application empowers users to receive practical guidelines for exposure and engage dynamically with existing EMF exposure initiatives.

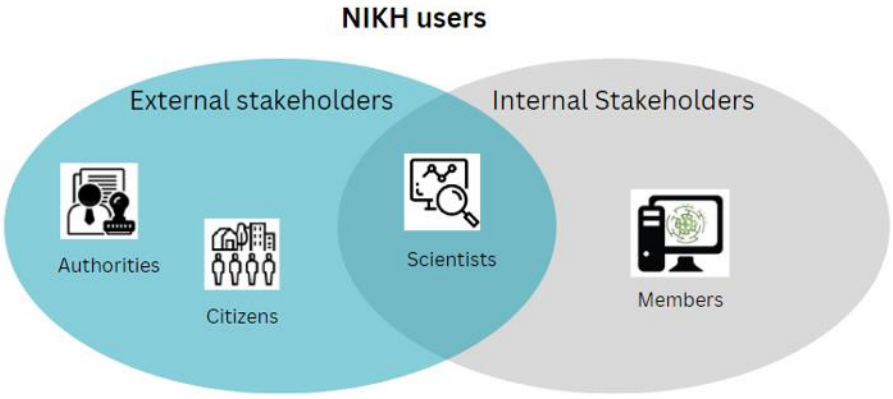

Figure 1: NIKH Platform user groups' classifications

The NextGEM platform caters to a diverse range of users, categorised into internal and external stakeholders, each with specific roles and affiliations. Internal stakeholders are members of the NextGEM and Cluster of European Projects on EMF and Health (CLUE-H)[1] consortia, such as Principal Investigators (PI) and other research staff. PIs hold administrative privileges, enabling comprehensive actions within the organisation, such as data management and access control. Other research staff have limited editing capabilities, primarily focused on viewing organisational resources.

External stakeholders extend beyond the consortia and include entities like authorities, citizens, and scientists from other organisations. Regulatory authorities will be able to obtain insights for policy formulation or updates related to EMF technologies whereas standardisation bodies will benefit from accessing diverse and up-to-date data, supporting informed decision-making in the development and revision of standards. EU citizens will be able to receive information about the latest research on the health effects of EMF radiation exposure, highlighting the platform's commitment to disseminating valuable information to the general public. Lastly, members of the external scientific community will have the ability to contribute metadata, which refers to descriptive information that provides additional

[1] Cluster of European Projects on EMF and Health (CLUE-H), https://www.emf-health-cluster.eu

context for the scientific raw or processed data and additional material to the NIKH platform, fostering collaboration and knowledge sharing.

Within the NextGEM platform, individuals are further categorised into members and non-members. Members encompass registered and authenticated users actively engaged in the platform. Non-members have access to limited permissions, such as viewing publicly available information. On the other hand, authenticated users can leverage the NIKH platform for additional data-related requests, including searching, viewing, uploading, and downloading restricted and publicly available data. The platform accommodates diverse user needs, ensuring both consortium members and external users can contribute, collaborate, and access information based on their roles and permissions.

2.1 Design phases of the NIKH Platform

2.1.1 Technical features

The graphical user interface of NIKH was developed to provide users with an intuitive and user-friendly way to interact with NIKH. The platform offers an intuitive interface for users to monitor NextGEM results and data while providing extra features, such as the searching of scientific literature from external data spaces. It was built using visual web-based programming tools to ensure robustness, high performance, multi-user access and compatibility across multiple platforms and popular operating systems, with an emphasis on improving application quality and ease of maintenance.

The NIKH platform allows users to interact with the NextGEM system intuitively by offering a user-friendly and visually appealing interface of the NIKH dashboard. Adhering to Graphical User Interface Design Principles [2] becomes crucial when designing a platform. A well-designed UI plays a pivotal role in effectively conveying complex data and insights to users in a visually appealing and user-friendly manner. To ensure accessibility from various devices in different locations, the platform will be implemented as a cloud-based web application based on open-source standards for web development. Cross-browser and multi-device compatibility are also essential considerations in modern web development. The latest technologies like HTML5 (Hypertext Markup Language), CSS3 (Cascading Style Sheets), and JavaScript [3] play a significant role in achieving cross-browser and multi-device compatibility and will be utilised for the implementation of the NIKH front-end component. The platform will be constructed to offer robustness and high performance, ensuring that the demands of real-time interactions and data processing can be handled efficiently. The platform aims to allow multiple users to use the system simultaneously without conflicts.

The NIKH GUI development involves a mixture of client-side and server-side programming languages to optimise its functionality [4]. Client-side refers to the execution of code on the user's device, typically within a web browser. Client-side languages, such as HTML, PHP, CSS, JavaScript are responsible for the presentation, interactivity, and user experience of a website or web application. When a user accesses a web page, the client-side code is downloaded and executed on their device. Server-side refers to the execution of code on the web server hosting the website or application. When a user interacts with a webpage, their actions are sent to the server, which processes the requests and generates a response to be sent back to the client.

2.1.2 Requirements gathering and functionality

The requirements gathering process for a platform is a pivotal phase in the development of a system, offering a comprehensive understanding of the project's needs, the prioritisation of requirements, as well as the alignment with business goals. This process was undertaken under Task "T2.4: System architecture design and technical specifications", which guided the development team to minimise misinterpretations and misunderstandings and to facilitate effective communication and collaboration among stakeholders. The requirements gathering process consists of several key steps described in Deliverable "D2.5: NextGEM architectural framework - Final version" [5], each designed to ensure the successful development and implementation of the system. The functionality of the GUI is provided based on the usage scenarios described in Deliverable D2.5, as outlined below:

- Members will be able to successfully log in with valid credentials. Incorrect credentials should result in an authentication failure error.
- A user will be able to successfully register, and the system should store the user's information securely.
- Data contributors should be able to upload data, and the system should capture and store metadata associated with the uploaded data.

- Users will be able to search for data using various criteria, and search results should be accurate and relevant. The user navigates to the catalogue search page.
- Users will be able to access and download relevant documents from the system.
- Members will be able to input parameters for modelling, and the system should produce accurate simulations and analyses.
- Members will be able to input relevant parameters for risk assessment, and the system should generate accurate risk assessments.
- Members will be able to access information about consortium partners, and the system should facilitate collaboration.
- External stakeholders will find the information relevant and accessible on the dedicated pages.

2.1.3 Implementation plan

Figure 2: Implementation plan

The development of the NIKH dashboard involved four key phases [6]. Each phase contributed to transforming the project vision into a functional platform, ensuring alignment with both project goals and user expectations. These iterative phases address the details of design, development, and testing, ensuring a user-centric and efficient platform. This structured approach guides the GUI project from concept to realisation. Based on the implementation plan, a 4-phase implementation process has been followed as described below:

- **Phase 1: Requirement collection and Design** - In this initial phase, the primary objective was to collect comprehensive requirements that would serve as the foundation for the NIKH Platform. Emphasis was placed on collecting both functional and non-functional requirements for the platform. These requirements were gathered to ensure alignment with the vision and objectives of the project. The focus extended to understanding the specific needs and expectations of the target audience, as well as defining various user profiles and their corresponding privileges.
- **Phase 2: Create Mock-up Designs -** During the second phase, mock-up designs were created to provide a visual blueprint for the platform. These visual representations not only defined the basic page structure and content placement but also served as a foundation for the user interface's development. A significant focus was placed on designing a user-friendly interface that considers the user's perspective and behaviour.
- **Phase 3: Prototype Implementation -** Phase 3 marks the transition to prototype development, building upon the approved designs. This stage initiates the actual development of the platform based on the design specifications and mock-ups.
- **Phase 4: Final Version Implementation -** Following the prototype phase, the GUI underwent extensive user testing. This testing focused on evaluating usability, user interface design, and the clarity of presented data. The feedback from these tests was integral in refining the platform and ensuring its alignment with user expectations and project goals.

The phases described were part of an iterative process, where they will be repeated for every set of requirements to ensure the continuous improvement and refinement of the NIKH platform. This iterative approach allows us to adapt to changing user needs, align with evolving project goals, and maintain a user-friendly interface throughout the development process. Phase 1 has been accomplished in T2.4 by designing the overall NIKH architecture along with the associated requirements, as presented in Deliverables D2.5 [5]. Phase 2 has produced visual mock-ups in the Figma[2] tool through continuous collaboration and feedback from the NextGEM partners.

The actualisation of the platform's original website, as such, had to fulfil certain requisites for web application development. In order to achieve successful website creation and launching, specific key principles have to be considered. Adherence to these general principles will enable the creation of a well-designed, user-friendly, and

[2] https://www.figma.com/

effective website that meets its goals and engages the target audience and are summarised in the form of necessary steps below:

1. Definition of goals and target audience.
2. Creation of a plan for the website's structure, navigation, and content organisation. Use of wireframes or mock-ups to visualise the layout and flow of the web pages. Development of a sitemap to outline the hierarchy of the website's pages.
3. User-centred design: Focus on creating a user-friendly interface and intuitive user experience. Keep the design clean, consistent, and visually appealing.
4. Responsive and mobile-friendly: Ensure that the website is responsive and adapts to different screen sizes and devices. Optimise the site for mobile viewing and usability.
5. Content strategy: Create engaging, informative, and relevant content that is easy to read and understand. Use a consistent tone and style throughout the website.
6. SEO Optimisation: Implement Search Engine Optimization (SEO) techniques to improve the website's visibility in search engine rankings. Optimise content, meta tags, headings, and Uniform Resource Locator (URLs) with relevant keywords. Ensure the website is easily crawlable by search engines.
7. Performance and speed: Optimize the website's performance by minimising file sizes, compressing images, and leveraging browser caching. Improve page load times to enhance the user experience and reduce bounce rates.
8. Testing and quality assurance: Test the website thoroughly across different browsers, devices, and operating systems to ensure consistent functionality and visual appeal. Check for broken links, validate your HTML and CSS code, and conduct usability testing.
9. Security and data protection: Implement security measures to protect the website and user data. Use SSL certificates to encrypt data transmission, regularly update software and plugins, and employ strong passwords and secure authentication methods.
10. Analytics and tracking: Set up web analytics tools (such as Google Analytics) to track visitor behaviour, traffic sources, and other key metrics. Analyse the data to gain insights, make informed decisions, and optimise website performance.
11. Regular updates and maintenance: Maintain the website by regularly updating content, fixing bugs, and addressing security vulnerabilities. Keep the website software, plugins, and themes updated to ensure optimal performance and security.

The first two steps include requirements collection and mock-ups design and are essential for the design phase of the platform. The first five steps as a whole corroborate a robust implementation. As such, the following subsections provide detailed mock-up versions of the graphical user interfaces, offering a visual representation of the user interactions and interface designs associated with the various components comprising the NextGEM GUI. These mock-ups offer a tangible insight into the user experience and functionalities within the NextGEM platform, allowing stakeholders to preview and understand the intuitive navigation, feature interactions, and overall design aesthetics. This visual documentation serves as a valuable tool for refining and validating the user interface design, ensuring alignment with user expectations and usability standards.

2.2 High-level architecture of NIKH web-based application platform

This section presents the functional components that make up the NIKH web-based application platform. Each component has a specific role contributing to the overall user experience, system management, and alignment with the project's requirements. Together, these components create a user-centric interface that facilitates user interaction, service management, and data access for an optimized navigation through the ecosystem.

The main goal is to provide a clear understanding of what each component does, how they relate to the project's requirements, and how they contribute to a seamless and feature-rich user experience. Specifically, this section aims to provide a detailed overview of each component's individual role, functionalities, and how the modules interact to ensure seamless operation.

- ***Application Portal***: The application portal's purpose is twofold since it provides a unique access point to both the internal and external stakeholders of NextGEM. Both the external and internal side of the application portal provide a visual way for users to interact with the various components of NIKH based on their access

rights. For the external dashboard the identified target groups including public authorities, citizens and the scientific community are able to visualise EMF related data and results such as practical guidelines, awareness campaigns, Frequently Asked Questions (FAQ) and many others. The internal dashboard is intended for registered members of the NIKH platform, such as NextGEM consortium partners and CLUE-H project partners, facilitating the visualisation of data and results from their EMF measurements, analytical models and biological investigations.

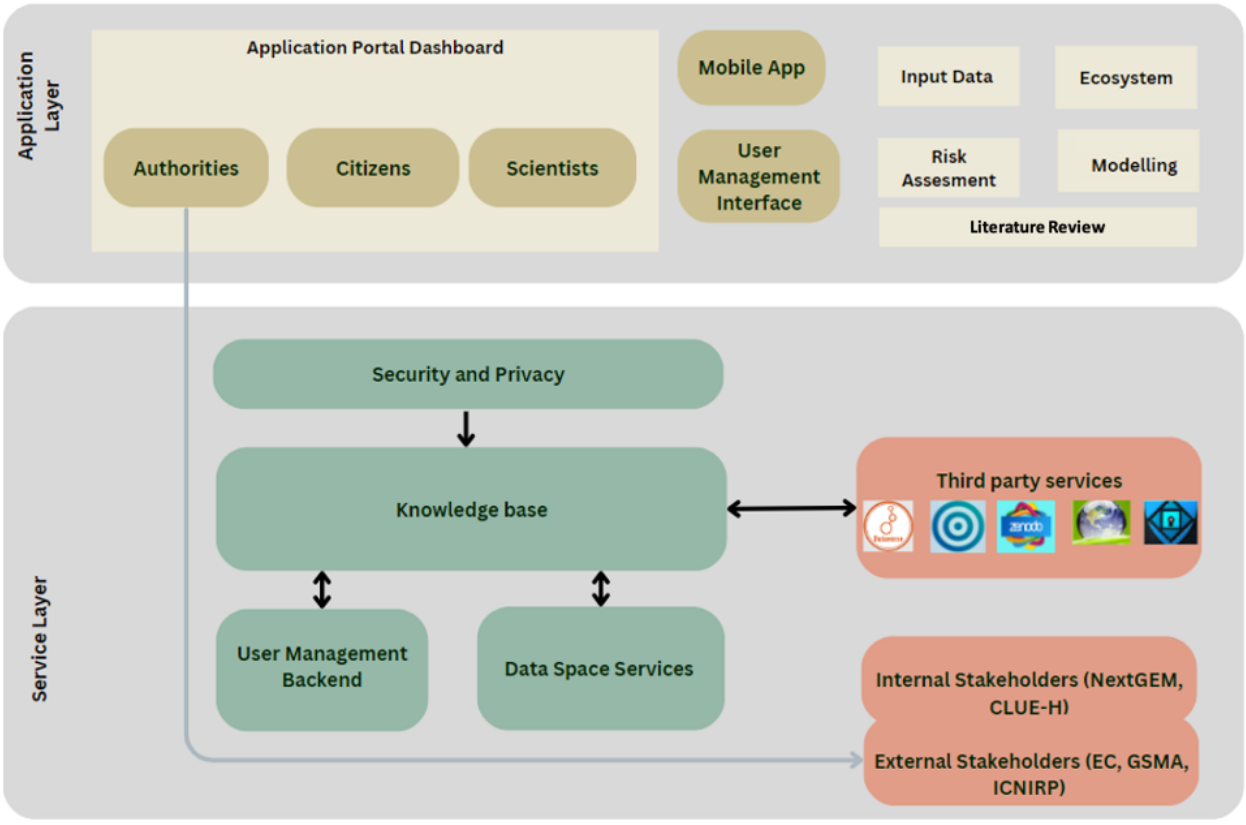

Figure 3: High-level architecture of NIKH web-based application platform

- ***Security and Privacy*:** This mechanism handles user authentication and authorization to ensure that only authorized users can access and interact with the NextGEM system from the dashboard. Specifically, this module is responsible for managing the use of the dashboard's functionality. Handles user login, registration, and authentication. Authorizes access based on roles and permissions, aligning with the specified user levels.
- ***Ecosystem Information:*** Offers a centralized space for information on consortium partners and their available infrastructure fostering collaboration and knowledge sharing.
- ***Modelling tool:*** Provides a GUI for ERMES modelling, allowing scientists and researchers to simulate and analyse electromagnetic exposure scenarios of human models.
- ***Literature review:*** Provides a GUI for conducting literature review based on available bibliography
- ***Risk assessment:*** Provides a GUI for conducting risk assessments based on EMF exposure scenarios.
- ***Data Management:*** Facilitates data contributors in selecting the data source, uploading data, and providing necessary metadata. Such data include internal data, files, posts and feeds.
    - **Knowledge base:** The purpose of Knowledge Base is to provide storage and retrieval capabilities for both scientific raw data and metadata.

- ***Third party services***: Through this component external sources including the Zenodo [3], the EMF-Portal [4], the Harvard Dataverse [5], the Yoda repository [6] and the European Health Data Space [7] are made available to the NIKH platform.

- ***Mobile Application:*** The external stakeholders of the NIKH platform are also offered a mobile-friendly experience which allows mobile-specific features that extend the core functionality while catering to the unique needs of mobile users.

The requirement gathering process for a platform is a pivotal phase in the development of a system offering a comprehensive understanding of the project's needs, the prioritization of requirements, as well as the alignment with business goals. This process has been followed during T2.4 allowing us to guide the development team, to minimize misinterpretations and misunderstandings, and to facilitate effective communication and collaboration among stakeholders. The requirement gathering process consists of several key steps described in D2.5, each designed to ensure the successful development and implementation of the system. Following, the functionality of the GUI is provided based on the usage scenarios described in D2.5:

- Members will be able to successfully log in with valid credentials. Incorrect credentials should result in an authentication failure error.
- A user will be able to successfully register, and the system should store the user's information securely.
- Data contributors should be able to upload data, and the system should capture and store metadata associated with the uploaded data.
- Users will be able to search for data using various criteria, and search results should be accurate and relevant. The user navigates to the catalogue search page.
- Users will be able to access and download relevant documents from the system.
- Members will be able to input parameters for modelling, and the system should produce accurate simulations and analyses.
- Members will be able to input relevant parameters for risk assessment, and the system should generate accurate risk assessments.
- Members will be able to access information about consortium partners, and the system should facilitate collaboration.
- External stakeholders will find the information relevant and accessible on the dedicated pages.

2.3 Sitemap

A sitemap is a structured diagram that outlines the structure of a website's pages, helping users navigate and understand the content [7]. It serves as a roadmap, providing a visual representation of the site's structure and the relationships between different pages. Specifically, for the NIKH GUI, the sitemap depicts the designed layout representing the platform's functionalities.

As elaborated in Section 3.3, NIKH employs a WordPress-based external dashboard website for its content-based frontend, while the NIKH Application Tools are facilitated in separate, React-based pages. The breakdown and differentiation between the two are outlined by the sitemap provided in Figure 4.

[3] Zenodo open repository, https://zenodo.org/

[4] EMF Porrtal, https://www.emf-portal.org/en

[5] Dataverse Open source research data repository https://dataverse.harvard.edu/

[6] Yoda - a research data management service, https://www.uu.nl/en/research/yoda

[7] European Health Data Space, https://www.european-health-data-space.com/

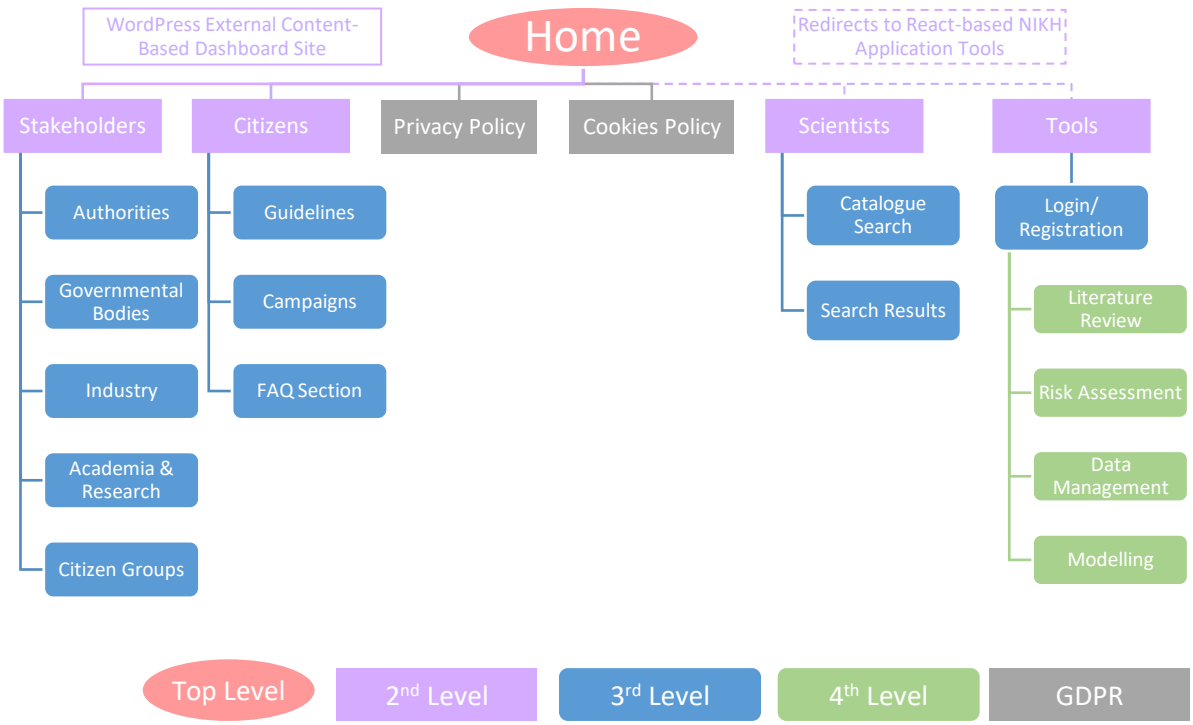

Figure 4: NIKH sitemap

Starting with the homepage, users are introduced to NIKH with an intuitive page summarising the different sections of the website. From the homepage, the four main 2nd level pages are accessible. There are also individual pages for NIKH's Privacy and Cookies policies, accessible via the website's footer. Below the "Stakeholders" page are the "Authorities", "Governmental Bodies", "Industry", "Academia & Research", and "Citizen Groups" subpages, which provide interactive lists of stakeholder organisations belonging under each classification. Nested under the "Citizens" page is the "Guidelines" page, which provides links to EMF exposure safety guidelines published by 3rd party bodies and organisations, the "Campaigns" for linking to external EMF-measurement campaigns across different geographic domains, and a general "FAQ" page regarding EMF and the current consensus regarding the associated health concerns. The "Scientist" page hosts the catalogue search page and search engine results pages, which are generated by filtering results. The "Tools" hosts the "User registration/login" section, which, upon successful sign-in, provides access to the internal dashboard pages. These include the "Literature Review", "Risk Assessment", "Data Management", and "Modelling" tools, which are explained in detail in Section 5 of this deliverable.

3 Application portal

According to the aforementioned Implementation Plan of the NIKH Platform, the need to clearly define the general requirements for development and deployment and specify the exact steps taken towards this direction takes precedence.

3.1 General requirements

The requirements, particularly for the External Dashboard of NIKH, include the definition of the target users and the goals and desired functionalities of the website.

As stated in Deliverable "D2.1: EMF value drivers towards stakeholders needs on real case studies" [8], the main types of the concerned stakeholders with regard to telecommunications' EMFs and their potential health effects are the following:

1. The telecommunications industry.
2. The governments, regulatory authorities, and health institutions.
3. The general population and its subgroups like workers, etc.
4. The scientific research community.
5. The educational institutions and the media as a means of EMF awareness.

Based on this discrimination of the different groups of people involved, the publicly available Dashboard of the NIKH platform was originally designed with the scope to welcome all kinds of visitors, introduce them to the platform, and directly navigate them to webpages with specialised content and functionalities suitable for each type of stakeholder.

The three main types of stakeholders which are taken into special concern for the initial webpage of the NIKH platform are the regulatory authorities, the citizens, and the scientific community. These three groups of people, which comprise essentially the whole population, are discriminated against on the basis of EMF governance relevance. Authorities are the most concerned group; scientists and researchers from diverse disciplines are also greatly involved, and of course, all common people of all societal and educational levels are concerned as end-users and need to be engaged in EMF awareness. These groups will constitute the vast majority of NIKH users, internal scientists aside. Thus, NIKH will play the role that it is intended for, i.e., to serve as an international hub of knowledge available to everyone and as a go-to tool for authorities and scientists.

In that scope, the External Dashboard of NIKH provides a general introduction and quick links to the specialised web pages for each type of user. In addition, the registration and login options for approved users offer additional privileges and enhanced access to more sensitive information, functionalities, and tools in accordance with the level of permissions assigned to each type of user, as described in the relevant passage. According to the aforementioned principles of modern, user-friendly web design, each user of the NIKH platform will be able to figure out immediately the structure and available functionalities of the website, instantly recognise their specific group type, and easily navigate directly to their relevant webpage with all the dedicated content and extra functionalities.

3.2 Design mock-ups

The original design and final mock-ups were made with the UI design software Figma, which combines the UX design through the creation of the original frames, mock-ups, and interactive prototypes of a website, along with its platform-based collaboration tools, as well as code generation tools for the development phase.

Based especially on the first five principles mentioned in Section 2.1, the original design of the initial webpage was made as simple as possible by providing a clean and clear graphical environment for the user, which contains only the necessary functionalities to initiate navigation.

After various drafts of different interactive mock-ups and valuable feedback reception from all partners in the plenary meeting of the NextGEM project in October 2023 at FORTH, along with extensive discussions among FORTH, eBOS, and ICOM development teams, the final structure of the initial webpage of NIKH was agreed, as depicted in Sections 2.2. and 2.3. In general, the external dashboard of NIKH serves the three aforementioned types of users without the requirement of registration and logging in.

3.3 Implementation

The implementation of NIKH application portal is based on a mixture of different web-based technologies to fulfil the requirements of NIKH. More specifically, NIKH application portal is developed in a hybrid mode, by integrating the WordPress [8] web content management system with the development of a custom web-based application, including front-end and back-end based built upon React.js [9] and Node.js [10].

The external dashboard of the application portal of NIKH is facilitated by WordPress web content management system and served by the knowledge base of NIKH. WordPress has been selected as the development platform for the external dashboard pages of the NIKH platform due to its user-friendly content management system. This offers rapid development capabilities along with a rich ecosystem of plugins essential to the NIKH platform's requirements. Additionally, WordPress as a tool enables easy creation and management of content without extensive technical expertise which allows all consortium partners to generate content for the external dashboard in a collaborative manner. Additional benefits of this tool include customisation options, community support, statistics, scalability, SEO-friendly nature, cost-effectiveness and many others. The Home Dashboard from the WordPress administrator portal is shown in Figure 5.

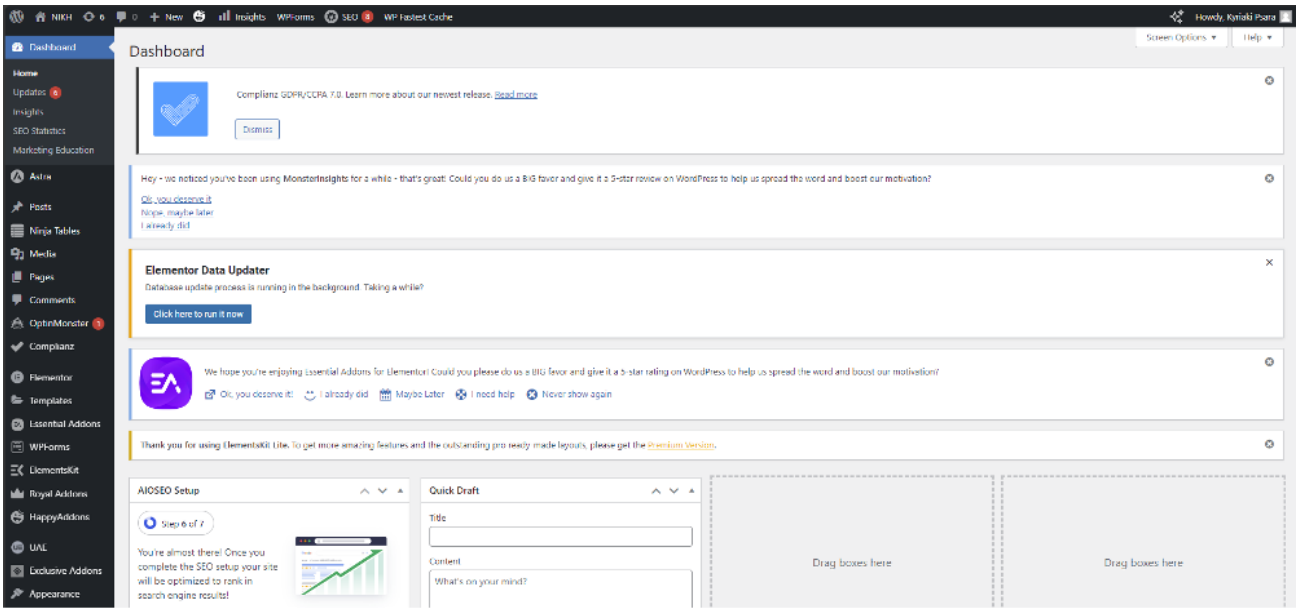

Figure 5: WordPress administrator home dashboard page

The Elementor [11] plugin for WordPress was used, as demonstrated in Figure 6. Elementor provides various user-friendly design features, including menus, tabs, interactive tables and animations. Combined with the general value WordPress offers, using Elementor allows for the easy design of a professional, intuitive and visually intriguing content-based NIKH frontend.

[8] WordPress web content management system https://wordpress.com

[9] React.js free and open-source front-end JavaScript library, https://react.dev

[10] Node.js cross-platform, open-source JavaScript runtime environment, https://nodejs.org

[11] Elementor plugin for WordPress https://elementor.com/

Figure 6: NIKH application portal website design using Elementor in WordPress

For the deployment of the Scientists, the Login and the Tools, including the data management, the modelling, the literature review and the risk assessment, custom web-based applications were developed. These pages of the GUI were built upon React.js and Node.js, two JavaScript-based technologies. React.js is a UI library developed by Meta, while Node.js is a JavaScript runtime environment that allows developers to run JavaScript on the server-side. More specifically, for the frond-end several react components were developed where some components represent pages in the context of file-based routing in the Next.js framework and other components as parts of the UI composing the page. To further optimize our development process and deliver a streamlined interface, we leveraged Next.js. Next.js is a popular React-based framework for building server-side rendered (SSR) and statically generated (SSG) websites and applications; SSR allows for seamless rendering of React components on the server, while SSG enables the generation of static HTML files, resulting in faster page loads and improved performance. In addition, a set of REST APIs are implemented in the backend to authenticate users and search publication metadata from external services in supported sources (PubMed, Zenodo, EMF-Portal, Web of Science, NextGEM, GOLIAT, SEAWave, and ETAIN), and upload metadata to NIKH based on front-end calls.

As shown in Figure 7, all pages and subpages of the NIKH application platform have a menu bar with access tabs to the NIKH pages (as per the sitemap). In addition, a footer is present at the bottom of all pages. This provides the required EU funding disclaimer, copyright notice, and links to the NIKH pages. As per GDPR requirements, there are links to the privacy and cookies policy.

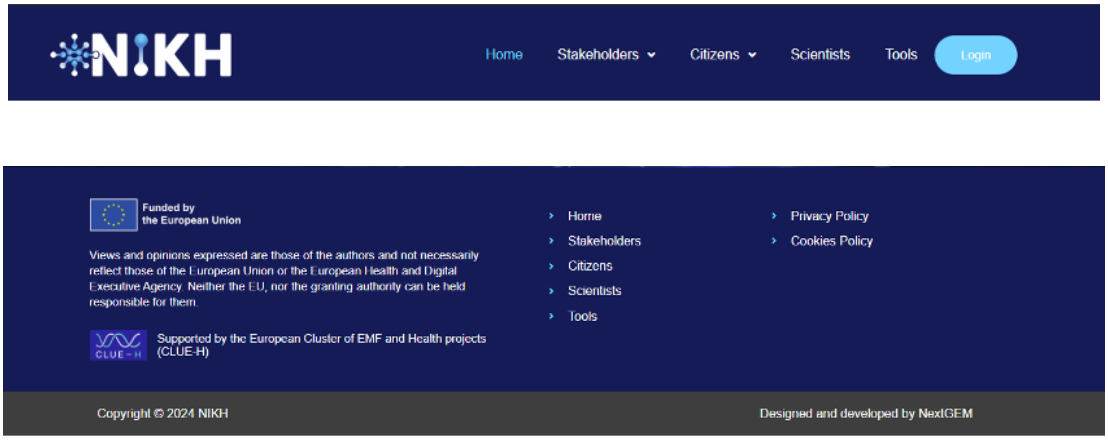

Figure 7: NIKH website header and footer

The presence of the header and footer on all pages of NIKH makes the navigation across the website easier for visitors. Since the header and footer are present on all NIKH pages, they will be omitted from the figures showing the pages of the NIKH frontend dashboard. This interface is accessed by redirecting users from the WordPress to React NIKH front-end, providing a seamless user experience.

3.4 Security and privacy

As the NIKH platform is using a significant volume of sensitive information, users have credentials, using authentication and authorisation in order to be allowed to access the data. User authentication is a crucial component of the NIKH platform for several reasons, such as data security, access control, personalisation, accountability, and confidentiality. The user management mechanism controls the accessibility to the NIKH platform and its collaborating back-end components through authentication and single sign-on mechanisms. A single sign-on system allows a user to log in once and gain access to all related systems without being prompted to log in again at each of them. Access and Authentication will be addressed by verifying that a person is a specific user, since he or she has correctly provided their security credentials. Access will be granted by confirming that a particular user is a registered member of the NIKH platform and, therefore, has permission to perform particular actions such as providing input data and accessing internal data. The distributed authentication and authorisation mechanism used for the NIKH platform is Keycloak, which is an open-source software product that allows single sign-on with identity and access management.

Figure 8 demonstrates the user experience of a registered user navigating through the login and home page of the NIKH platform, thus initiating the user management mechanism. The user navigates to the login page, where she/he enters her/his registered username and password. The platform verifies the credentials using the Keycloak mechanism. The user is redirected to the main menu page if the credentials are correct. If the credentials are incorrect, a clear error message is displayed, prompting the user to enter valid information interested in accessing the NIKH platform.

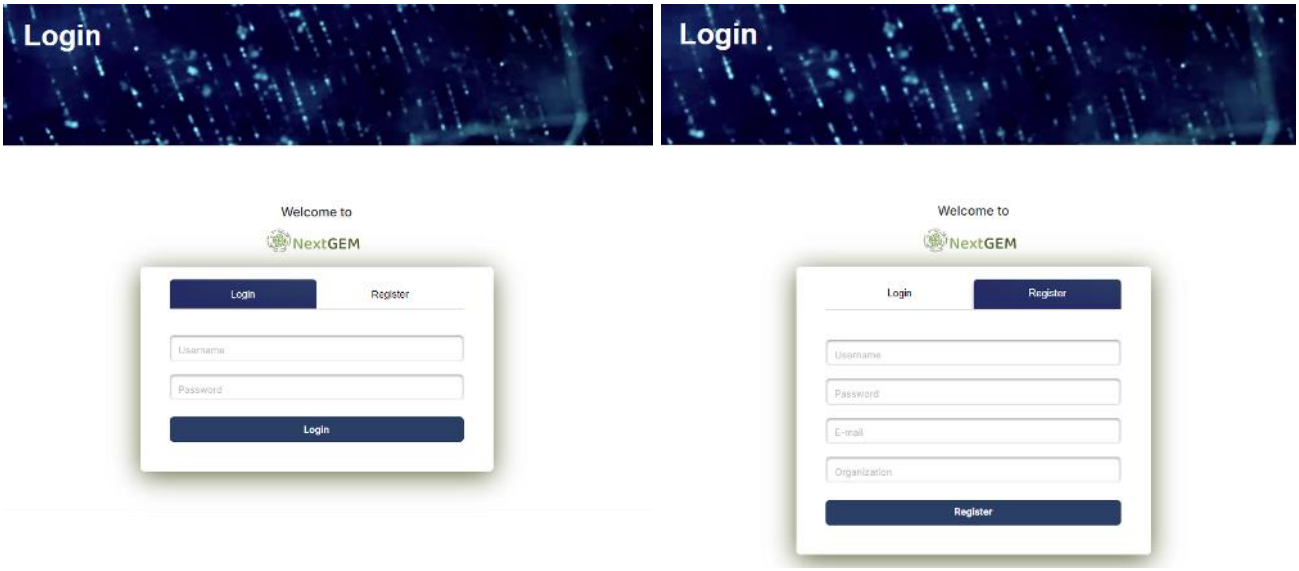

Figure 8: Login and registration webpage form

Keycloak is an open-source tool licensed under Apache License 2.0 for identity and access management. Keycloak supports a Single-Sign-On mechanism for centralised user management while also providing customisation features for user roles, groups and permissions. Within the context of NIKH, Keycloak serves as the central authentication and authorisation service, allowing for secure communication and interaction with NIKH's services.

For the purposes of the NIKH platform, a new realm named "NextGEM" was created, which encapsulates all the users, groups and roles that are part of the NIKH platform, as shown in Figure 9. A realm is a term coined within Keycloak to represent individuals or organisations operating within a shared context and having similar interests.

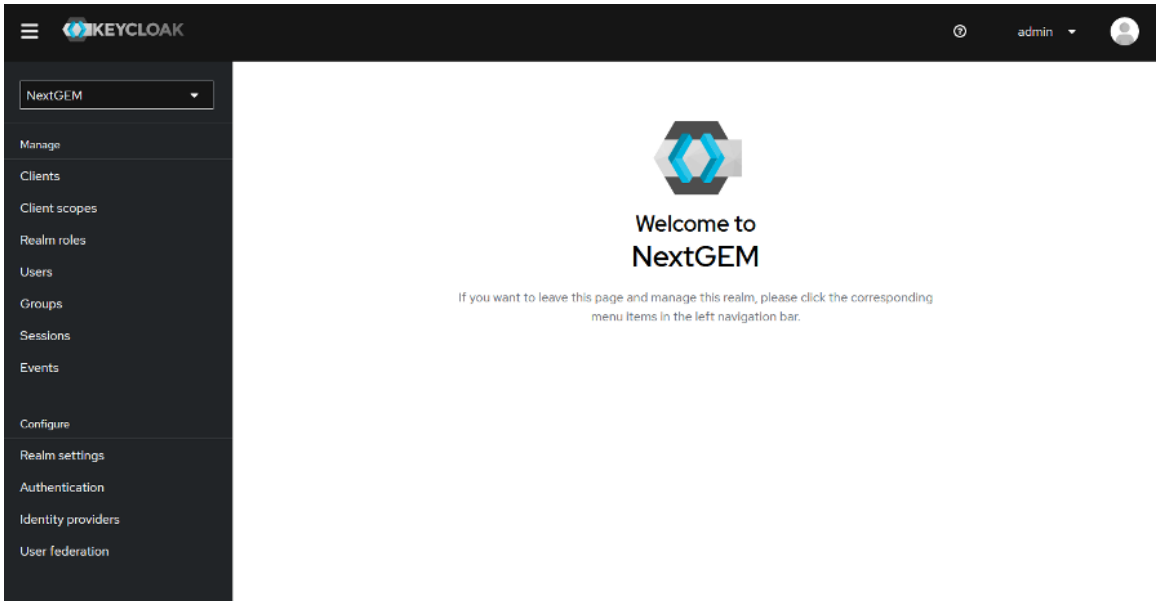

Figure 9: Keycloak Set up GUI

Keycloak permits the creation of groups within a realm for the purpose of encapsulating users under a single entity for easier management. It provides the ability to define roles in a group, which are automatically attached to a user assigned to that group. Roles can also be created on the realm level, but assigning roles to a user in the realm has to be manual via Keycloak's GUI. For the needs of NIKH, we have chosen the latter approach and defined three role levels: user and administrator, as shown in Table 2. The role of administrator is manually assigned by the master user of Keycloak while the other two are selected by the users upon registration and assigned using the Keycloak API when the registration request is accepted.

Some of the data handled by NIKH can be sensitive and should not be available for public or unauthorised access. For that reason, we have introduced the registration request in the platform. The registration request works like a normal registration process. Still, the user input is temporarily stored in a database until the corresponding administrator of the selected organisation accepts or rejects the request. If the administrator accepts the request, then a new user account is created on Keycloak, and the user can then log in to the NIKH platform using the credentials defined in the registration request. If the administrator rejects the request, no further action is taken.

Table 2: User roles and permissions.

	Create/Upload	Search	View	Edit	Delete
Administrator	✓	✓	✓	✓	✓
Simple User		✓	✓		

NextGEM has deployed and is maintaining the Keycloak [9] authentication/authorisation mechanisms for the NIKH platform. Communication of the Keycloak component is realised by providing RESTful APIs to expose its services with JavaScript Object Notation (JSON) [10], mainly being used for the format of the data. The user interface does not directly communicate with Keycloak. Instead, it interfaces with a web service API (*Controller-Auth*) that encapsulates the business logic needed for user authentication/authorisation and registration. The business logic contains the functions that ultimately request and receive data from Keycloak in JSON, which, in turn, feeds back to the user interface after some processing.

4 External dashboard

4.1 Home page

The homepage of the external dashboard on the NIKH platform is designed to cater to visitors of all target stakeholder groups and registered members to provide an overview of the website's different sections. It serves as a gateway to relevant pages specific to the respective user groups while providing a thorough overview of each section. Upon accessing the home page, as shown in Figure 10 and Figure 11, visitors are greeted with a welcome message laid over an animated graphic.

The animated graphic, which illustrates a dynamic digital web of nodes connected via straight beam lines, communicates the collaborative and data-sharing aspects of NIKH with reference to technology and the web and is present on all pages of NIKH. This is followed by four separate sections with descriptions and links for the "Stakeholders", "Citizens", "Scientific community", and "Tools" sections of NIKH, accompanied by relevant graphical elements to communicate better the section contents and enhance user experience.

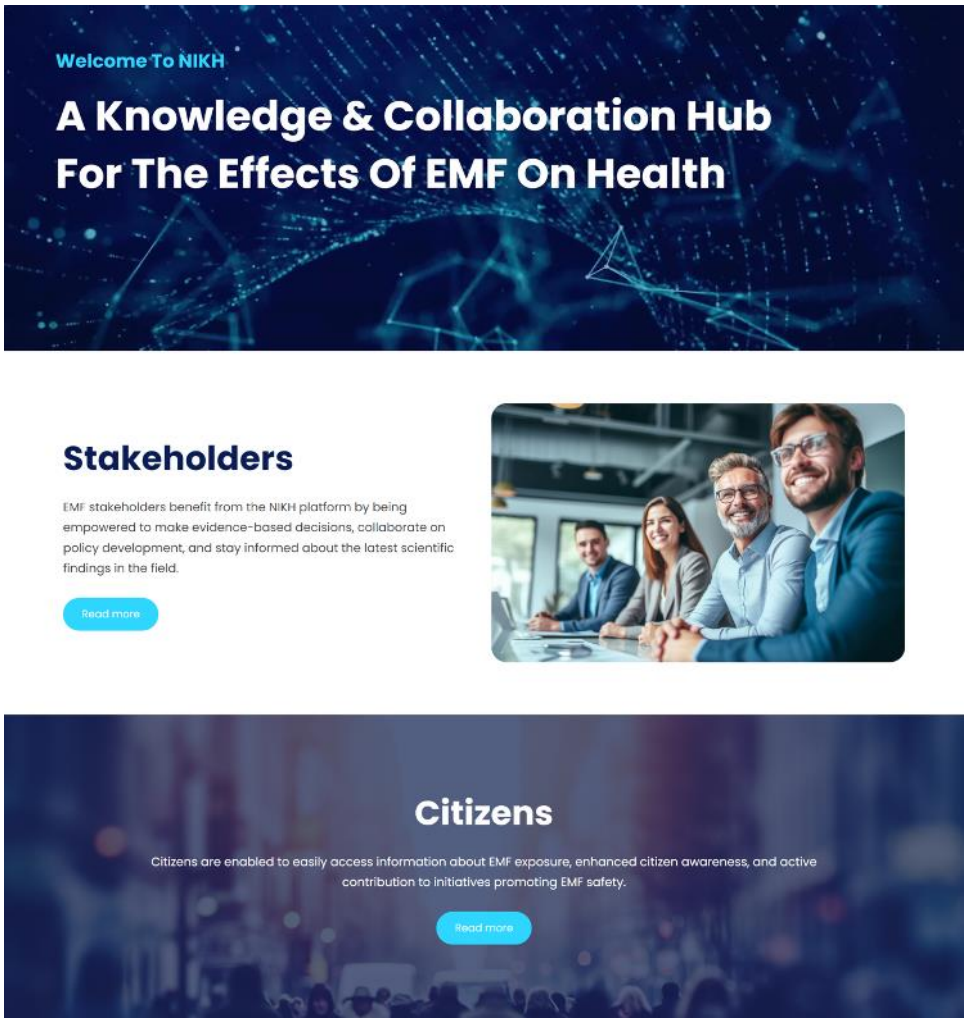

Figure 10: NIKH Homepage (Part 1 of 2)

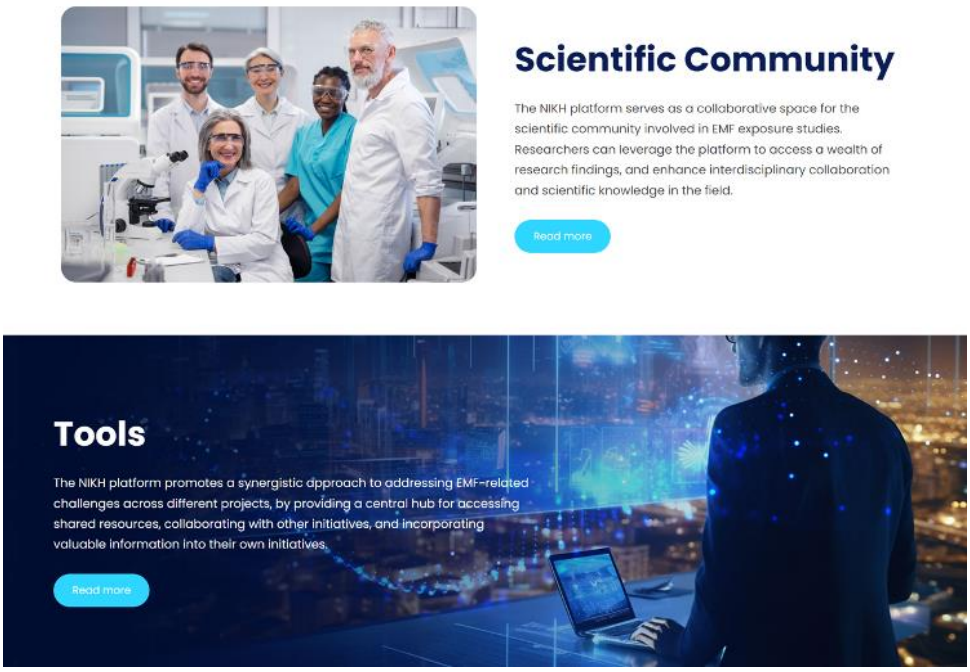

Figure 11: NIKH Homepage (Part 2 of 2)

4.2 Stakeholders

The "Stakeholders" page provides links to each of the five subcategories of stakeholders captured by NIKH, as shown in Figure 12.

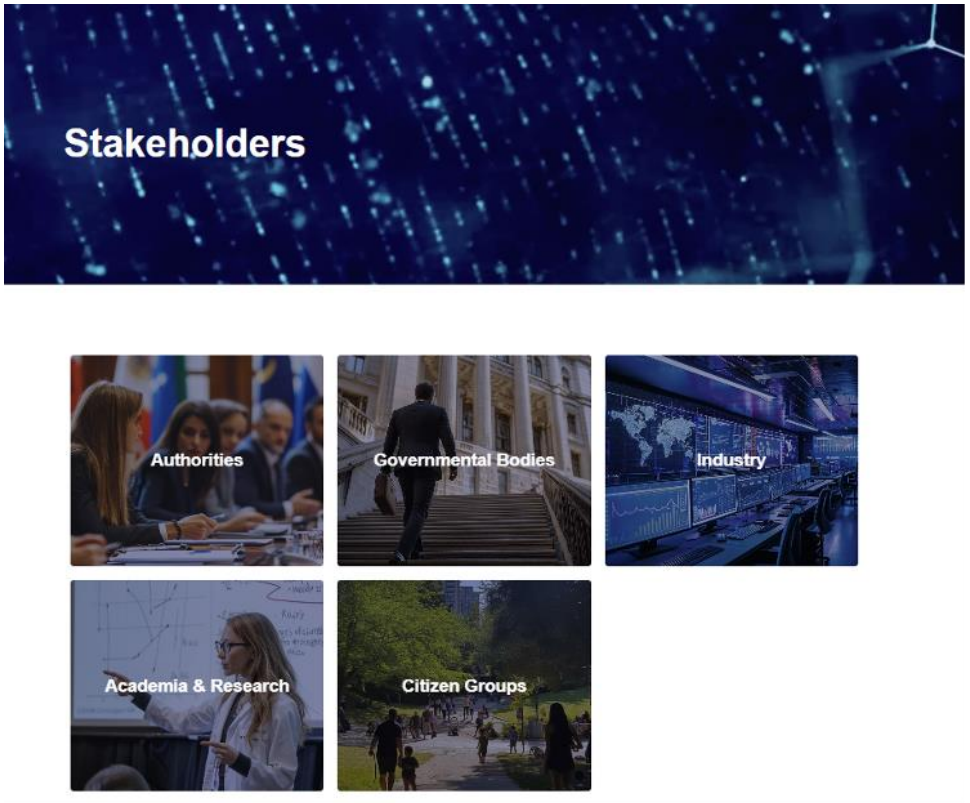

Figure 12: NIKH Stakeholders page

The menu adopts a "flip-card" format, where the selection card of each subsection flips when the cursor is placed over it, revealing a text summary of the page. An example demonstrating the description of the "Authorities" section is given in Figure 13.

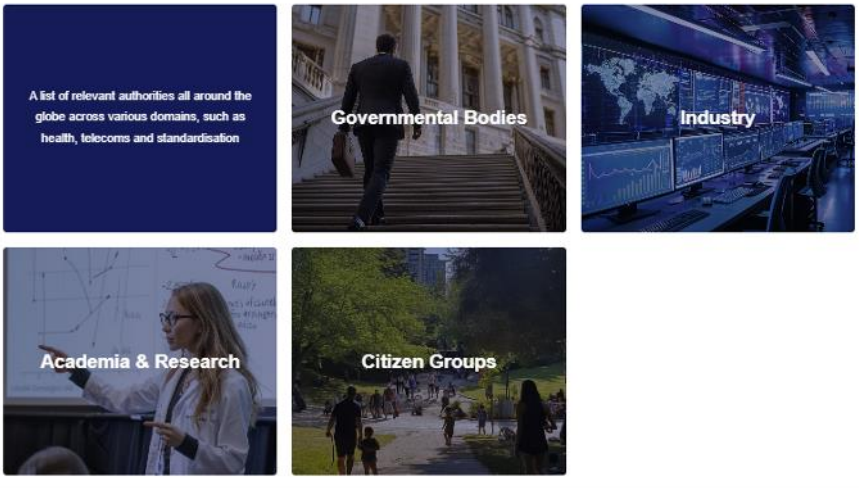

Figure 13: NIKH Stakeholder page with the Authorities flip-card flipped

All the subpages under the "Stakeholders" page share the same core design, displaying the various stakeholder groups in a table format, with relevant details and website links included. The search function of all tables allows visitors to filter the tables by any text string they wish (e.g. if they are searching for an industry stakeholder from a specific country or a specific type of authority stakeholder organisation). In addition, the tables can be sorted alphabetically based on any table column. Figure 14, Figure 15, Figure 16, Figure 17 and Figure 18 show the "Authorities", "Governmental Bodies", "Industry", "Academia & Research" and "Citizen Groups" subpages, respectively.

Search

Name	Description	Type	Website
CEN	European Committee for Standardization	Standardization	Link
CENELEC	European Electrotechnical Committee	Standardization	Link
ETSI	European Telecommunications Standards Institute	Standardization	Link
IARC	Agency For Research On Cancer (IARC) - EMF And Cancer	Intergovernmental organization	Link
ICNIRP	International Commission for Non-Ionizing Radiation Protection	International Commission	Link
IEC	International Electrotechnical Commission	International Commission	Link
IEEE-ICES	International Committee on Electromagnetic Safety	International Committee	Link
IRPA	International Radiation Protection Association	International Association	Link
ITU	International Telecommunication Union	International Agency	Link
URSI	International Union of Radio Science	Intergovernmental organization	Link
WHO	World Health Organization	Intergovernmental organization	Link

Figure 14: NIKH Stakeholders: Authorities subpage

Search

Name	Description	Country	Website
ADAE	Greek Authority for Communication Security & Privacy	Greece	Link
AGCOM	Autorità per le Garanzie nelle Comunicazioni	Italy	Link
BAG	Bundesamt für Gesundheit	Switzerland	Link
BfS	German Federal Office for Radiation Protection; The Competence Centre for Electromagnetic Fields	Germany	Link
EEAE	Greek Atomic Energy Commission	Greece	Link
EEKT	Union of Mobile Telecommunication Providers	Greece	Link
EETT	Greek Telecommunications Commission	Greece	Link
ENEA	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile	Italy	Link
EZK	Ministry of Economic Affairs and Climate Policy	Netherlands	Link
FCC	Federal Communications Commission (FCC) - RF Safety	USA	Link

Figure 15: NIKH Stakeholders: Governmental Bodies dubpage

Search

Name	Description	Country	Website
AENOR	Asociación Española de Normalización	Spain	Link
Asstel	Association of TLC Operators	Italy	Link
CEI	National Electrotechnical Committee (member of IEC and CENELEC)	Italy	Link
Cosmote/OTE	Hellenic Telecommunications Organization S.A.	Greece	Link
Ericsson	Mobile communications equipment	Sweden	Link
Hellas Sat	Satellite Communication & Connectivity Solutions Company	Greece	Link
Monet	Dutch association of network operators KPN, Vodafone and Odido	Netherlands	Link
NEC-EMF	National Electrotechnical Committee (member of IEC and CENELEC)	Netherlands	Link
NOVA	Greek mobile provider	Greece	Link
OTE	Hellenic Telecommunications Organisation S.A. (OTE Group)	Greece	Link
Vodafone	Vodafone Greece	Greece	Link

Figure 16: NIKH Stakeholders: Industry subpage

Search

Name	Description	Country	Website
AIRP	Associazione Italiana di Radioprotezione	Italy	Link
AUTH	Aristotelian University of Thessaloniki	Greece	Link
CNIT	Consorzio Nazionale Interuniversitario per le Telecomunicazioni	Italy	Link
CNR	Consiglio Nazionale Delle Ricerche	Italy	Link
CNSA	Centro Nacional de Sanidad Ambiental	Spain	Link
ETHZ	Eidgenössische Technische Hochschule Zürich	Switzerland	Link
FORTH	Foundation for Research and Technology - Hellas	Greece	Link
GTTI	Gruppo Telecomunicazioni e Tecnologie dell'Informazione	Italy	Link
ICCS	Institute of Communication and Computer Systems	Greece	Link
ICEmB	Inter-University Centre for the study of the Interaction between Electromagnetic Fields and Biosystems	Italy	Link
ISGLOBAL	Barcelona Institute for Global Health	Spain	Link
IT'IS	Foundation for Research on Information Technologies in Society	Switzerland	Link

Figure 17: NIKH Stakeholders: Academica & research subpage

Search

Name	Description	Country	Website
ADICONSUM	Associazione Difesa Consumatori APS	Italy	Link
ADOC	Association for the Defense and Orientation of Consumers	Italy	Link
AIRM	Italian Association of Medical Radioprotection	Italy	Link
Altroconsumo	Organizzazione di consumatori	Italy	Link
Amici della Terra	Associazione ambientalista riconosciuta	Italy	Link
ANCI	Associazione Nazionale Comuni Italiani	Italy	Link
ANPCI	Associazione Nazionale Piccoli Comuni di Italia	Italy	Link
Cittadinanzattiva	Active citizenship network	Italy	Link
ELINYAE	Greek Institute for Occupational Health & Safety	Greece	Link
EMHET	Union of Telecommunications Scientists & Engineers OTE	Greece	Link
Federconsumatori	Associazione di Promozione Sociale	Italy	Link
FOR	Fondazione Ottimisti e Razionali	Italy	Link
INSHT	Instituto Nacional de Seguridad e Higiene en el Trabajo	Spain	Link

Figure 18: NIKH Stakeholders: Citizen groups subpage

4.3 Citizens

The "Citizens" page provides links to the "Guidelines", "Campaigns" and "FAQ Section" subpages. Below the links, an informative piece of writing accompanied by an antenna graphic emitting waves is present, informing the citizen visitors of the page of the concerns regarding the potential effects of EMF on health. Figure 19 presents the "Citizens" page. The "Guidelines" and "Campaigns" subpages, shown in Figure 20 and Figure 21, respectively, share a similar design and provide external links to EMF-related health and safety guidelines and EMF-measurement campaigns from relevant organisations and bodies. Lastly, the "FAQ Section", as provided in Figure 22, provides simple answers to potential questions citizens might have regarding EMF and its potential impacts on health. It adopts a collapsible "accordion" format, revealing answers upon clicking a question.

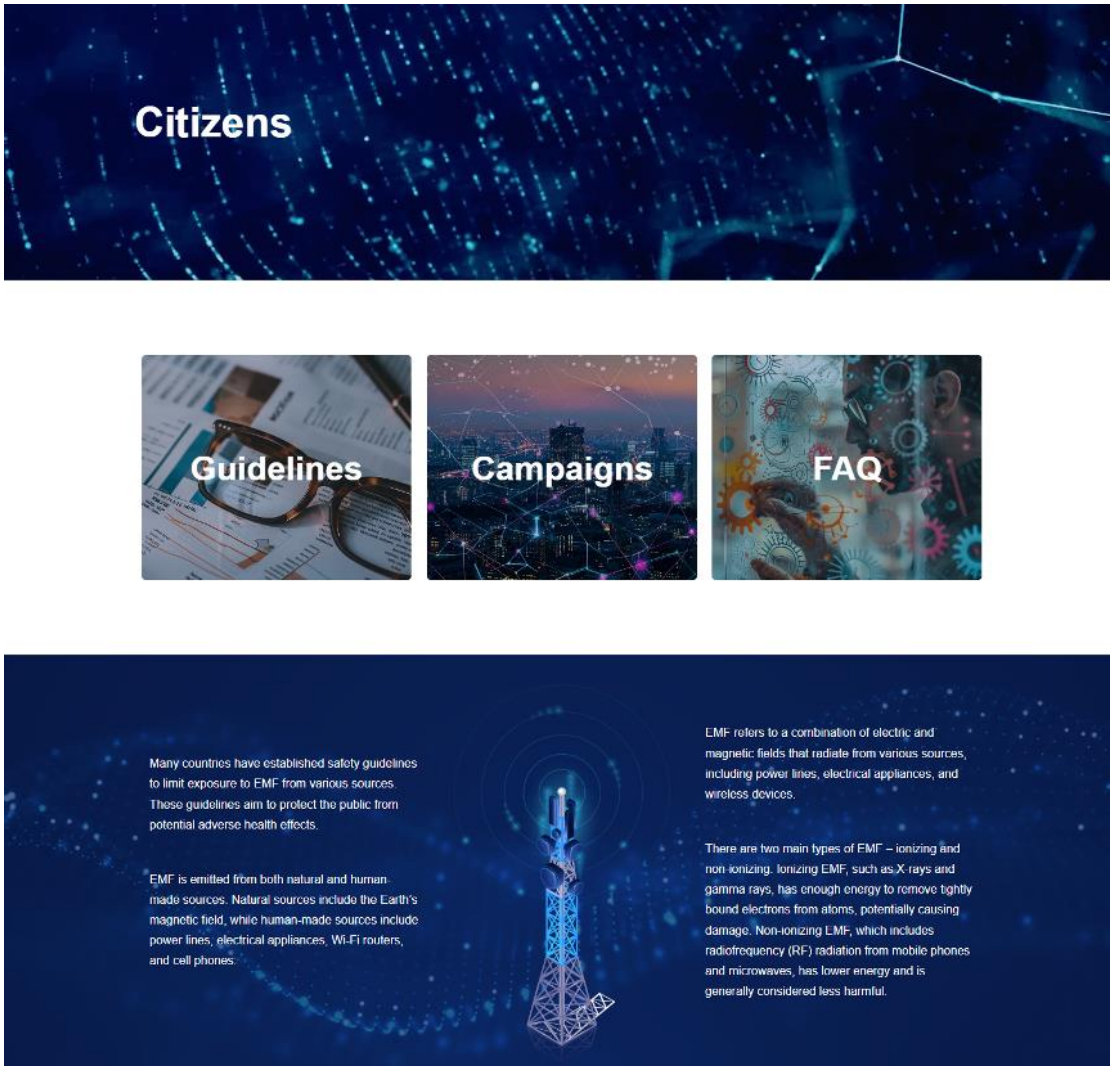

Figure 19: NIKH Citizens main page

Figure 20: NIKH Guidelines section

Figure 21: NIKH Campaign section

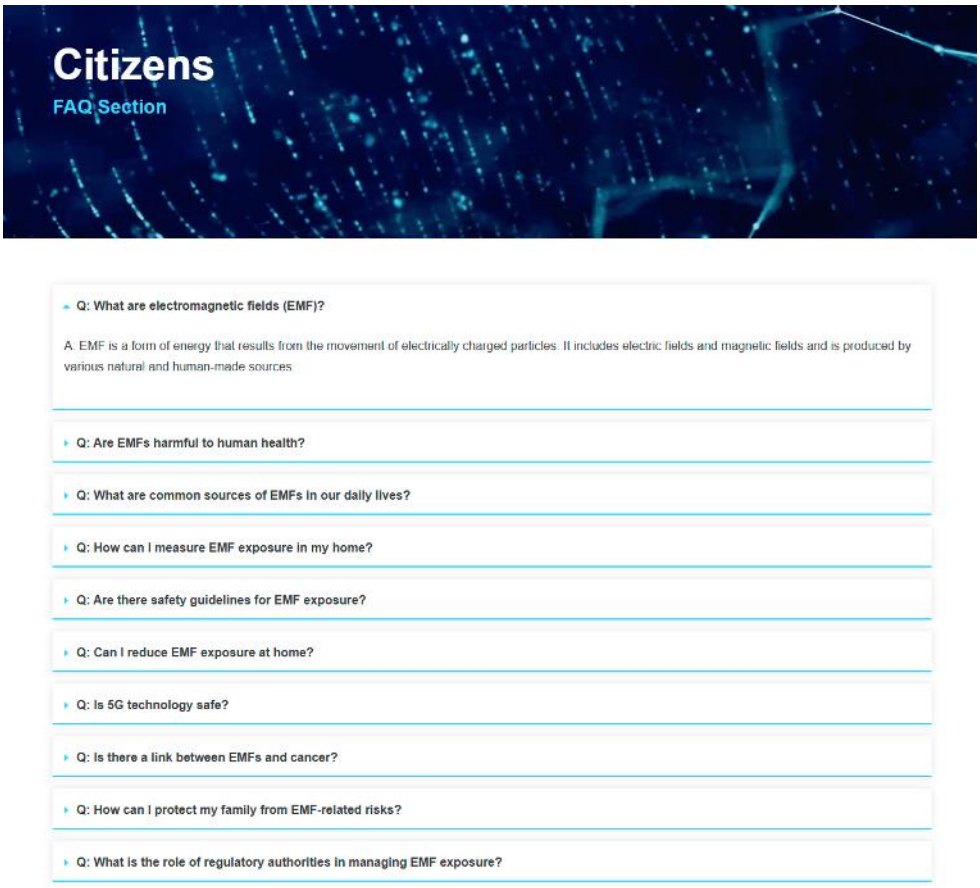

Figure 22: NIKH FAQ Page with accordion style menu demonstrated

4.4 Scientists

Under the "Scientist" section, a GUI was developed that allows users to search, filter, and retrieve specific data from the catalogue efficiently based on their permissions, as presented in Figure 23, which provides a search catalogue to all resources of the Hub, such as a list of all the latest publications on EMF & Health topics, extensive informational content, feeds from international scientific journals and institutes and many others. Scientists will be able to utilise the search engine of the Hub and immediately look for EMF studies, datasets, and all kinds of scientific content from external sources such as major international scientific databases, like EMF-portal, Zenodo, Dataverse, PubMed, Web of Science, SEAWave, GOLIAT, ETAIN and NextGEM. This way, the users will also be able to search for all the publicly available outcomes of the scientific research conducted within the European Cluster of projects CLUE-H, retrieved from the internal catalogue stored in the MongoDB database of the Hub. The results of a search are presented clearly in paged list format, as shown in Figure 24.

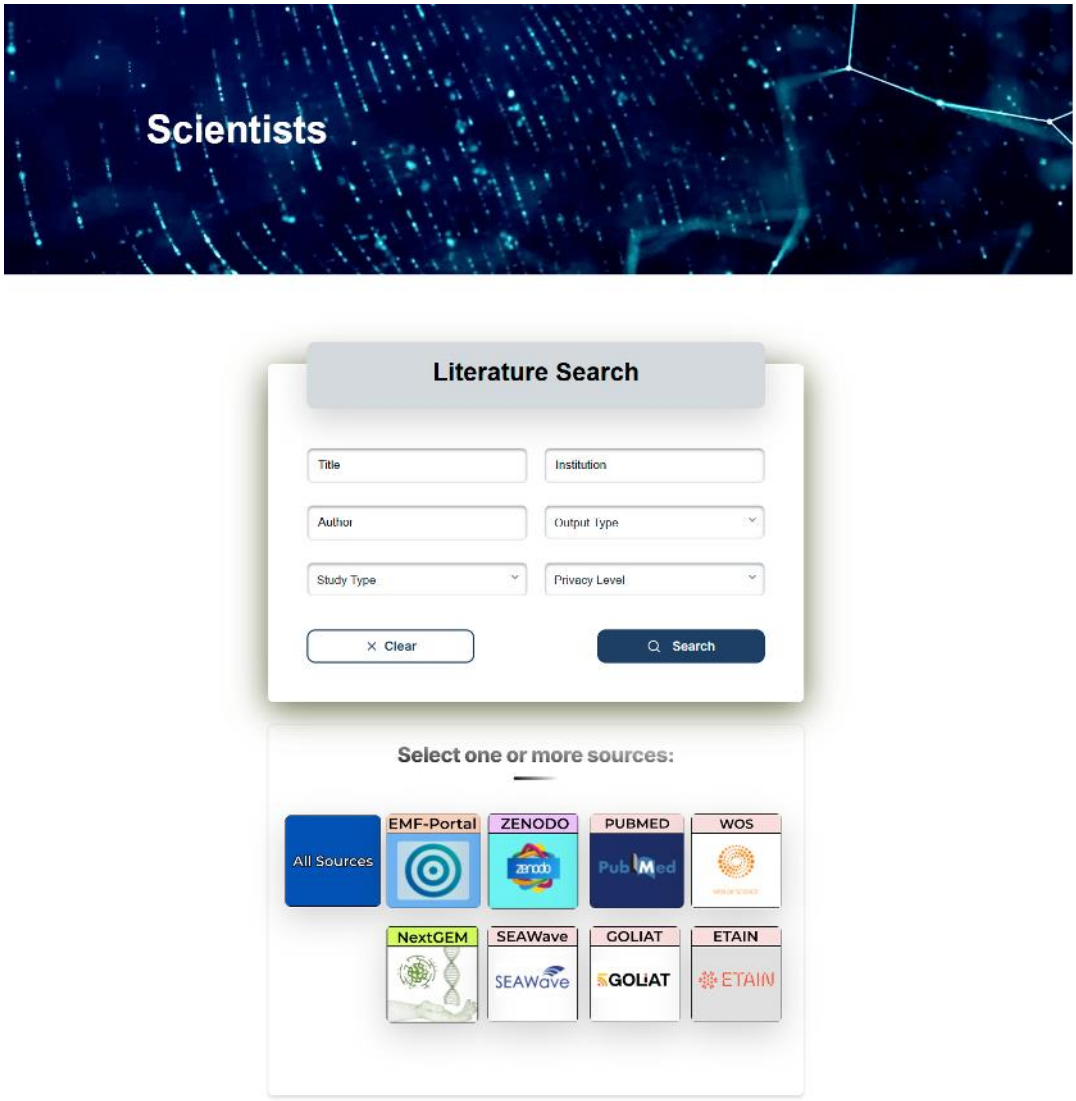

Figure 23: NIKH Scientific catalogue search page

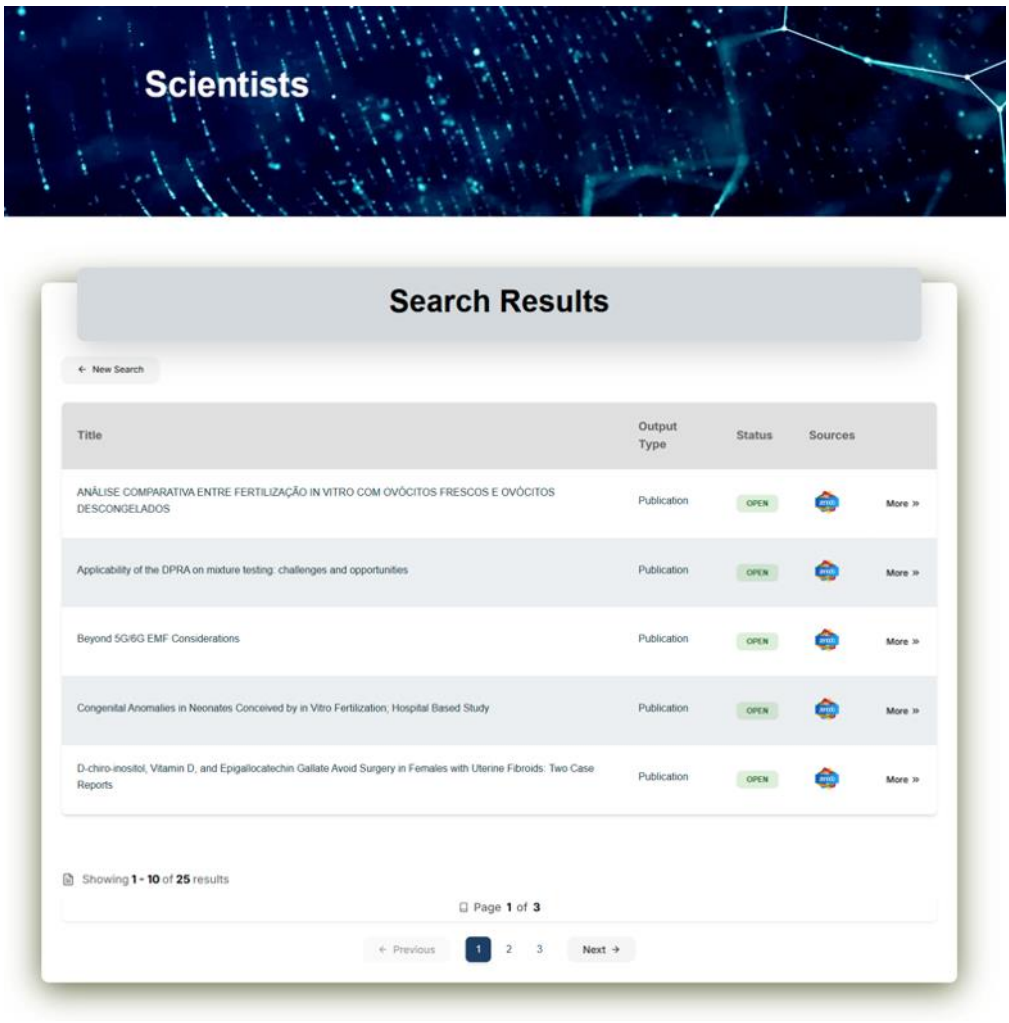

Figure 24: NIKH Scientific catalogue search results

External and internal users can view and download open-access material derived from PubMed, Zenodo, EMF-Portal, Web of Science, SEAWave, GOLIAT, ETAIN and NextGEM. On the other hand, internal stakeholders who are users within the NextGEM consortium and CLUE-H members have access to material generated during the NextGEM project and any other projects that belong to the CLUE-H cluster. These internal members would need to be registered in the NIKH platform and log in with their credentials to have access to these additional sources.

These external services allow the user to access consolidated information derived from various EMF-related initiatives and repositories. When a user selects the third-party services, it initiates an integration point with each selected source, generating a unified selection of material gathered from all chosen sources simultaneously. This makes NIKH a platform consolidating multiple sources and thus empowering users to customise their selection criteria to simplify their research activities through a single channel.

4.5 Privacy & cookies policies

The NIKH website has a "Cookies Policy" page and a "Privacy Policy" page to ensure transparency, compliance with legal regulations, and to build trust with its users. The "Cookies Policy" informs users about the use of cookies, how they enhance functionality, and how users can manage their preferences, aligning with GDPR and other data protection frameworks. Similarly, the "Privacy Policy" page is critical for detailing how the platform collects, uses, stores, and protects personal data and the rights users have over their data. These pages demonstrate the platform's commitment to data security, user privacy, and ethical information handling, fostering confidence among stakeholders accessing the NIKH platform. Both pages are demonstrated in Figure 25 and Figure 26.

Introduction

The NextGEM Innovation & Knowledge Hub (NIKH) is managed by the NextGEM Consortium. This Privacy Notice will inform you as to how the NextGEM Consortium (hereinafter referred to as the "Consortium", "we", "us" and "our") collects and processes information about you and in particular your personal data. We hereby assure you that this Privacy and Personal Data Protection Policy ("Policy") fully respects and complies with EU Regulation 679/2016 ("Regulation") and any other relevant legislation.

The processing of personal data, such as name, address or e-mail address of a data subject shall always be in line with the General Data Protection Regulation (GDPR), and in accordance with the country-specific data protection regulations applicable to the *NextGEM* Consortium. Through this data protection declaration, we would like to inform anyone concerned and the general public of the nature, scope, and purpose of the personal data we collect, use and process. Furthermore, data subjects are informed, by means of this data protection declaration, of the rights to which they are entitled.

As the data controller, the *NextGEM* Consortium has implemented numerous technical and organizational measures to ensure comprehensive protection of personal data processed through this website.

Useful Definitions

- **Personal Data**
  Personal Data is any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, indicatively by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person.
- **Personal data breach**
  Personal data breach is a breach of security leading to the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to personal data transmitted, stored or otherwise processed.
- **Controller**
  Controller is the natural or legal person, public authority, agency or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data.

Figure 25: NIKH Privacy policy page

In order to make your visits to the NextGEM Innovation & Knowledge Hub (NIKH) as pleasant as possible, the NextGEM Consortium uses cookies. These cookies automatically track and collect certain technical information that your browser sends to us. This information might include Internet protocol (IP) addresses, the browser type, browser language, Internet service providers (ISP), referring/exit pages, URLs, operating systems, date/time stamps, and other similar information. However, this information doesn't identify individual users and we use it exclusively to analyse trends, to administer the site, to track user movements around the site as a whole to improve the services provided.

What is a Cookie?

Cookies are simple text files downloaded to your computer or mobile device when you visit a website or page, so the website can recognize your device the next time you visit. They're essential for easy navigation, making your experience faster, easier, and more personalized. The term "cookies" in this Policy is used to refer to all files that collect information in this way.

There are many functions cookies serve. For example, they can help us to remember your language preferences or login information or analyse how well the site is performing, or even allow us to recommend content we believe will be most relevant to you.

There are cookies set by us called first party cookies;

A third-party cookie is a cookie that is associated with a domain name different from that of the page where the cookie is encountered. Third-party cookies are placed by the external social media profiles used in NextGEM's website.

Third-party cookies are different from First-party cookies, which are associated with the domain of the page being visited.

Figure 26: NIKH Cookies policy page

The "Manage Consent" tab is present on the bottom right of the webpage upon visiting, as shown in Figure 27, and provides users with control over their data preferences and consent regarding the use of cookies and similar technologies. By enabling or disabling specific types of cookies, users can decide how their browsing data, such as behaviour or unique IDs, is processed to enhance their experience. Again, this is implemented to ensure transparency and compliance with data protection laws like GDPR, allowing users to "Accept", "Deny", or customise their choices via the "View preferences option", as shown in Figure 27. Links to the "Cookies Policy" and "Privacy Policy" pages are provided for more detailed information on how data is collected, used, and safeguarded.

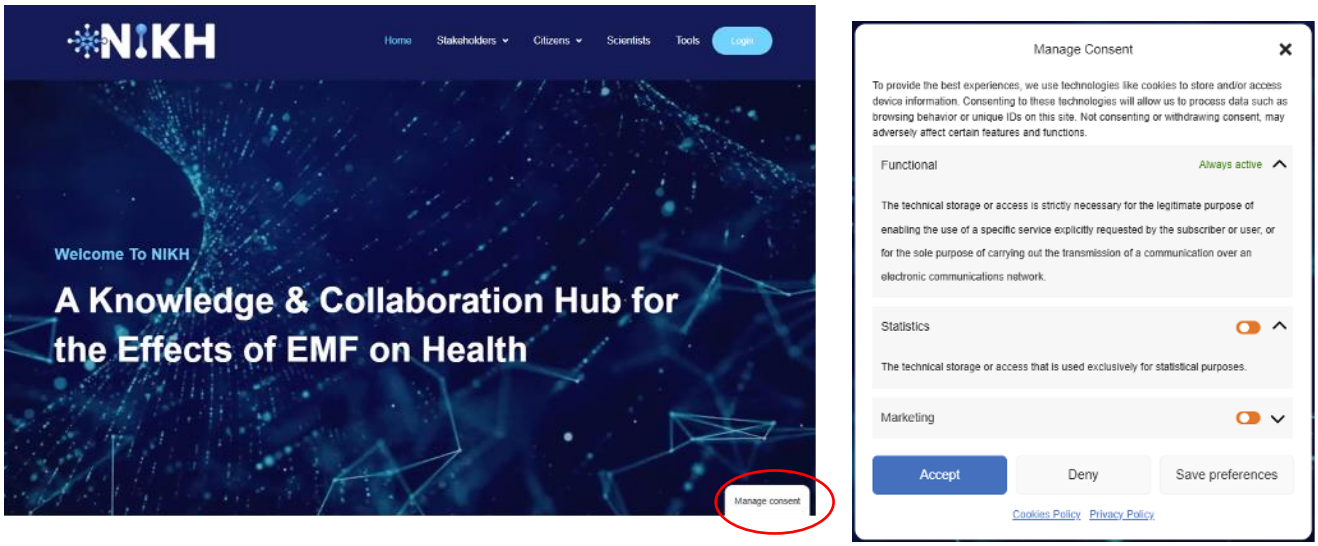

Figure 27: NIKH Homepage with manage consent tab menu

5 NIKH tools

In the explicit case of registered users as members of the NIKH Platform, the initial webpage after login i.e., the NIKH tools, will provide four main modules as depicted in Figure 28. All registered users are required to be authenticated, which will allow them to view the home page on the internal side of the NIKH platform. On this page, the user encounters a menu of four options: Literature Review, Risk Assessment, Data Management and Modelling.

The input data page facilitates data contributors in selecting the data source, uploading real-time data, and providing necessary metadata. The modelling menu option provides a GUI for ERMES modelling, allowing scientists and researchers to simulate and analyse electromagnetic scenarios. The Risk Assessment tool provides a GUI for conducting risk assessments based on EMF exposure scenarios. Finally, the Ecosystem option offers a centralised space for information on consortium partners, fostering collaboration and knowledge sharing.

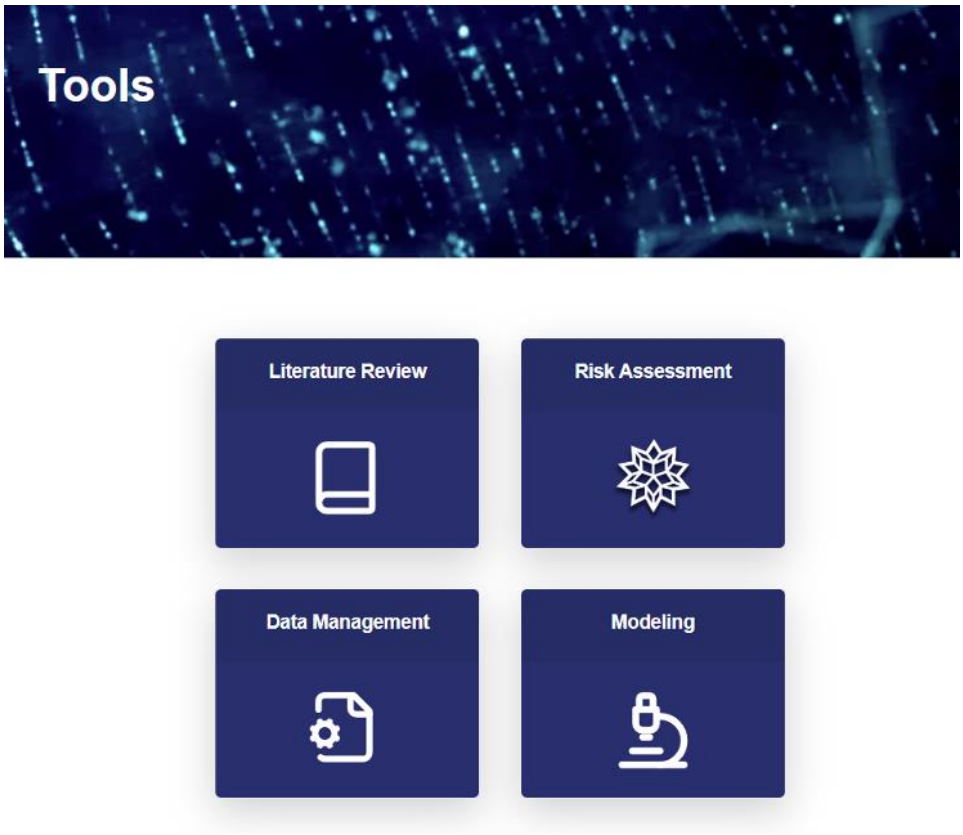

Figure 28: NIKH Tools main page

The modules described in the following sections will provide all the necessary functionalities for a complete and sophisticated utilisation of all the available resources and tools provided by the complex system integration of the involved data spaces, external sources, and services. A more thorough description of each module of the Internal Dashboard is delivered in the following relevant passages of this document.

5.1 Literature review

In the NIKH dashboard, registered users can initiate a new literature review, which enables them to search for publications, eliminate duplicates by identifying publications that appear on multiple sources, and combine multiple queries for a more comprehensive search.

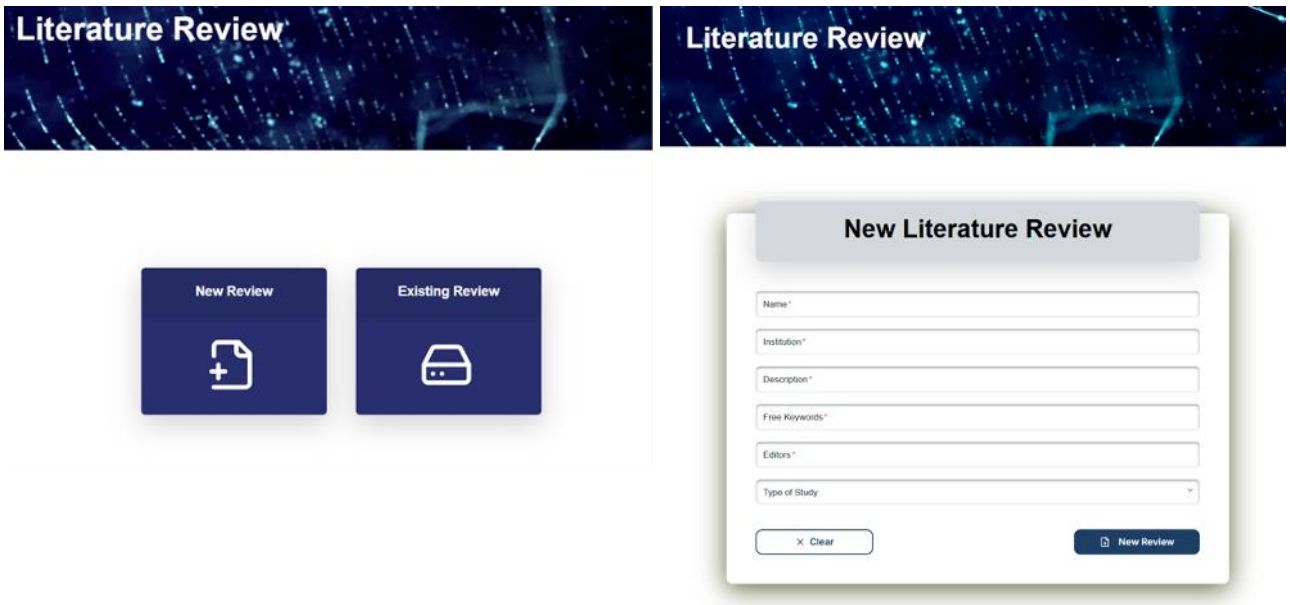

Figure 29: NIKH New review page form literature review tool

The user must first create a literature review before capturing the literature in question. This is done by selecting the "New Review" option, where the "New Literature Review" form is presented, as show in Figure 29. This requires the user to input the details of the literature review before pressing the "New Review" button to save it.

Each literature review query is saved, enabling users to easily access their search history through a dedicated literature review history page. This feature allows users to track their progress and revisit previous searches as needed. The literature review history data will be saved in the MongoDB database as a separate collection named "search history". The data saved are stored in JSON format.

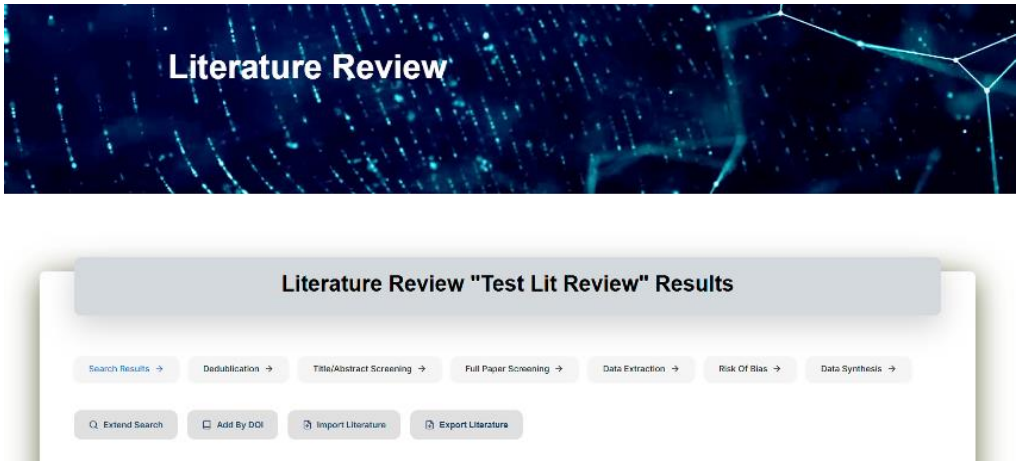

Figure 30: NIKH Conduct literature review in the literature review tool

The Literature Review Tool supports extensive searches across platforms like Zenodo, EMF-Portal, PubMed, and Web of Science, with potential for additional integrations. Users can tailor their searches by specifying parameters such as Title, Author, or Study Type and broaden results using varied criteria across sources. Search results, displayed in the tool's first tab, include essential publication details like title, authors, abstract, publication date, DOI, and metadata, ensuring efficient access for review. Additionally, literature can be added via DOI, which fetches metadata automatically, or imported directly through file uploads. The tool also enables deduplication, allowing users to consolidate duplicate records from different sources based on parameters like title and DOI. This functionality ensures a streamlined and efficient review process while gathering comprehensive metadata from multiple repositories.

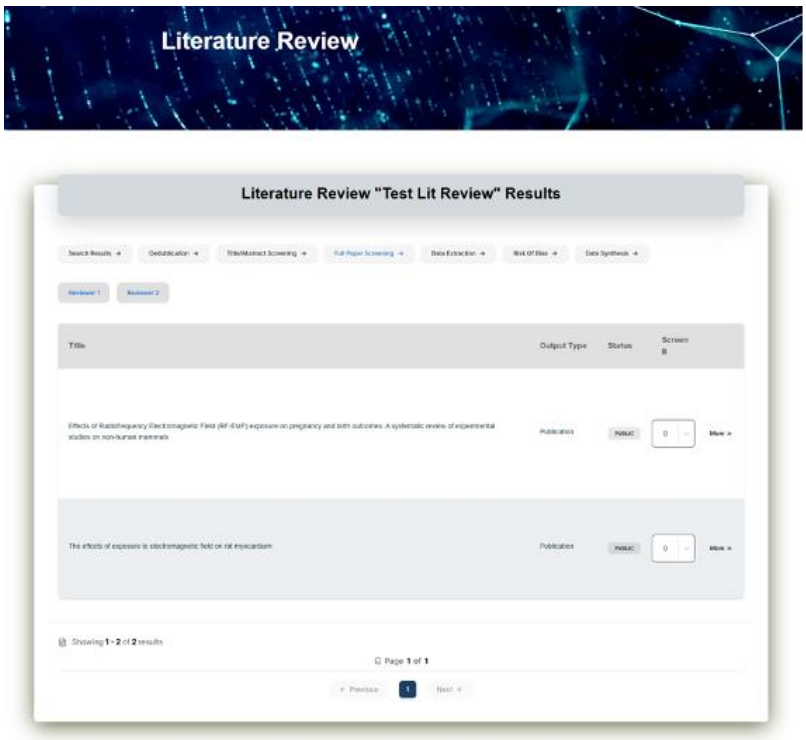

Figure 31: NIKH Full paper screening form of the literature review tool

As shown in Figure 31, the screening process includes two stages: Title/Abstract Screening and Full Paper Screening. During Title/Abstract Screening, users can act as "Reviewer 1" or "Reviewer 2" to categorize papers as irrelevant, relevant, or unclear. Papers deemed relevant or unclear proceed to Full Paper Screening, where they are classified as irrelevant, ineligible, or eligible for inclusion.

After finalizing the list of included papers, users engage in data extraction through a structured form, capturing critical data for review. The tool also features a Risk of Bias assessment form for evaluating included papers using methods like AMSTAR-2. Finally, the results are synthesized, incorporating insights from the bias assessment.

Criteria Classification
Yes
Partially Yes
No
No meta-analysis conducted
Overall Classification
H (High)
M (Moderate_
L (Low)
CL (Critically Low)

Table 3: NIKH Risk of bias assessment classifications

5.2 Risk assessment

The Risk Assessment tool within the NextGEM project will be used to systematically address hazards and risks associated with EMF exposures. The tool will assess the appropriateness of information for various stages of risk assessment, including hazard identification, exposure assessment, and risk characterisation. Its goal is to generate an evidence-based integrative risk assessment for EMF, ensuring a comprehensive understanding of potential health impacts. The tool will have an iterative process which involves feedback mechanisms and tackles the challenge of poor data quality by systematically analysing existing health studies. Through both quantitative and qualitative assessments, the tool will significantly contribute to NextGEM's mission of advancing knowledge and understanding in the field of EMF exposure.

The NIKH platform encompasses various capabilities essential for effective RA, including tools for literature insertion and data management. The Risk Assessment Tool's graphical user interface aim to provide users with a comprehensive and intuitive platform for evaluating and managing RF-EMF exposure risks. As users access this module, they will encounter a user-friendly interface that serves as the central hub for risk assessment activities Figure 32. The risk assessor (a scientist or a professional representing a competent authority) accesses the RA Tool section. The specific exposure characteristics and the appropriate health-relevant endpoints are entered. Depending on the quantity and quality of available data regarding exposure assessment, hazard identification, and characterisation, a quantitative or qualitative RA will run on the GUI. The RA Tool will provide an RA analysis, including advice for risk mitigation and risk communication as needed.

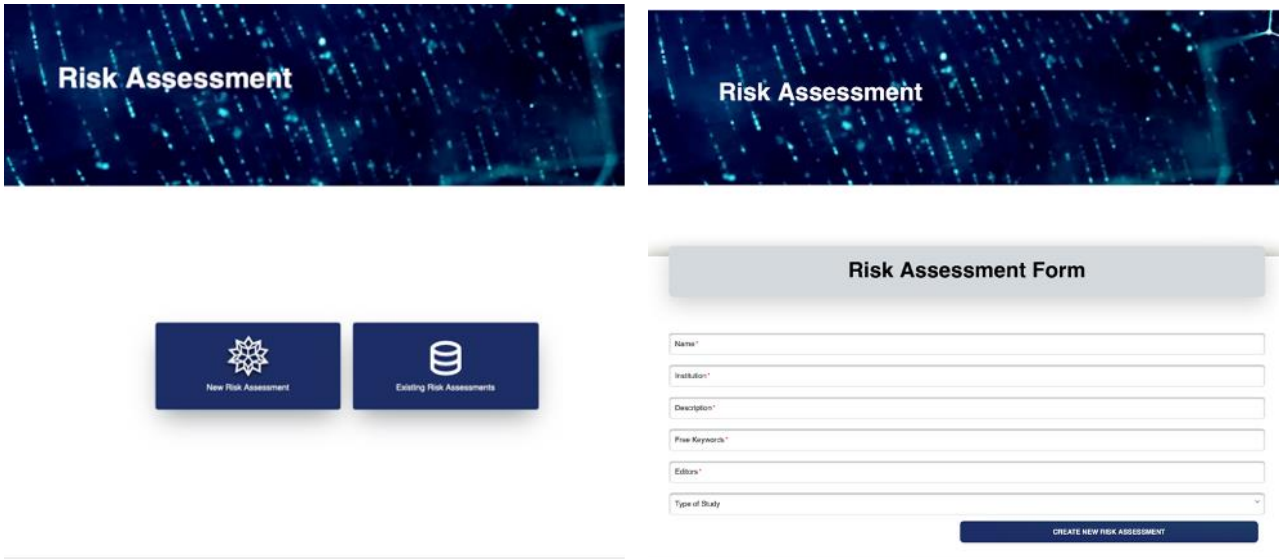

Figure 32: NIKH Creation of a new risk assessment

The literature review is the initial step in conducting a health RA using the NIKH platform. The RA tool facilitates access to literature from sources like Zenodo, EMF-Portal, PubMed, and Web of Science, integrating data from NextGEM and CLUE-H projects. Users can select sources, customize searches with specific criteria, and consolidate materials into a unified repository. NIKH enables efficient data extraction, combining processed data and metadata from experimental activities, exposure assessments, and other resources. Queries and search histories are saved for future reference, supporting comprehensive analyses. The platform incorporates guidelines from various authorities to enhance RA processes. A three-step inclusion/exclusion method ensures relevant sources are systematically screened and classified for eligibility. The tool adapts risk assessment models for EMF-specific analyses, incorporating data from studies, monitoring campaigns, and "grey literature." By correlating biological endpoints and dose-response relationships, it facilitates both qualitative and quantitative assessments. The final RA process synthesizes evidence from diverse studies, offering stakeholders detailed risk assessments, mitigation strategies, and reports. The current NIKH RA tool supports literature review and data extraction, with future versions to include additional functionalities for enhanced RA integration.

5.3 Data management

The following functionalities are intended for all the registered members of the internal scientific community interested in interacting with NIKH, uploading metadata records, making appropriate edits to records, and initiating data-sharing procedures in the NIKH platform. A user-friendly interface is provided to the NextGEM members, allowing them to actively contribute to growing the platform's content. Their involvement helps build a comprehensive knowledge base, providing a one-stop info source for all players in the electromagnetic exposure and health ecosystem.

When a user wants to upload a new data resource to the NIKH Platform, he/she should log into the platform, navigate to the "Input Data" section and select the relevant data type, as shown in Figure 33. The user can either select to upload descriptions of scientific data or to upload files.

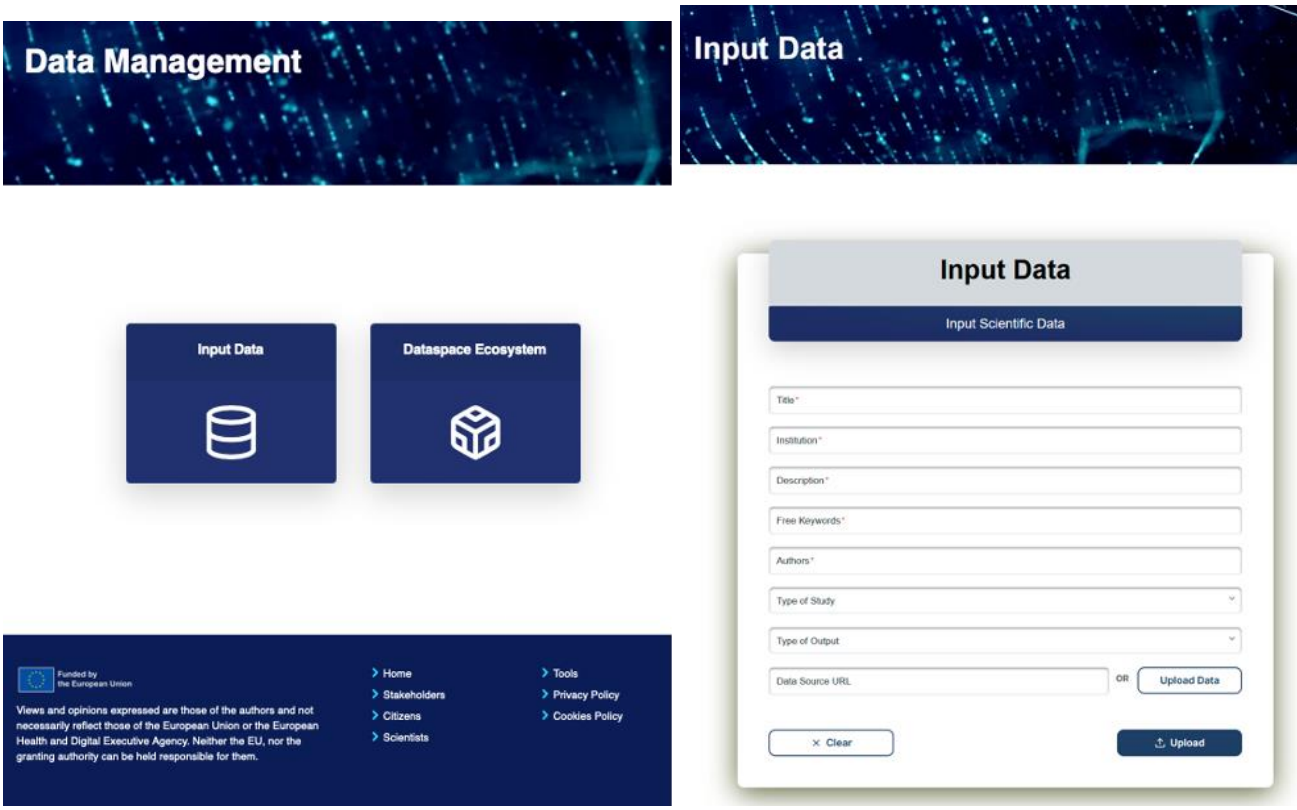

Figure 33: NIKH Data management main page and input scientific data form

It is possible for the user to either upload the data manually from the local user device by clicking the "Upload Data" button (bringing up a file browser window for selecting the associated file) or link to a file URL. To be able to upload the scientific data, the user should first provide the necessary metadata for the uploaded data, such as institutions, description, free keywords, data source URL, authors, etc. Once the metadata is provided and the data to be uploaded is selected, the upload can be triggered via a REST-API endpoint, which transmits the data for secure storage within the NIKH knowledge base by clicking the "Upload" button.

The user interface allows the NextGEM users to upload various forms of research output files, spanning from data files to presentation files. Given the diversity of research outputs, the platform allows users to upload a wide array of files, including raw data, documentation, images, videos and many others.

5.3.1 Knowledge base

The knowledge base is one of the primary components of the NIKH platform, supporting the functionality of the front-end pages and allowing users to upload and download data. The purpose Knowledge Base is essentially a large library providing end users with rich content of information related to the project's activities and outputs, such as public deliverables, publications, guidelines, policy recommendations, and articles related to the project concept.

One of the central components of the NIKH platform is the Metadata Manager, which manages and handles the lifecycle of the resource metadata that are registered on the platform. This lifecycle includes the creation of a new metadata record, the modification of an existing record, the removal of a record, and the retrieval of a list of metadata records or singular ones by their identifier. Additionally, the controller supports the extraction of metadata from a selected number of third-party repositories for registration in the platform. The latter function requires prior knowledge of the record's identifier so that it can be successfully retrieved. Finally, it should be noted that a subset of the fields of a record is mandatory for a successful registration.

5.3.2 Dataspace ecosystem

The NIKH Platform aims to seamlessly connect a variety of digital infrastructures existing in remote locations, enabling the interconnection of a wide variety of systems into a tightly integrated dataspace ecosystem. In addition, it establishes policies for trust and reliable data sharing and exchange based on the data owner's rules, ensuring data ownership and control. Finally, it leverages the collected data to provide unified services that various healthcare stakeholders can access and utilise heterogeneous data.

This section describes the implementation of the Ecosystem Module for accessing and managing distributed premises. The vast number of available data sources requires the development of a module capable of integrating, accessing, and acquiring the data related to these sources. The integration of data sources of different origins is a challenging task, and it is summarised to the following objectives:

- **Seamless remote location discovery**: The UI provides a user-friendly interface that allows user to identify and access various remote locations effortlessly. This includes features such as remote location preview, filtering and searching.
- **Unified data exploration:** The UI should facilitate users to explore and analyse data from different locations in a unified manner, facilitating seamless data exploration for a holistic view.

NIKH provides a REST API, exposed by the Controller, responsible for providing a unified interface for all internal services, converting the collected data into presentable structures. All available interfaces of the Controller mechanism and thus functionalities have been described in the previous Section. The Ecosystem is the input data component to the platform, as well as the retrieval component responsible for acquiring and present data to the final users, using the REST API. The main functionalities of the Ecosystem are summarized as follows and shown in Figure 34:

- **Asset**. Data or service that is being shared within the dataspace through EDC, defining the unit of sharing.
- **Assets' discovery:** Users are able to discover available assets, including its metadata, description, provider and associated data types.
- **Contract Offer.** Obligations and permissions associated with an Asset and acts as a starting point for negotiation process.
- **Contract Agreement.** Formal agreement between parties and results from a contract negotiation process.
- **Premises monitoring and discovery:** Users are able to monitor and discover all the available premises based on various criteria, including type, description, and location.
- **Participants management:** Authorized users can add, remove, and manage participants, ensuring proper authorization and access control over data access.
- **Policy.** Collection of rules that govern usage permissions or restrictions in data sharing.
- **Policy management:** Users are able to define and manage asset policies, ensuring compliance with data governance and sovereignty requirements.

The ecosystem interface within the NIKH platform offers a comprehensive overview of CLUE-H cluster dynamics, CLUE-H projects, and infrastructure. Within this interface, users are able to observe an overview about CLUE-H projects including their roles and contributions within the collaborative environment. A holistic view of their collective efforts is presented in terms of premises, tasks, objectives, activities, and new publications of each project. Through this interface the participants of the CLUE-H cluster are able to be up to date with the latest developments in CLUE-H projects.

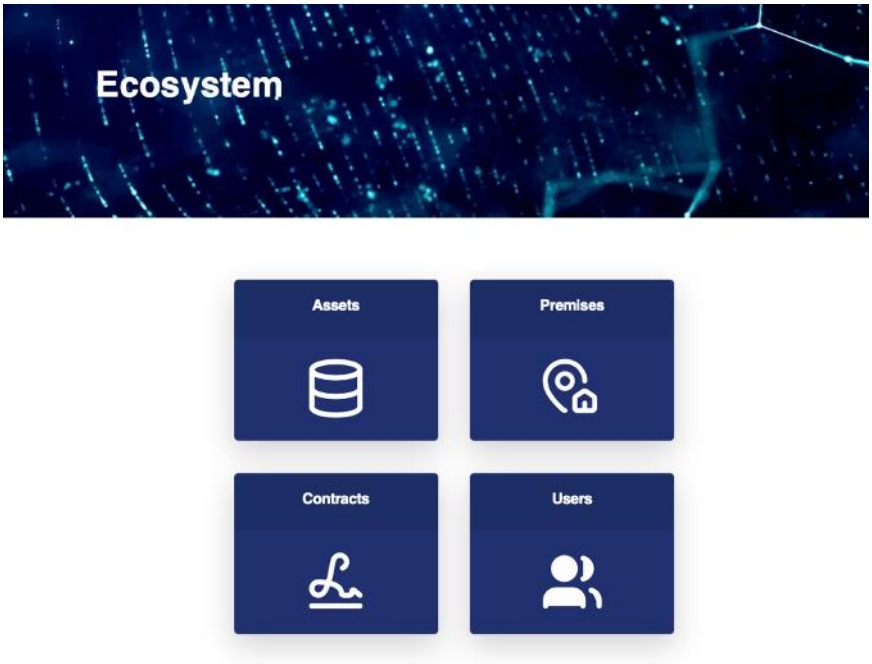

Figure 34: NIKH Ecosystem module interface

The technical infrastructure can be observed in terms of the physical infrastructure which is deployed at FORTH's main data center, and the virtual infrastructure that enables the platform to support multiple virtual machines (VMs). A repository of valuable resources is accessible under the asset menu option where users can access a diverse range of assets, including datasets, publications, and other relevant materials contributed by consortium members and collaborators. The contracts menu option introduces a structured approach to manage agreements and collaborations within the NIKH ecosystem. Users can engage in contract negotiations related to data access, usage policies, and collaborative initiatives. Finally, administrators can also adjust settings, manage their profiles and manage their users within the ecosystem interface.

In conclusion, the ecosystem interface within the NIKH platform offers a comprehensive overview of CLUE-H cluster dynamics, CLUE-H projects, and infrastructure. Within this interface, users are able to observe an overview about CLUE-H projects including their roles and contributions within the collaborative environment. A holistic view of their collective efforts is presented in terms of premises, tasks, objectives, activities, and new publications of each project. Through this interface the participants of the CLUE-H cluster are able to be up to date with the latest developments in all CLUE-H projects.

5.4 Modelling

The "Modelling" main page is given in Figure 35Figure 54. The "NextGEM Simulations" page is meant to present all simulation data obtained through the NextGEM project's research. This will include 5G Urban Planning, Human Exposure, Biological Models Exposure and the project's Case Studies. These tool components are to be completed by the final development cycle of NIKH.

In addition, there will be an "ERMES" modelling component. ERMES [12] (Electric Regularized Maxwell Equations with Singularities) [11] is an open-source finite element code written in C++ which implements a simplified version of the weighted regularised Maxwell equation method. This is done by allowing users to select the most stable formulation, producing well-conditioned matrices that can be solved efficiently with low-memory-consuming iterative methods.

[12] ERMES - Electric Regularized Maxwell Equations with Singularities, http://tts.cimne.com/ermes/software.html

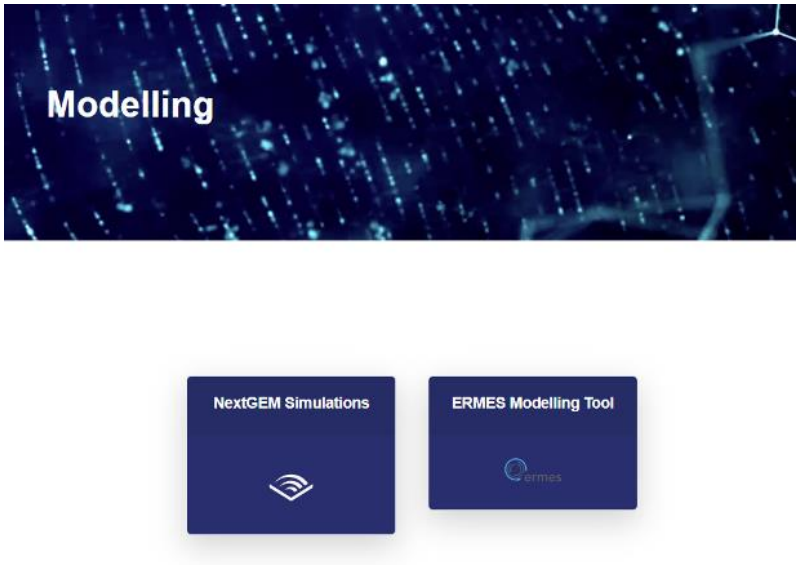

Figure 35: NIKH Modelling main page

A registered member will be able to access the ERMES modelling section trough the main menu of the internal side of the NIKH platform. The user will then be able to define the electromagnetic scenarios and parameters needed for retrieving simulation results. This will allow users to utilise a user-friendly GUI to run ERMES modelling that unifies all services provided under the NIKH functionality. The users will use this interface to analyse and interpret the results of the electromagnetic scenarios. This component is to be completed by the final development cycle of NIKH, and an envisioned version of what its page will look like is presented in Figure 36.

ERMES is an open-source product that eliminates licensing costs, making advanced simulation capabilities accessible to a broader audience. It is available for both Windows and Linux operating systems, featuring a user-friendly interface integrated into the pre- and post-processor GiD [13]. GiD handles geometrical modelling, data input, meshing, and result visualisation. ERMES is licensed under the open-source software 2-Clause BSD License, and its current version, ERMES v7.0, is available for free download from the Computer Physics Communications Program Library or the developer's website.

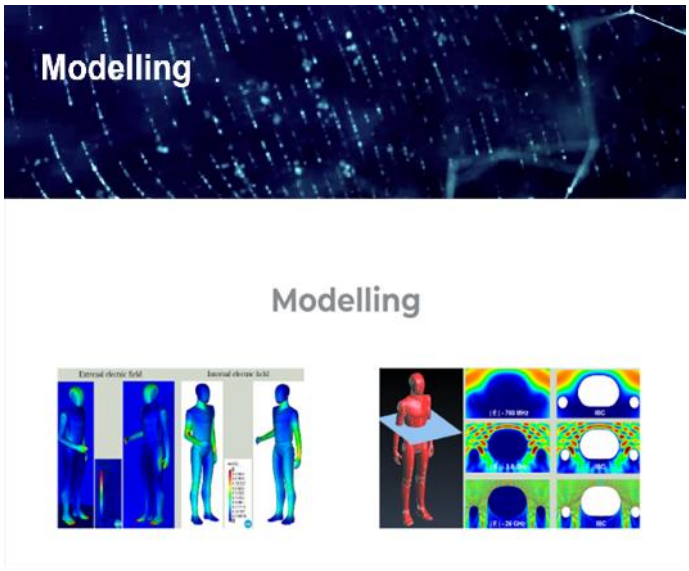

Figure 36: NIKH ERMES Modelling tool page (Envisioned)

[13] GiD Simulation Solutions, https://www.gidsimulation.com/

6 Mobile application

The incorporation of a mobile app alongside the NextGEM website aligns with the project's goal which is to ensure EU citizens' safety when employing existing and future EMF based telecommunication technologies. The safety of EU citizens in relation to EMF exposure can be ensured by providing citizens with the fundamental right of self-awareness of possible adverse health outcomes related to the choices particularly the usage of next generation telecommunication networks. This mobile app allows users to access information on-the-go, promoting self-awareness about EMF-related health risks. It's a user-friendly way to interact with NextGEM resources, aligning with modern preferences for mobile access. This not only enhances user engagement but also supports NextGEM's goal of ensuring citizen safety. This is one of the main objectives of the NIKH platform which can be enhanced with a mobile version which aligns with contemporary user preferences for on-the-go access to information. It enhances user engagement by providing a convenient and accessible solution for interacting with NextGEM resources.

A mobile app complements the NextGEM website by harnessing the unique capabilities of mobile devices. It not only provides an accessible user experience but also encourages active citizen participation, promoting awareness, and ensuring the well-being of EU citizens in the realm of EMF exposure (Figure 37). By offering enhanced accessibility, a mobile app provides users with the flexibility to access critical information on the go, fostering widespread awareness and engagement. This dynamic platform extends beyond traditional websites, delivering a personalized user experience through tailored features.

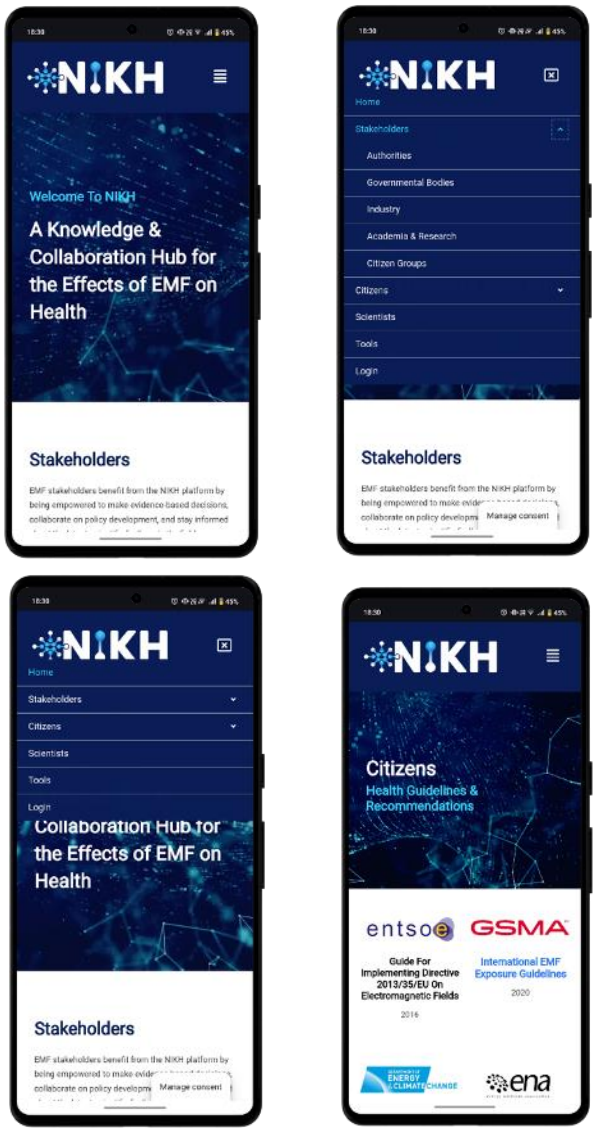

Figure 37: NIKH Mobile app UIs

The interactive nature of mobile apps offers additional channels for citizen participation through interactive information and multimedia elements. The mobile app serves as a conduit for continuous engagement, fostering a two-way communication channel between citizens and the project. Features like user feedback mechanisms enable citizens to report concerns, ask questions, and provide valuable insights. Additionally, integration with social media platforms amplifies the reach and impact of the project, as users can easily share information, findings, or concerns with their networks through their phones.

Since the NIKH Mobile Application is web-based, users can access it by simply navigating to the NIKH website via their mobile device's browser, making accessibility easier by removing the need to download any additional applications onto their mobile devices, regardless of the device operating system. The performance of this app will be similar to the web application running in a browser. However, it may not have the same level of features as the web application. Essentially, by identifying that the website is accessed by a mobile device, such as a smartphone, the regular version of NIKH is replaced with the mobile application. However, this means that access to the internet is required to use the mobile application. Any redesign to the NIKH application platform has to be reflected in the mobile application as well. Since the content is shared between the regular and mobile versions of NIKH, the overall visual identity of the mobile version will be readjusted if any major updates are made to the desktop-based version of the NIKH application portal. Finally, further user testing will be carried out to test the usability of the mobile version of NIKH and perform potential improvements to the UI to enhance user experience.

7 Conclusion

This report builds on the results of NIKH platform GUI, tools, dashboard and mobile application. Initially, the report identifies the objectives and scope of task T6.1 and defined the necessary approach to set up and design the NIKH platform of NextGEM. The business impact of the NIKH platform remains at the core of this project task and promises to ensure EU citizens' safety when employing existing and future EMF based telecommunication technologies. This goal directs all activities behind this task in an effort to provide a unified interconnection between the tools of the project. The work presented in this deliverable has been informed by collective research within the project including exchange of opinions in search of the right parameters to develop the appropriate solution.

In addition, this deliverable covers all aspects of the NIKH platform and in line with future developments and project objectives. It is presented a clearer vision of the services offered towards the development of a unified visualization through the NIKH GUI, providing further enhancements focused on refining and expanding the functionalities provided by the platform.

To that end, the deliverable showcases the ongoing work that is relevant to this task. More specifically, it includes the methodology as well as the interrelationship and mechanics behind the NIKH components. Significant progress has been made to refine and finalise the platform. The platform's architecture has been strengthened to ensure smooth integration with external services and datasets, while the external dashboard has been fully developed to provide user-friendly interfaces for different stakeholders. Security and privacy measures have been added to ensure compliance with GDPR and provide safe and secure interactions for users, as well as adding the required policies to the website. Additionally, a mobile version of the NIKH External Dashboard has been implemented, offering convenient access to its resources and features across different devices. Tools such as the Risk Assessment and Modelling tools remain to be fully implemented by the last development cycle of NIKH.

This deliverable marks the formal conclusion of Task "T6.1: Tools development, Dashboard and Mobile App" . With the next and final iteration cycle of NIKH due to be delivered by M38, any alterations or adjustments to support the development and final state of the NIKH components yet to be completed, such as the Risk Assessment and Modelling tools, will be done under the scope of Task "T6.4: Full system integration, release planning and dry-run testing".

8 References

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