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ECHO

ENGAGING CITIZENS IN SOIL SCIENCE:
THE ROAD TO HEALTHIER SOILS

Deliverable 4.1
"Report on identification and engagement of end-users of citizen science generated soil health data"

Co-funded by the European Union

UK Research and Innovation

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Short description of the deliverable

This deliverable summarises the results of Task 4.1, focused on identifying and engaging end-users who can benefit from citizen science soil health data of the ECHO project. It details the process of identifying stakeholders across sectors, including agriculture, urban planning, forest management, and ecosystem services, through a “snowball sampling” approach.

The deliverable describes the methodology for compiling and mapping end-users, highlighting collaborative efforts of project partners through an Excel matrix that records key data, such as users' sector, geographical location, motivations, and interests in soil health data. Insights from surveys and interviews highlight stakeholder preferences, challenges, and needs.

The analysis identifies priority areas for current and potential end-users, provides stakeholder mapping, and includes recommendations to optimise engagement strategies, ensuring the data’s relevance and alignment with ECHO’s goals.

Versioning and contribution history

Version	Date	Modified by	Notes
1	20/11/2024	Francisco Sanz, Adrián Gaibar (IBERCIVIS)	Draft version
2	28/11/2024	Claudia Cappello, Celine Laurent (UNIBZ)	Revision
3	05/12/2024	Riccardo Borgia (UNIBO)	Revision
4	06/12/2024	Hannes Pasanen (UEF)	Revision
5	12/12/2024	Tanja Mimmo (UNIBZ)	Revision
6	13/12/2024	Francisco Sanz, Adrián Gaibar, Alba Peiro (IBERCIVIS)	Final version

Foreword

Soil is a vital, yet often disregarded, resource that supports life on Earth by providing the foundation for agriculture, forests, and various other natural ecosystems. However, soil degradation is a growing concern around the world, and it can have severe consequences for our planet like reduced crop yields, increased greenhouse gas emissions, and decreased biodiversity. The ECHO project aims to prevent this by bringing together citizens and volunteer scientists from around Europe to work towards a common goal of protecting and preserving our soils, thus contributing to the transition towards healthy soils of the EU Mission: "A Soil Deal for Europe".

ECHO will generate new data on the health status of EU soils, complementing existing soil mapping and monitoring in EU Member States and Scotland, including the EU Soil Observatory (EUSO). The project will develop and deploy 28 tailor-made citizen science initiatives across EU Member States and Scotland, considering different land-uses, soil types, and biogeographical regions, as well as stakeholder needs. With 16 participants from all over Europe, including 10 leading universities and research centres, 4 SMEs, and 2 Foundations, under the coordination of the Free University of Bolzano-Bozen, ECHO will assess 16,500 sites in different climate and biogeographic regions to achieve its ambitious goals.

The project aims to engage citizens in protecting and restoring soils by building their capacities and enhancing their knowledge. Citizens will thereby not only actively contribute to the project's data collection but also promote soil stewardship and foster behavioural change across the EU. The ECHOREPO, a long-term open access repository with a direct link to the EUSO, will make the citizen science data available for exploitation not only by scientists but also by citizens, policy makers, farmers, landowners and other end-users, providing added value to existing data and other relevant soil monitoring initiatives. ECHOREPO will thus provide valuable information about the state of soil health in various regions, and help citizens make informed decisions about land use and conservation.

We believe that the ECHO project will have a significant impact on soil health and citizen engagement across Europe and become an important step towards protecting and preserving our soil for future generations. By working together, we can ensure that our soil remains healthy and productive, and that we continue to enjoy the many benefits it provides.

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1. Introduction

This deliverable explores the critical role of end-users within the ECHO project, a citizen science initiative committed to assess soil health across diverse European regions. This report explains the meticulous processes of identifying and engaging the stakeholders who will benefit most from citizen-generated soil health data. This deliverable combines methodological rigor with participatory strategies, highlighting the synergy between ECHO's scientific objectives and the practical needs of sectors such as agriculture, urban planning, forest management, and environmental policy.

This report begins by placing the importance of end-user involvement in the broader context of ECHO and the European Union's commitment to environmental sustainability (**Definition of end-users**). By underscoring the critical role of end-users in transforming citizen science data into practical insights, we provide a foundation for understanding how Task 4.1 aligns with the broader goals of the project. This background is crucial to frame the sections that follow, each of which builds on the understanding that effective soil health monitoring is not merely a scientific task, but also a cooperative effort among diverse stakeholders.

Methodology details the methodological framework used in Task 4.1, outlining a structured approach to identifying and engaging end-users through the "snowball sampling" technique, which has been widely recognised for building representative networks in complex stakeholder landscapes (*e.g., Goodman, 1961; Biernacki & Waldorf, 1981*). Snowball sampling, as originally described by *Goodman (1961) in The Annals of Mathematical Statistics*, has proven effective for generating robust networks in diverse and dispersed populations, making it particularly suitable for ECHO's goals of stakeholder engagement. This approach ensures a broad and representative stakeholder network, effectively addressing sectoral silos and geographical dispersion. The comprehensive end-user matrix captures key information on stakeholder motivations, data usage, and technology preferences, offering insights into their diverse needs.

Results present an in-depth analysis of the identified end-users. It examines their sectors, roles, and interactions with soil health data, categorising them by their specific needs and potential contributions to the ECHO (**4.1 Identification and classification of end-users**). By examining their preferences for data formats, visualisation tools, and platforms, this section offers a nuanced understanding of how citizen-generated data can be tailored for practical applications (**4.2 Survey results**, **4.3 Shared insights from interviews**).

Discussion presents key conclusions from surveys and interviews with end-users. It highlights the challenges they face in accessing and using soil health data, as well as their expectations in terms of data quality, accessibility, and support. This section highlights the dual focus of end-user engagement: addressing technical needs for seamless data integration, while fostering collaborative relationships to enhance the value and impact of citizen science initiatives.

Drawing from these insights, the report consolidates key information to pinpoint strategic opportunities for maximising the impact of ECHO. **Conclusion** outlines our findings and offers targeted recommendations for future engagement, stressing the importance of user-focused design, skill development, and ongoing communication with stakeholders. This section reflects the successful completion of Task 4.1, intended to integrate end-user perspectives into the next phases of the project and ensure that citizen-generated soil health data are both relevant and actionable.

Throughout this deliverable, we highlight the transformative potential of aligning citizen science efforts with the practical needs of end-users. By bridging the gap between data collection and application, ECHO not only contributes to advancing scientific understanding, but also supports the empowerment of communities, policy makers, and end-users.

2. Definition of end-users

Under ECHO, end-users are identified as a diverse range of stakeholders, including individual citizens, institutions and private companies, all with a potential interest in the application and results of soil health data collected by citizens. These users are defined as those who will directly or indirectly leverage the data generated to make informed decisions, guide research initiatives, or develop policy. End-users span different sectors, such as agriculture, environmental management, urban planning, forestry, and ecosystem services, each bringing a unique perspective and set of needs to the data generated by ECHO.

The role of end-users in citizen science goes beyond simply receiving data to actively participating in the process. As the primary beneficiaries of the data, end-users apply this knowledge in a variety of areas, using it for scientific research, environmental conservation, agricultural practices, and public policy support. They also play an essential role in the project's feedback loop, where their needs and perspectives help shape the structure, accessibility, and utility of the data. This approach, which aligns with end-user requirements from the outset, reinforces the relevance of ECHO, ensuring that the data collected is translated into practical and actionable results.

As part of its approach, ECHO has liaised with relevant soil health initiatives such as NATI00NS and PREPSOIL[1], leveraging their expertise and experience to identify end-users effectively. These collaborations have provided valuable guidance on stakeholder engagement, offering insights into best practices for building networks and tailoring data to user needs.

By incorporating insights from these initiatives, ECHO strengthens its ability to build a network of stakeholders who benefit from and contribute to soil health data, ensuring that the data is not only scientifically robust but also practically valuable for a wide range of applications.

Soil health data represents a fundamental resource for a wide range of actors, each applying it according to their priorities. In agriculture, it is essential for improving land management practices, optimising crop production, and maintaining soil sustainability. Government agencies and policymakers rely on this data to design and implement policies that promote sustainable land use, soil conservation, and resource efficiency. For urban planners and developers, soil quality data aids in green space planning, urban agriculture, and climate change resilience strategies.

[1] PREPSOIL website: https://prepsoil.eu/ and NATI00NS website: https://nati00ns.eu

Beyond these applications, environmental organisations and ecosystem service providers use accurate soil health data to assess and improve conservation efforts, habitat restoration, and biodiversity preservation. Academic researchers and scientific institutions use these data in broader studies on ecosystem health, climate change, and sustainable land use, linking soil health metrics to other environmental indicators. By providing a transparent and accessible repository of soil health data, ECHO not only improves the ability of these actors to make informed decisions but also aligns their work with regional and international sustainability goals, strengthening resilience to the environmental challenges of the 21st century.

Systematic identification and engagement of end-users is critical to ensure that data from ECHO are impactful, relevant, and accessible. Lessons learned from previous citizen science projects highlight the value of early and continuous collaboration with stakeholders to maximise the usefulness and relevance of the data. Task 4.1 builds on this understanding by adopting an iterative and structured approach to engage a broad range of end-users.

Using methods such as "snowball sampling", ECHO aims to map and connect with key stakeholders, ensuring that the project incorporates their preferences, data needs, and technical requirements from the outset. This approach fosters a network of actively engaged stakeholders who both contribute to and benefit from ECHO's ongoing work in soil health.

3. Methodology

3.1 Matrix development process

The matrix was developed as a tool to systematically identify and engage end-users within ECHO, enabling the mapping of stakeholders across various sectors. Its construction was carried out collaboratively, leveraging platforms such as Google Drive and Teams. Ibercivis led the initial design process, identifying the most relevant and useful fields to classify and organise end-users. Key fields included user group, stakeholder type, country and region, interest in ECHO, and interest for the end-user. These categories were carefully chosen to ensure the matrix captured essential information that would facilitate the alignment of the project with their needs. As shown in Figure 1, the matrix provides a general overview of the classification process and its practical application.

To standardise the data entry process and ensure consistency, a step-by-step guide was created to outline the process. Additionally, the essence of each field was explained directly within the Excel matrix to provide immediate context. Continuous support was offered to partners to address any questions or uncertainties regarding the data entry process, ensuring clarity and alignment throughout.

The data collected within the matrix was analysed descriptively, using absolute and relative frequencies to identify trends and patterns among end-users. This approach helped to contextualise the information and suggest actionable insights into stakeholder needs and preferences. By examining these distributions, the project highlighted the representation of various sectors and identified gaps for targeted engagement in future phases.

ECHO partner	End-User / Organisation name	User group (Group 1: agricultural soil health Group 2: urban and peri-urban green soil health, Group 3: ecosystem services and food quality initiatives, Group 4: forest soil health)	Stakeholder type (Quadruple-Helix)	Country	Region or city	Interest for end-user (focus areas and motivation)	Interest for ECHO (Description of relevant activities or projects in which the end-user is involved)
IBERCIVIS	Escuela Politécnica Superior - Universidad Zaragoza	Group 4: forest soil health	Academia	Spain	Aragón	Academic studies, students' thesis and final projects	Plenty of experience in scientific dissemination activities
IBERCIVIS	Departamento Agricultura, Ganadería y Alimentación - Gobierno de Aragón	Group 1: agricultural soil health	Government	Spain	Aragón	Constant need of environmental and agricultural updated data	Impact on policies
IBERCIVIS	Asociación de Jóvenes Agricultores (ASAJA)	Group 1: agricultural soil health	Civil Society	Spain	Madrid	Representing young farmers, fostering generational renewal, promoting agricultural entrepreneurship	Insights into soil health for sustainable farming and rural renewal.
IBERCIVIS	COAG (Coordinadora de Organizaciones de Agricultores y Ganaderos)	Group 1: agricultural soil health	Civil Society	Spain	Madrid	Defending interests of farmers, promoting agricultural social model, and family farming.	Insights into soil health impact on family farming and agricultural policies at national and European levels.
IBERCIVIS	Unión de Pequeños Agricultores y Ganaderos (UPA)	Group 1: agricultural soil health	Civil Society	Spain	Madrid	Defending the interests of small and medium farmers and livestock breeders, focusing on family farming and rural development.	Insights into soil health impacts on family farming, rural development, and agriculture-related policies at regional, national, and European levels.
IBERCIVIS	Unión de Cooperativas Agroalimentarias de Navarra (UCAN)	Group 1: agricultural soil health	Civil Society	Spain	Navarra	Support agricultural cooperatives in challenges such as climate change adaptation, generational renewal, talent attraction, and technological innovation.	UCAN is involved in projects related to agricultural innovation, environmental sustainability, and cooperative integration, making them relevant for understanding soil health impacts and contributing to sustainable agricultural practices
IBERCIVIS	Fundación Global Nature	Group 3: ecosystem services and food quality initiatives	Civil Society	Spain	Madrid	Conservation of natural habitats, wetland restoration, and sustainable agricultural practices.	Engaged in biodiversity and habitat conservation, relevant for implementing sustainable soil health practices and understanding ecosystem services.
IBERCIVIS	WWF España (World Wildlife Fund)	Group 3: ecosystem services and food quality initiatives	Civil Society	Spain	Madrid	Conservation of nature, biodiversity, and climate action, promoting sustainability across sectors.	environmental protection and biodiversity conservation, making them a valuable partner for soil health monitoring and sustainable land use practices under the ECHO
IBERCIVIS	Santander Capital Natural	Group 2: urban and peri-urban green soil health	Government	Spain	Santander	Enhancing urban biodiversity, restoring degraded areas, and promoting urban resilience in the context of climate change.	"Santander Capital Natural" focuses on the conservation of urban and peri-urban green spaces, involving citizens in nature conservation and improving urban quality of life. This aligns with ECHO's objectives of soil health and sustainability
IBERCIVIS	Fundación Entretantos	Group 3: ecosystem services and food quality initiatives	Civil Society	Spain	Valladolid	Promoting agroecology, extensive livestock farming, and sustainable food systems.	Active in collaborative approaches to sustainability and rural development, could provide valuable insights into the social aspects of soil health initiatives.

Figure 1: General overview of part of the end-user's matrix.

This structured approach ensured that the matrix was not only comprehensive but also user-friendly, allowing all partners to effectively collaborate and contribute to its development. The complete end-user matrix is available for download via this link, providing a comprehensive overview of user sectors, preferences, and geographic distribution. The structure of the matrix is also provided in **Appendix 1** for reference.

Once the matrix was constructed, ECHO partners populated it with data. Using their domain knowledge, prior networks, and expertise, partners identified initial end-users relevant to the project. These included stakeholders from sectors such as agriculture, environmental management, urban planning, and policy-making.

A "snowball sampling" technique was employed to expand the matrix further. Initial end-users identified through partner knowledge were asked to suggest additional relevant stakeholders. This iterative approach allowed the matrix to evolve dynamically, incorporating diverse profiles and broadening the scope of engagement.

The matrix was continually updated as new end-users were identified. Each entry included detailed information on sector classification, geographical location, and specific data needs, ensuring the matrix remained a dynamic and inclusive resource. This iterative and collaborative process ensured that all pertinent information was systematically captured, reinforcing ECHO's commitment to aligning project outputs with the needs of end-users.

3.2 Surveys

The survey was developed as a complementary tool to the end-user matrix, designed to gather additional qualitative and quantitative information on the needs, preferences, and expectations of the identified stakeholders. Hosted on the LimeSurvey platform, the survey was created and supervised by Ibercivis and was structured with questions aligned with the matrix fields, focusing on the practical use of soil health data. This alignment ensured consistency and complementarity between the two tools, enabling a cohesive approach to end-user engagement.

To ensure accessibility and inclusivity, the survey was translated into Spanish, Italian, German, Portuguese, Finnish, Greek, Polish, and English, covering all the official languages of the ECHO project member countries. This multilingual approach aims to encourage participation by reducing potential language barriers, thereby allowing stakeholders from diverse linguistic backgrounds to engage fully and share their insights.

The survey included questions designed to explore various aspects of soil data usage, such as typical applications, preferred formats, visualisation tools, platforms for accessing data, technical support needs, and the repositories commonly used by stakeholders. Additionally, it incorporated a question to identify potential new end-users through recommendations, facilitating the application of the "snowball sampling" methodology. Respondents were also asked to share their expectations regarding data quality and the functionalities that could enhance their experience with the ECHO platform. A complete list of the survey questions is included in **Appendix 2** for transparency and reference.

Survey data was also analysed descriptively, focusing on response distributions across stakeholder types and data usage fields. This analysis revealed common patterns, such as preferred data formats and visualisation tools, while highlighting underrepresented areas that may require additional attention in future project phases.

The first question of the survey asked respondents to provide their name and the name of their organisation: *Could you provide your name and the name of your organisation?* This question was critical for identifying and categorising end-users effectively within the ECHO project. By gathering this information, the project was able to link responses to specific stakeholder groups and sectors, facilitating a better understanding of the diverse needs and operational contexts of the participants. Furthermore, this information allowed for more tailored follow-up actions, such as targeted outreach, the development of sector-specific recommendations, and alignment of data outputs with the priorities of identified organisations. The ability to attribute responses to specific individuals and institutions was essential to ensuring that the project's engagement strategies were both relevant and impactful.

As part of the survey, a privacy and data protection statement was integrated to ensure full compliance with the General Data Protection Regulation (GDPR) (EU) 2016/679. End-users were informed that their personal information, specifically their name, would be handled with complete confidentiality and used solely for enhancing soil data and its application within the ECHO project. They were assured that their information would not be shared with third parties without their explicit consent. Additionally, respondents were provided with the rights granted by GDPR, including the right to access, rectify, or delete their personal data, and were directed to the Ibercivis Foundation (via rgpd@ibercivis.es) for any data-related requests. Participants were required to select one of the following options: "I accept" or "I do not accept," ensuring informed consent before proceeding with the survey.

Once finalised, the survey was strategically distributed online to a selected list of end-users identified through the matrix developed in Task 4.1. To broaden its reach and maximise participation, the survey was not only sent via personalised emails to these end-users but also shared through ECHO's social media channels and included in the JRC newsletter. This additional step, beyond the initial identification process undertaken by the partners, was specifically intended to broaden the range of interested stakeholders and enhance the visibility of the project's data. Respondents who completed the survey and were not previously registered in the matrix were added as new end-users, enhancing the database with additional perspectives and expanding its diversity.

The “snowball sampling” approach further expanded the scope of participation. Identified end-users were encouraged to recommend other professionals or communities who could benefit from using soil data. These recommended contacts were also added to the matrix and invited to participate in the survey, creating a dynamic and iterative engagement process.

ECHO project partners played a crucial role in ensuring the successful completion of the survey through continuous communication with stakeholders. Follow-ups were conducted to address any questions or technical issues, fostering detailed and meaningful responses.

3.3 Interviews

To complement the surveys, an interview script was created to guide in-depth discussions with selected end-users. Designed to build on key topics covered in the survey, the script included targeted questions aimed at capturing more detailed insights and recommendations. It sought to explore stakeholders’ specific challenges, data needs, and preferences while encouraging them to share new ideas for improving the practical application of citizen-generated soil health data. The complete list of interview questions is provided in **Appendix 2** to ensure clarity and transparency. This flexible approach allowed for deeper conversations and richer insights to inform the development of the ECHO platform.

The interviews were conducted both remotely and in person, depending on the availability and preferences of the participants. End-users were selected based on their relevance to the project, including survey respondents who expressed interest in further engagement, as well as key stakeholders known to have significant expertise or accessibility.

Discussions focused on stakeholders' specific needs and challenges in using soil health data, including potential improvements to data formats, visualisation tools, and integration with existing platforms. Additional topics included technical support needs, such as training resources and tutorials, to ensure effective data utilisation.

The qualitative insights gathered from these interviews were instrumental in identifying how ECHO’s citizen-generated soil health data could address existing gaps and better align with stakeholders' operational requirements. By fostering an interactive and iterative dialogue with end-users, the interviews strengthened the project’s capacity to deliver scientifically robust and practically relevant data solutions across multiple sectors.

3.4 Limitations and challenges

While the ECHO project has made significant strides in engaging end-users, Task 4.1 encountered several limitations and challenges that impacted the extent and depth of engagement achieved. One of the primary limitations was the difficulty in identifying and establishing consistent communication with end-users in remote or less digitally connected areas. While online surveys and digital communication platforms were used extensively, it is reasonable to assume that stakeholders in regions with limited access to reliable internet connections or digital tools may have been underrepresented, potentially leading to a gap in insights from these areas.

The diversity of end-users also introduced complexity in aligning the data outputs with varied sectoral needs. This challenge highlighted the need for flexible, customisable data formats that could adapt to a range of user requirements while maintaining consistency in data quality and usability.

A significant issue encountered was the disparity in response rates among identified end-users. While a considerable number of stakeholders were initially identified, response rates to surveys and project communications were lower than anticipated. Many end-users did not respond to outreach attempts, which limited the dataset on how these users interact with soil health data. Out of the **453** identified end-users, **225** responded, providing valuable insights but leaving a significant portion of stakeholders unrepresented in the dataset. In addition, 12 respondents did not consent to the requirements of the General Data Protection Regulation (GDPR), which limited the project's ability to include their comments in subsequent analyses. This made it difficult to obtain a representative sample of the population under study of end-users' needs and preferences, indicating a possible need for a more targeted engagement strategy in future phases of the project.

Additionally, varying levels of data literacy among end-users proved to be a barrier. Some stakeholders, especially those from smaller organisations or rural settings, faced challenges in analysing and interpreting complex soil health data. This highlighted a potential gap in resources and technical support, suggesting the need for accessible data visualisation tools or training resources to bridge the skill gap and facilitate data usage.

Finally, establishing a standardised approach to data sharing and confidentiality posed an ongoing challenge due to the different levels of familiarity and comfort with data-sharing protocols among end-users. Navigating these issues emphasised the importance of transparent, user-friendly agreements on data usage and privacy to foster trust and active participation among all stakeholder groups.

4. Results

4.1 Identification and classification of end-users

In total, **453** end-users were identified, representing a wide array of sectors and backgrounds. Of these, nearly **49.7%** completed the survey, offering critical insights into their data requirements, preferences, and involvement with soil health matters. Additionally, around **11.3%** of end-users took part in detailed interviews, providing deeper insights into the specific needs, obstacles, and expectations of key stakeholders.

The end-user groups were determined based on prior initiatives related to WP3 and consist of a broad range of participants, including farmers, land stewards, researchers, enterprises, policymakers, educators, and institutions engaged in soil management. These groups align with the specific domains outlined in the Grant Agreement, ensuring a comprehensive representation of stakeholders.

The identified end-users were classified into four main categories, each with specific and unique interests and applications for soil health data (Figure 2). Together, these categories cover the priority fields that ECHO aims to address:

- **Agricultural soil health (Group 1):** approximately **44.3%** of end-users fall within this group, including stakeholders like farmers, urban orchard users, decision-makers, and scientists who focus on sustainable agricultural practices, soil conservation, and productivity enhancement. Their engagement is vital as they interact closely with soil resources, allowing them to apply soil health data directly to their practices and research.
- **Ecosystem services and food quality initiatives (Group 3)**: representing **34.9%** of end-users, this group includes stakeholders invested in ecosystem functions, soil's role in biodiversity, and food quality. The group spans across environmental and public health sectors and involves consumer groups and other actors interested in the cross-sectoral impact of soil health on ecosystem services and food safety.
- **Urban and peri-urban green soil health (Group 2)**: representing **11.3%** of end-users belong to this group, which focuses on urban land use, green infrastructure, and soil quality in urban and peri-urban areas. This category includes community-based organisations, such as school groups, student associations, and senior activity groups, who contribute to the sustainability and environmental quality of urban landscapes.
- **Forest soil health (Group 4)**: representing **9.5%** of end-users, this group includes forest owners, local councils, advocacy groups for forest biodiversity, and organisations devoted to outdoor and forestry activities. Their involvement highlights the vital role of soil health in forest ecosystems, such as carbon storage and biodiversity conservation.

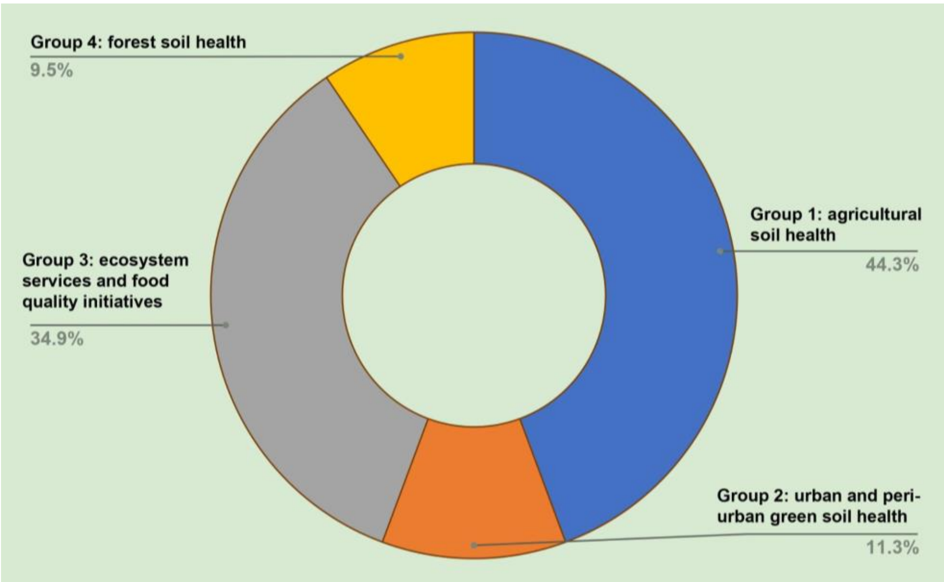

Figure 2: Donut chart of user groups.

To ensure balanced representation across social sectors, end-users were also classified according to the Quadruple-Helix model, encompassing academia, industry, government, and civil society. This classification aligns with ECHO's mission to promote cross-sector collaboration for soil health (*Carayannis & Campbell, 2009*).

The distribution by stakeholder type within each group is as follows (Figure 3):

- **Academia:** representing **34.6%** of end-users, this segment suggests a strong academic interest in soil data for research and educational purposes, with academic institutions and scientists seeking to analyse and validate soil health data, drive innovations in soil science, and conduct studies that support evidence-based environmental policy.
- **Government:** representing **26.8%** of end-users, this group encompasses public sector entities such as government departments and regulatory organisations that rely on soil health data for drafting policies, planning land use, and enforcing environmental standards.
- **Civil society:** representing **20.0%** of end-users, this segment consists of non-governmental organisations, community collectives, and citizen-led initiatives focused on fostering environmental sustainability, advancing soil health education, and raising public consciousness. This cohort plays a pivotal role in advocating for soil preservation, driving educational outreach, and championing sustainable practices.
- **Industry:** representing **18.6%** of end-users, primarily in the agricultural, environmental, and technology sectors, this group indicates a notable interest in utilising soil health data for commercial and industrial applications, such as precision agriculture.

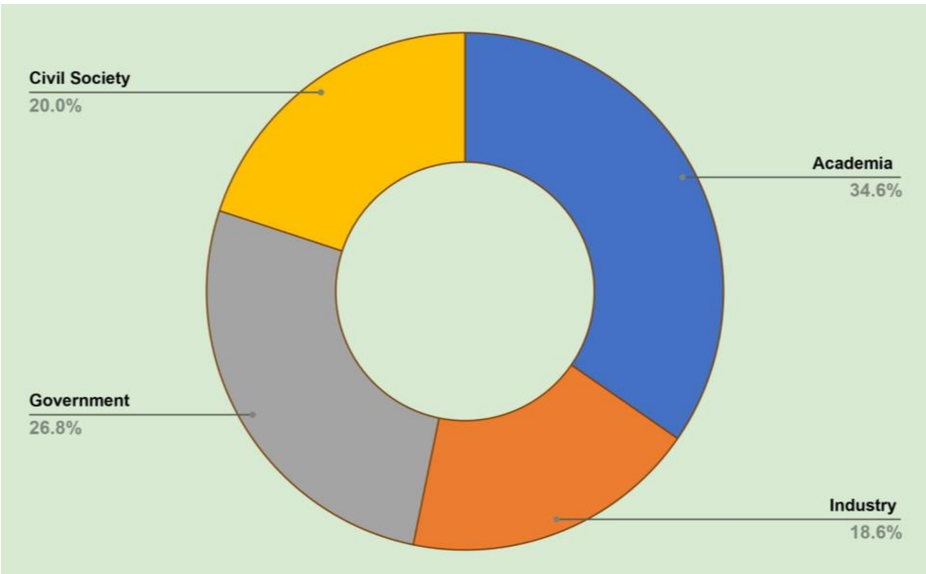

Figure 3: Donut chart of stakeholder types.

To better understand the relationship between stakeholder type and end-user group, we aim to analyse the dependence of one on the other. Figure 4 illustrates this distribution, providing insights into how different stakeholder types (academia, industry, government, and civil society) are represented across the identified user groups. The percentages shown reflect the relative proportion of responses from each stakeholder type within the total responses for each user group.

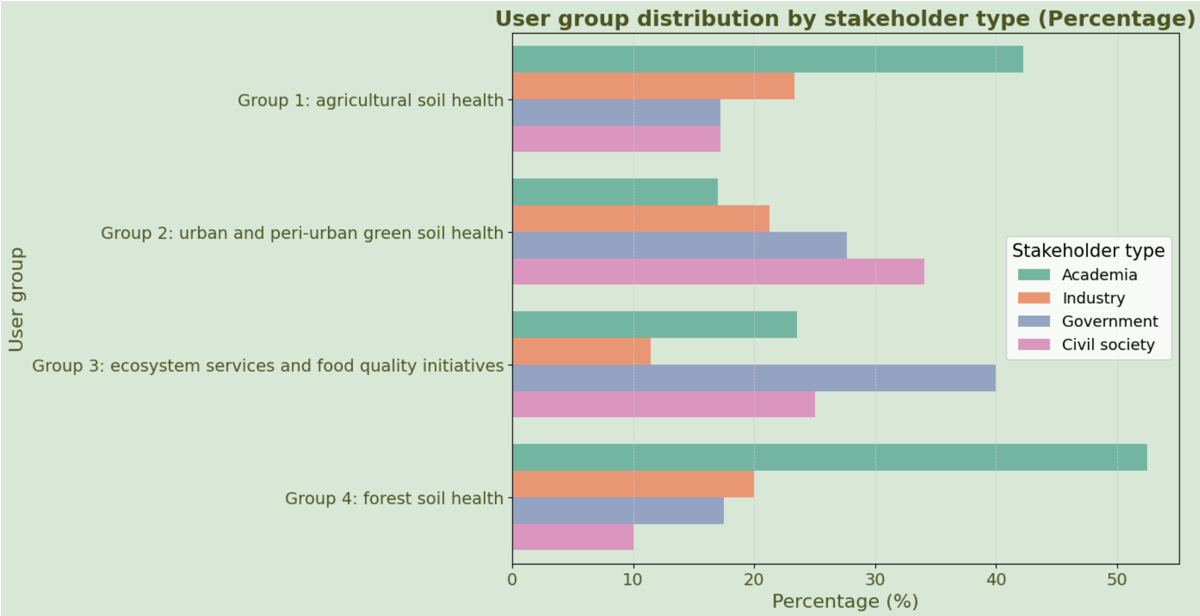

Figure 4: Horizontal bar graph of end-user distribution by groups and stakeholder types.

Analysing figure 4 suggests certain important trends in the distribution of stakeholder types within each end-user group. In **Group 1, agricultural soil health**, academia (**42.2%**) and industry (**23.3%**) are strongly represented, highlighting substantial interest in applied research and commercial uses, such as precision agriculture. In contrast, government and civil society both have an equal but smaller representation (**17.2%**), suggesting their involvement in applying agricultural soil data is less prominent.

In **Group 2, soil health in urban and peri-urban green** areas, civil society (**34.0%**) and government (**27.7%**) dominate, reflecting the group's emphasis on public management and urban green infrastructures. Industry (**21.3%**) and academia (**17.0%**) show smaller participation, indicating a more localised interest from public administrations and community organisations.

In **Group 3, ecosystem services and food quality initiatives**, government leads with the highest representation (**40.0%**), reflecting its prominent role in developing policies and managing resources related to soil health. It is followed by civil society (**25.0%**) and academia (**23.6%**), both of which contribute significantly through ecosystem preservation efforts, food safety initiatives, and research. Industry shows the lowest representation (**11.4%**), highlighting its comparatively limited role in this domain.

In **Group 4, forest soil health,** academia leads with the highest representation (**52.5%**), highlighting its pivotal role in biodiversity conservation and forest-related research. Industry (**20.0%**) and government (**17.5%**) follow, reflecting their contributions to forest-specific activities and policy development. Civil society (**10.0%**) has the lowest engagement, indicating a significantly more limited involvement compared to the other stakeholder types.

4.2 Survey results

All the information and results presented in this section are derived from the responses collected through the online surveys conducted with the end-users identified in the comprehensive Excel matrix developed during the ECHO project. It is important to note that the survey questions permitted multiple responses per participant; therefore, the graphs in this section reflect percentages based on the total number of responses rather than the total number of surveys completed. Consequently, the combined percentages for all options exceed 100%.

4.2.1 Common practices for soil data usage

The analysis of survey responses reveals varied practices for soil data usage across multiple sectors, such as agriculture, environmental policy, education, and community engagement. These insights stem from the question posed to end-users in the survey: **"For what purposes or goals do you typically use soil data in your activities or projects?"**.

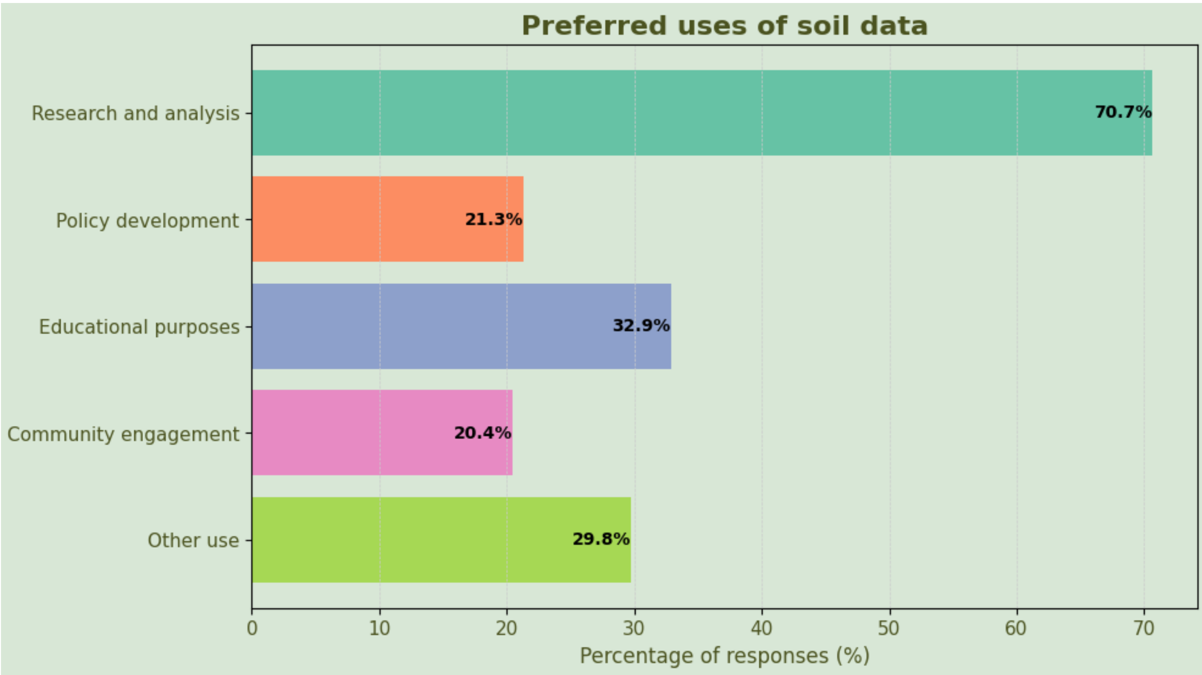

Figure 5: Horizontal bar graph of end-user common practices for soil data usage.

The main soil data applications reported by ECHO end-users span diverse fields, highlighting the broad range of needs and cross-sectoral interests in leveraging this information (Figure 5). The most prominent application, **research and analysis**, accounts for **70.7%** of responses, demonstrating a strong demand among academics, research organisations, and environmental consultancies. Soil data in this area is used to evaluate essential environmental parameters such as soil quality, biodiversity, carbon emissions, and soil degradation.

Educational purposes, accounting **32.9%** of responses, highlight the importance of soil data in fostering environmental awareness and sustainability education. This segment benefits from simplified data formats and visualisation tools, which make complex information more accessible and engaging for students and the public.

"**Other Uses**" comprises **29.8%** of responses and covers a broad spectrum of technical, educational, and commercial applications. These include agronomic consultancy, product development, environmental impact assessments, and soil fertility enhancement.

Policy development represents another important application, comprising **21.3%** of responses. Policymakers rely on soil data to inform land-use regulations, resource management, and conservation policies. Here, data accessibility and precision are paramount, as effective policy relies on accurate, accessible information that can guide land management practices on various levels.

Community engagement constitutes **20.4%** of the responses, reflecting how soil data empowers community groups, NGOs, and citizen science programs to involve local populations in conservation and restoration activities.

4.2.2 Preferred data formats and visualisation tools

End-users of ECHO show specific preferences for data formats and visualisation tools, driven by the need for efficiency, accessibility, and compatibility with various analytical platforms (Figure 6). These insights are based on the survey question posed to end-users: **"What format do you usually prefer for receiving soil data?"**.

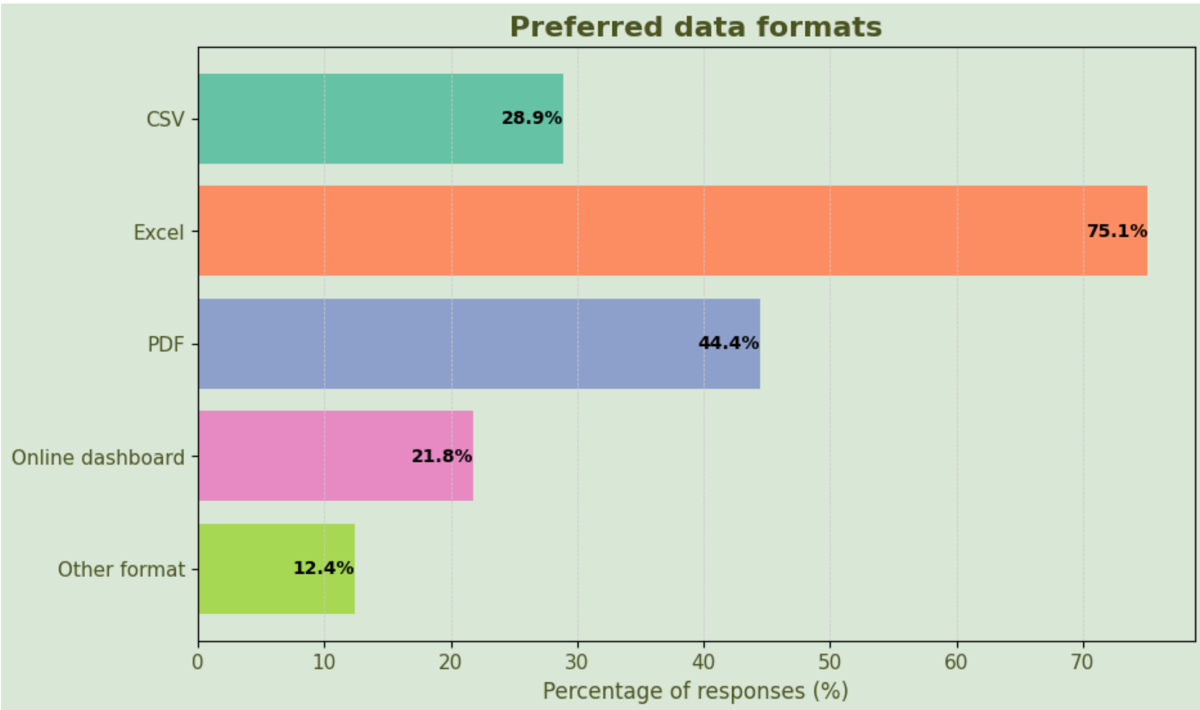

Figure 6: Horizontal bar graph of end-user data format preferences.

Among the preferred data formats, **Excel** stands out as the top choice, with **75.1%** of respondents indicating its use. This format is preferred for its flexibility in data manipulation and compatibility with standard analysis software, making it especially popular among researchers and technicians who handle large datasets for detailed analysis. **PDF**, chosen by **44.4%**, is popular for producing finalised, sharable reports in a professional format. **CSV**, preferred by **28.9%**, is valued for its simplicity and ease of integration with statistical software. Meanwhile, **21.8%** favour **online dashboards**, offering real-time access and quick insights without the need for extensive data processing.

Some end-users highlighted **specific needs** (**12.4%**) for GIS-compatible formats, such as Shape Files (shp) and GeoTIFF, essential for spatial data in environmental conservation, land-use planning, and detailed analyses. Geographic database files (gdb) and links to online resources were also frequently mentioned, highlighting the importance of interoperability for seamless system integration and ease of access. Additionally, stakeholders noted specific needs, including compatibility with operational records, such as tools for mapping or logging, to enable smooth transitions across platforms, particularly in agricultural and environmental applications. Other formats like raster files, JPEGs, and MS Access were also noted for generalised use, while PDFs and online services were mentioned for providing quick overviews.

These preferences are derived from the survey question: **"What types of data visualisations help you the most when analysing soil data?"**.

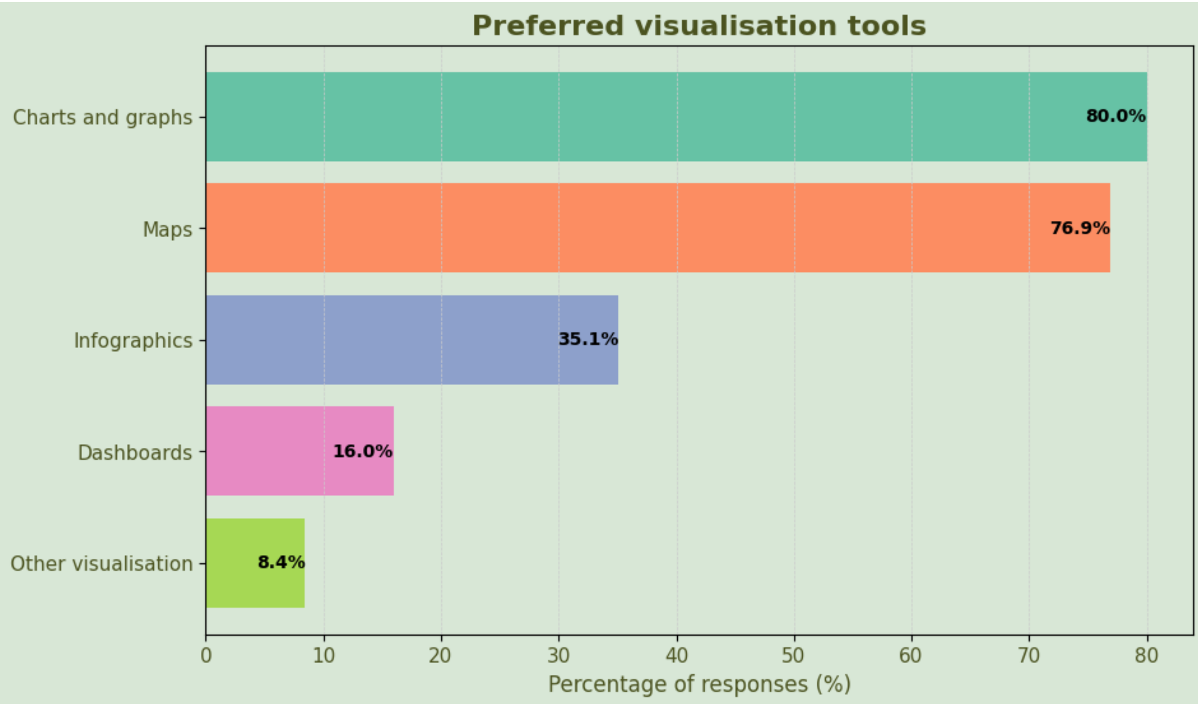

Figure 7: Horizontal bar graph of end-user visualisation tool preferences.

Regarding visualisation tools (Figure 7), **Charts and graphs**, preferred by **80.0%**, are valued for simplifying complex data and highlighting trends. **Maps**, favoured by **76.9%**, are crucial for spatial planning and environmental management. **Infographics**, chosen by **35.1%**, present technical information in an engaging, accessible format, ideal for education and outreach. **Dashboards**, preferred by **16.0%**, support real-time data interaction for immediate insights. Additionally, **8.4%** mentioned **other specialised tools**, like heat maps and borehole visualisations (e.g. GeoDin, AutoCAD), Excel, raw data tables, interactive visualisations, videos, animations, real images of soil profiles, turf as bioindicators, and microbiological analyses, highlighting the importance of clear classifications, user-friendly formats, and flexible options for diverse analytical needs.

4.2.3 Platforms and tools used for soil data access

The platforms and tools preferred by ECHO end-users for accessing soil data reflect the diversity in technical requirements, sector-specific needs, and data literacy levels among different user profiles. Each platform used is selected for its functionality, compatibility with data formats, and alignment with organisational workflows. This section analyses the platforms and tools currently in use, highlighting their relevance and applicability across sectors (Figure 8). These preferences are based on the survey question: **“What platforms or tools do you typically use to access and work with soil data?"**.

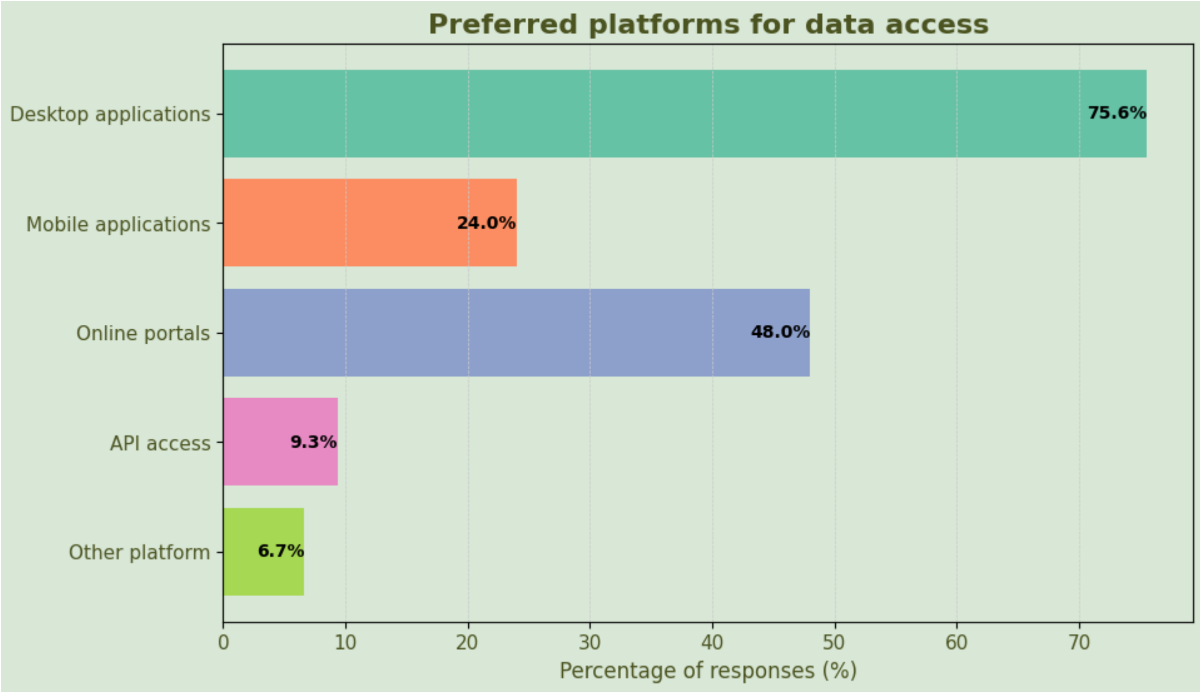

Figure 8: Horizontal bar chart of end-user preferences for soil data access platforms.

Desktop applications, preferred by **75.6%**, are widely used in academia, government, and consultancy, for advanced data manipulation, visualisation, and analysis, essential for handling large dataset and flexible analysis.

Online portals, preferred by **48.0%**, provide centralised access to updated data and long-term project tracking, supporting real-time monitoring and planning for environmental agencies, urban planners, and consultants.

Mobile applications, used by **24.0%**, are popular among field-based users, such as agricultural professionals and environmental NGOs, enabling on-site data collection and real-time decision-making in dynamic settings.

API access, chosen by **9.3%**, is essential for advanced data integration, enabling automated co-links to visualisation platforms and decision-support systems.

A smaller group (**6.7%**) use **specialised tools**, such as Geographic Information Systems (GIS), databases, and custom Excel solutions. GIS platforms, for example, are particularly useful for spatial planning and environmental impact assessments, providing geospatial insights into soil conditions. Additionally, local or regional platforms, such as the Environmental Atlas of Bavaria and the Soil Information System of Bavaria, are used for tailored regulatory and compliance resources. Other tools mentioned include RStudio, JRC BDAP, and RS, reflecting diverse approaches to accessing and managing soil data. Some respondents also noted using PDFs and bibliographic references for supplementary information.

4.2.4 Technical support needs

Survey results indicate that ECHO end-users require a range of technical support to maximise soil data usability, reflecting varying data literacy and technical needs across sectors (Figure 9). These findings are based on the survey question: **"What kind of technical support would make it easier for you to use soil data in your work or projects?"**.

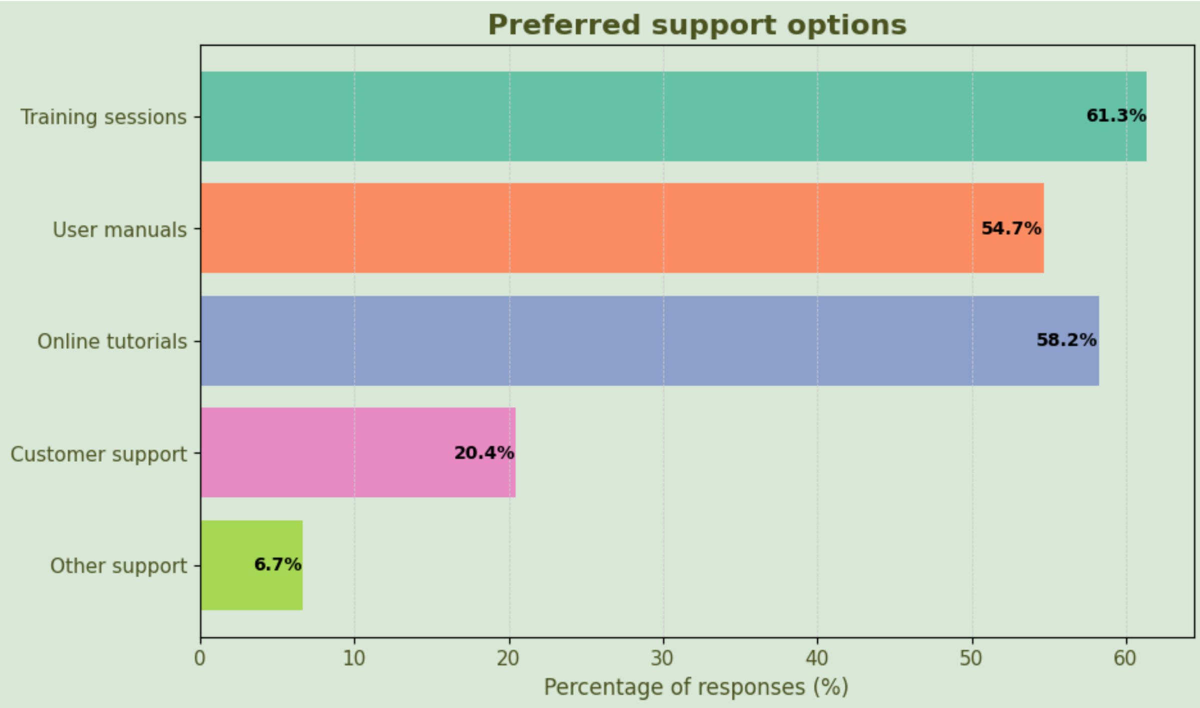

Figure 9: Horizontal bar chart of end-user preferences for technical support needs.

Training sessions, requested by **61.3%**, highlight strong demand for capacity-building resources to improve understanding and application of soil data.

Online tutorials (**58.2%**) and **user manuals** (**54.7%**) follow closely, and are also highly valued, offering accessible, self-paced materials. Online tutorials appeal to digital learners, while manuals provide reliable reference tools.

Customer support, cited by **20.4%**, highlights the need for direct, on-demand assistance to address unique or complex issues promptly.

The remaining **6.7%** mentioned **other specific support needs**, such as enhanced statistical tools, bioinformatics, improved data accuracy and geographic precision, and clearer metadata with methodological transparency, including units of measurement. Many expressed a preference for practical, hands-on exercises over theoretical instruction. Some also highlighted the importance of broader access to publicly available data and solutions tailored to their specific applications.

4.2.5 Preferred data repositories

ECHO end-users access soil data through various established repositories, vital for data collection, comparison, and analysis across research, policy, and community applications. This section analyses the most preferred repositories and their relevance to stakeholders needs (Figure 10). These findings are based on the survey question: **“What official data repositories do you currently use to access soil data, if any?"**.

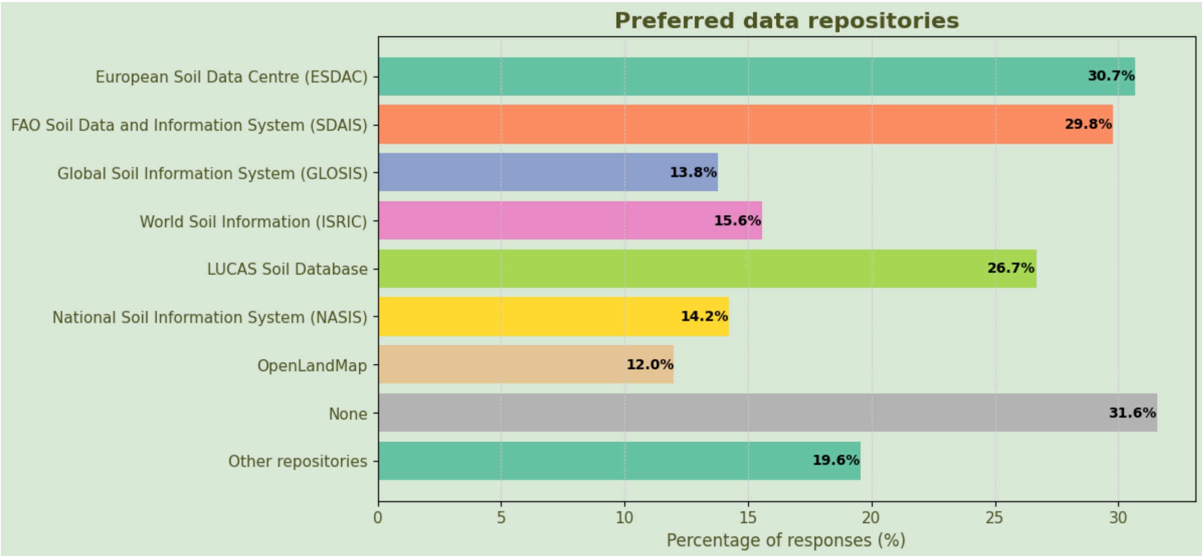

Figure 10: Horizontal bar chart of end-user preferences for soil data repositories.

The **European Soil Data Centre (ESDAC)** is the most utilised repository, with **30.7%** of respondents indicating its use. As a key EU resource, it provides detailed soil data essential for research, policy development, and land management, highlighting its importance among stakeholders.

The **FAO Soil Data and Information System (SDAIS)** is close behind, preferred by **29.8%** of respondents. This global repository offers standardised soil information critical for international and comparative research, making it a valuable tool for diverse applications.

The **LUCAS Soil Database**, used by **26.7%**, provides comprehensive EU data on land use and soil health, making it particularly useful for agriculture and environmental monitoring across the region.

Other repositories, reported by **19.6%** of respondents, include international databases like FOREGS Geochemical Baseline Database, ESDAC, SoilGrids, and EUSO dashboard, as well as regional and national portals for environmental and soil data. Public institutional websites and GIS-compatible platforms were also commonly noted, reflecting a reliance on accessible and tailored repositories for diverse needs.

World Soil Information (ISRIC), used by **15.6%** of respondents, offers standardised global datasets that support cross-border studies and comparative analyses.

The **National Soil Information System (NASIS)** follows closely at **14.2%**, providing tailored, country-specific data that aligns with local regulations and conditions, making it particularly valuable for stakeholders involved in national policy development and land management.

Global Soil Information System (GLOSIS), utilised by **13.8%**, serves as a vital resource for international research, offering datasets to facilitate comparative studies.

OpenLandMap, used by **12.0%** of respondents, addresses specific localised data needs, proving essential for stakeholders requiring alignment with national contexts.

Interestingly, **31.6%** of respondents reported not using formal repositories, suggesting gaps in awareness or accessibility to existing resources. Additionally, this highlights an opportunity for ECHO to enhance data literacy by promoting available repositories and offering tutorials, guidance, and tools to support their effective use.

4.2.6 In-depth analysis of survey responses

The analysis of the heat maps reveals key patterns in the relationship between various types of soil data usage and the preferred support tools, data formats, platforms, visualisation options, and repositories. These visualisations provide a clear and concise way of presenting complex relationships within the dataset, enabling the identification of trends and overlaps that might not be immediately evident in other formats. Heat maps are particularly useful for highlighting the intensity of preferences across categories, making them an effective tool for interpreting survey data and informing actionable insights for the ECHO project.

The data format heat map (Figure 11) compares data usage fields (e.g., research and analysis, policy development, educational purposes, and community engagement) with end-user preferences for specific data formats. Excel stands out as the most preferred format across all usage types, particularly in research and analysis (**47.1%**), educational purposes (**43.2%**) and policy development (**42.7%**). This highlights its role in enabling detailed data manipulation and compatibility with analytical tools.

PDF is prominently used in community engagement (**29.2%**) and educational purposes (**27.3%**), reflecting its utility in presenting polished and structured reports. Other formats, such as CSV (**20.2%** in policy development and **19.9%** in research and analysis) and online dashboards (**18.0%** in community engagement), cater to more specific needs, such as data export and interactive data access.

Regarding visualisation tools (Figure 12), the heat map compares types of soil data usage with end-user preferences for visualisation formats, such as charts and graphs, maps, infographics, and dashboards. Charts and graphs emerge as the most preferred tool for research and analysis (**41.2%**), highlighting their role in simplifying complex datasets and identifying trends. Maps follow closely, particularly in policy development (**38.4%**) and community engagement (**36.9%**), underscoring their utility in spatial representation and planning.

Infographics are notably used in community engagement (**22.5%**) and educational purposes (**22.1%**), reflecting their effectiveness in presenting data in an accessible and visually appealing way. Dashboards, while less favoured overall, maintain relevance in policy development (**8.9%**), providing real-time interactivity and immediate insights.

The platform heat map (Figure 13) compares data usage types with preferred platforms for accessing soil data. Desktop applications emerge as the most preferred platform for research and analysis (**47.8%**) and educational purposes (**44.4%**), reflecting their importance for detailed data analysis and traditional academic workflows.

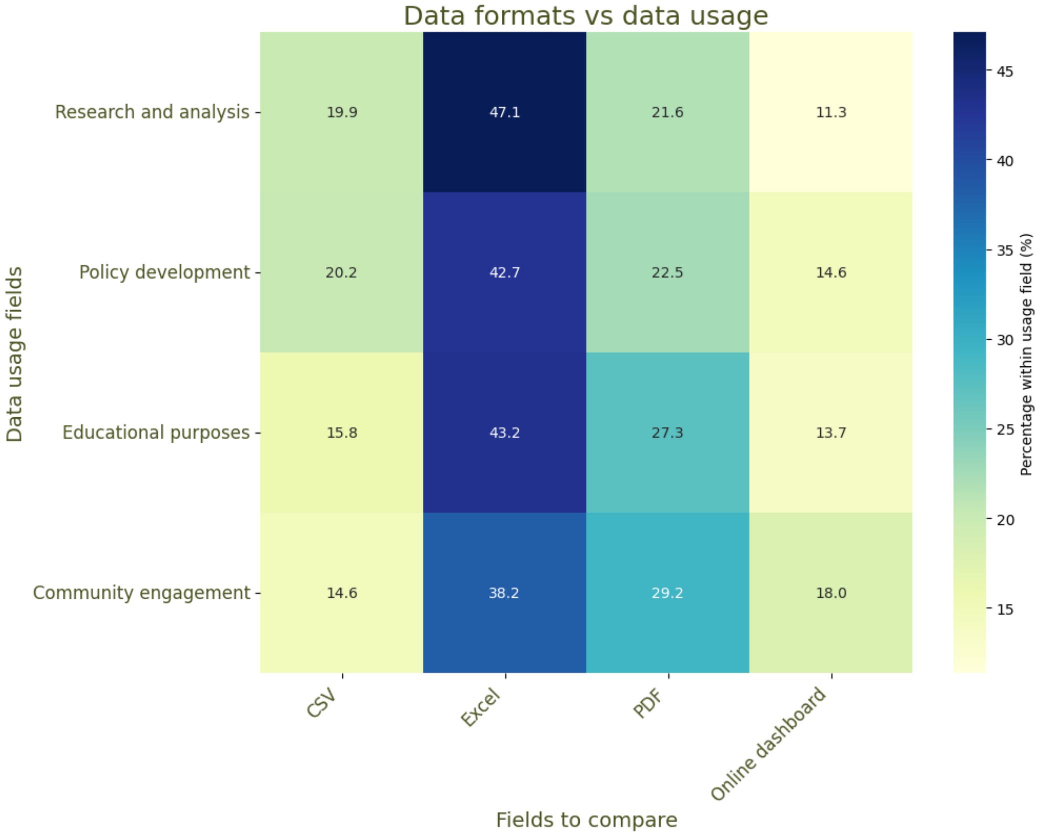

Figure 11: Heatmap of data formats vs. data usage.

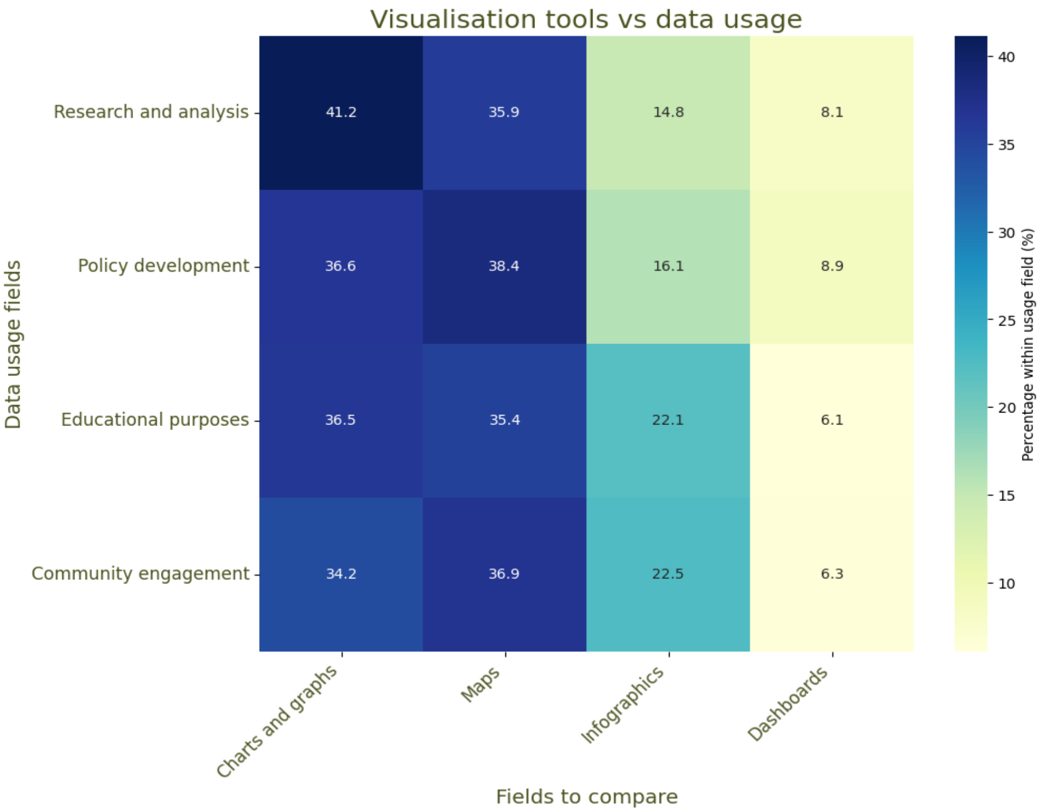

Figure 12: Heatmap of visualisation tools vs. data usage.

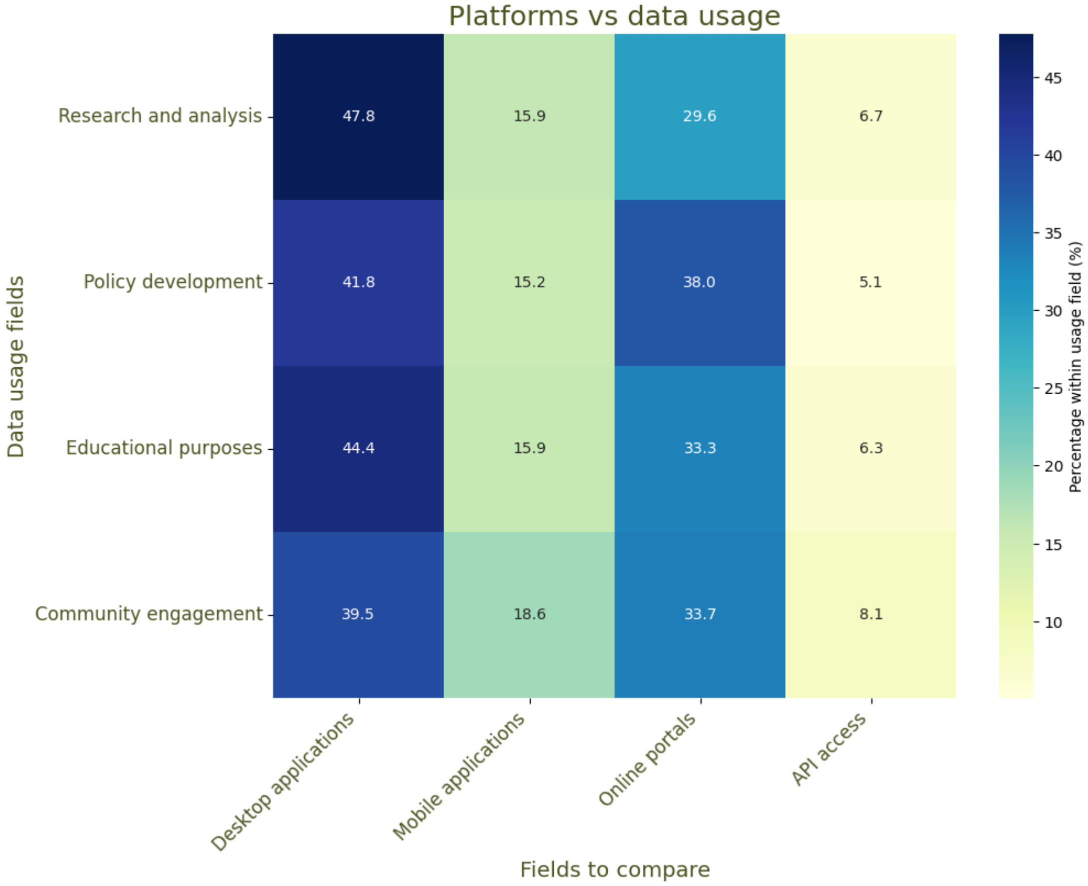

Figure 13: Heatmap of platforms vs. data usage.

Online portals show strong relevance in policy development (**38.0%**), indicating their utility for collaborative work and accessibility to broader audiences. Mobile applications have moderate use in community engagement (**18.6%**), suggesting their growing relevance in sectors requiring flexibility and field accessibility. API access is less frequently used overall, with the highest usage in community engagement (**8.1%**), highlighting a potential area for development to attract technical users or integrate with other systems.

In terms of support options (Figure 14), the heatmap compares types of soil data usage with preferred support mechanisms. Training sessions are the most significant for community engagement (**37.2%**), highlighting their role in building capacity and enabling effective participation in soil data projects.

Online tutorials emerge as a key preference for educational purposes (**33.1%**) and policy development (**32.7%**), reflecting their value as flexible and accessible learning tools. User manuals are consistently relevant across all data usage fields, with notable demand in research and analysis (**28.2%**), demonstrating their importance in guiding technical processes.

Customer support has the lowest demand overall, with its highest relevance in research and analysis (**11.5%**), indicating that while personalised assistance is less sought after, it still holds importance for complex data applications.

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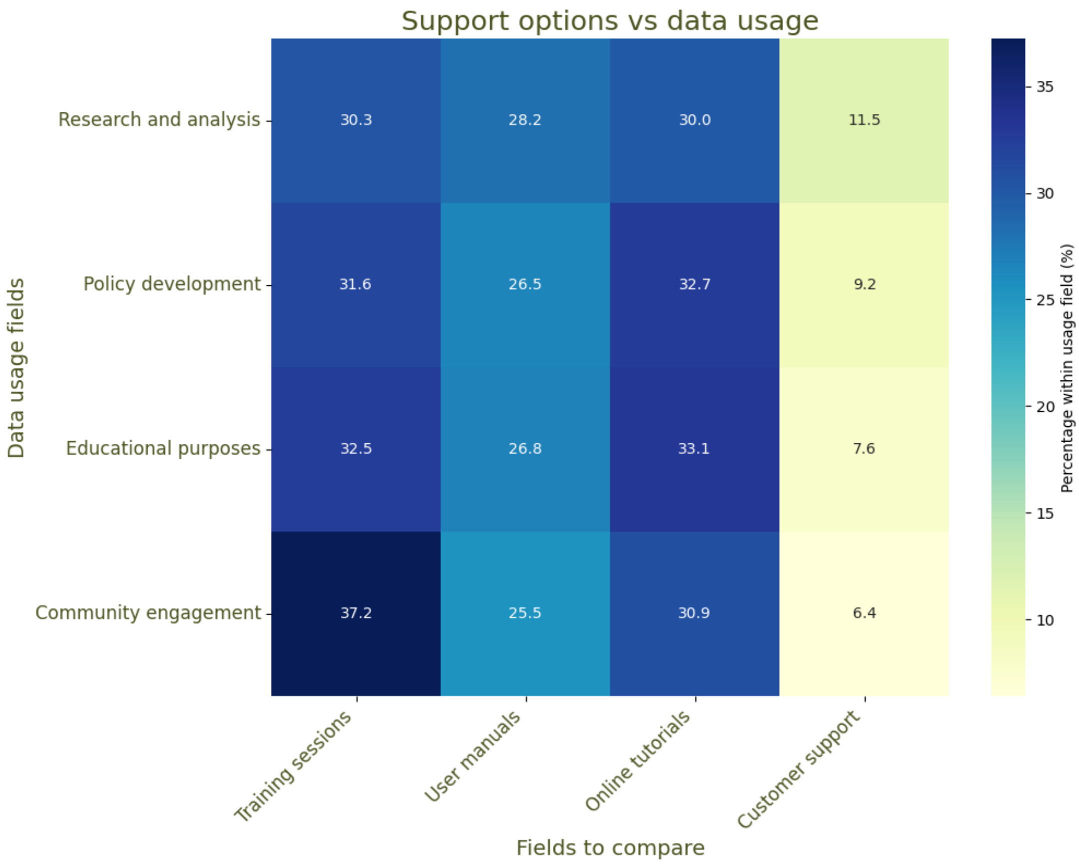

Figure 14: Heatmap of support options vs. data usage.

The repository heat map (Figure 15) provides a detailed comparison of data usage types and end-user preferences for soil data repositories. For research and analysis, the most utilised repositories are the European Soil Data Centre (ESDAC) (**22.6%**), LUCAS Soil Database (**20.0%**) and the FAO Soil Information System (**19.6%**), indicating their pivotal role in supporting detailed analytical work and research initiatives.

In policy development, the most utilised repositories are the European Soil Data Centre (ESDAC) (**22.6%**), LUCAS Soil Database (**20.4%**) and the FAO Soil Information System (**18.3%**), reflecting their importance in harmonised and cross-border policymaking and its relevance in decision-making processes and policy creation..

For educational purposes, the FAO Soil Information System (23.0%) and ESDAC (**20.9%**) dominate, indicating their suitability for teaching and learning activities. Similarly, community engagement highlights reliance on the European Soil Data Centre (ESDAC) (**23.8%**), underscoring their accessibility and role in promoting public awareness.

Other repositories, such as NASIS and ISRIC, exhibit moderate use, emphasising the need to maintain interoperability with these sources to maximise the utility and relevance of ECHO data across diverse applications.

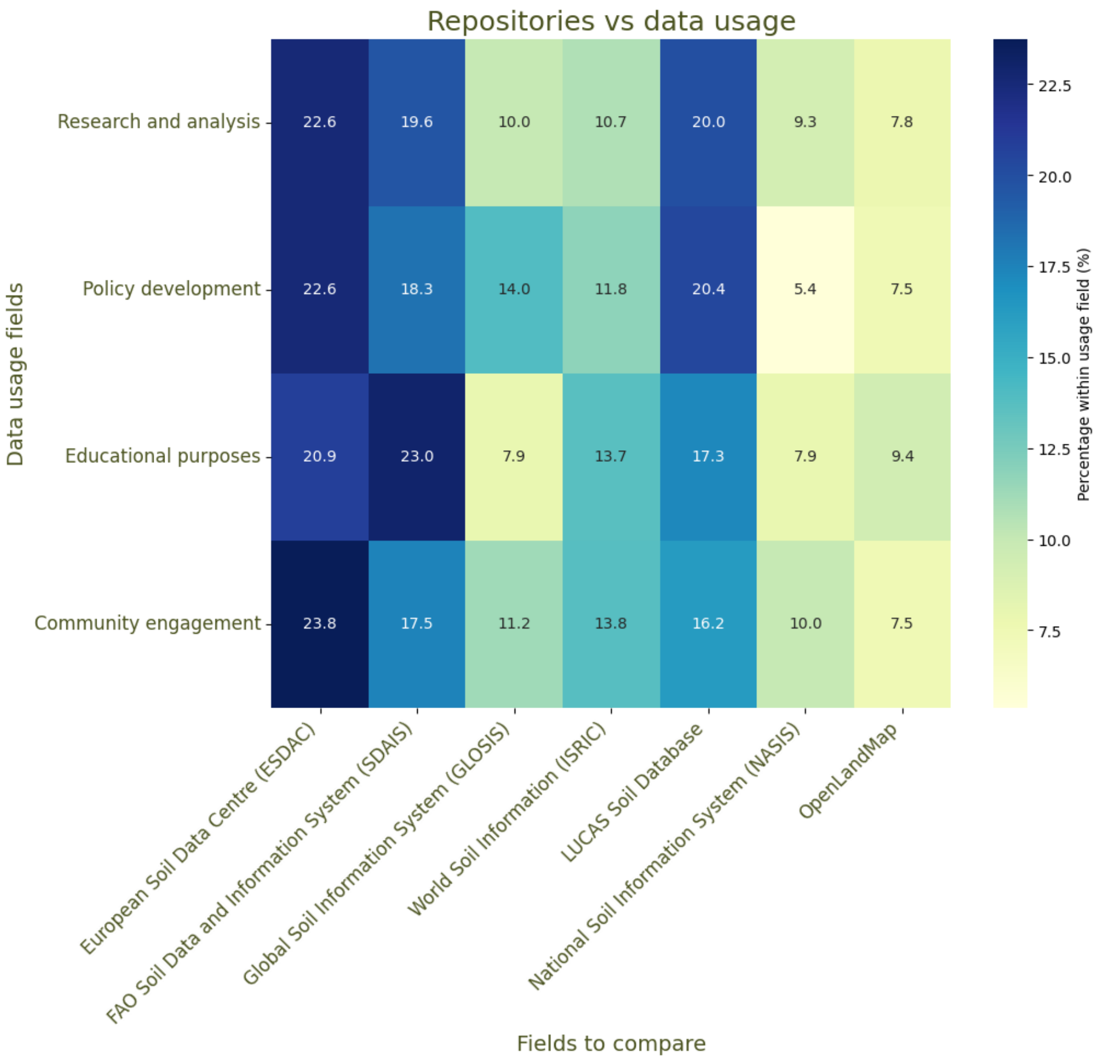

Figure 15: Heatmap of repositories vs. data usage.

The heat maps highlight distinct patterns in soil data usage preferences, showcasing fundamental connections between usage types and the tools, formats, and platforms most valued by end-users. These visualisations effectively capture key trends and provide actionable insights, supporting the ECHO project in addressing diverse stakeholder needs.

4.3 Shared insights from interviews

As part of Task 4.1, ECHO project partners, including Ibercivis, IFC.ID, PlantPress, RESOIL, UEF, UEX, UHOH, UNIBZ, UNIBO and USV, conducted **51 interviews** with a diverse range of end-users identified through the project's stakeholder matrix. This collaborative effort aimed to complement survey data by providing qualitative insights into the specific needs and preferences of stakeholders from academia, government, industry, and civil society. Each partner played a key role in ensuring a comprehensive and representative approach to engaging end-users, leveraging their regional expertise and networks to capture the diversity of perspectives across sectors. The classification of interviewees by stakeholder type is presented in Figure 16, which provides a visual breakdown of the distribution of interviews across the four main stakeholder categories.

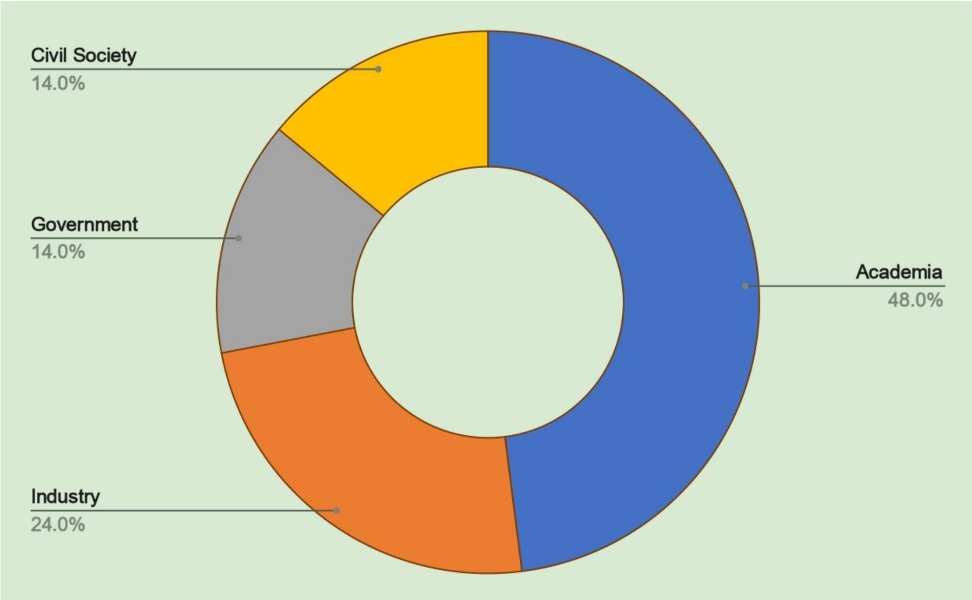

Figure 16: Distribution of interviews by stakeholder type (Academia, Industry, Government, Civil society)

Interviews with **academic stakeholders** highlighted the importance of accessible and scientifically robust formats such as CSV and Excel. These formats were seen as essential for data analysis, visualisation, and integration with research workflows. Georeferenced data emerged as a critical need, particularly for applications in local decision-making and policy development. Tools like maps, graphs, and interactive charts were identified as indispensable for teaching and research, while infographics were considered effective for communicating complex data to broader audiences, including non-specialists. One key insight emphasised the vital role of metadata in understanding soil variability across locations, underscoring the importance of contextual information like soil type. Academics also stressed the need for enhanced training resources, including video tutorials and user manuals, as well as reliable repositories with comprehensive metadata to maintain data quality and reproducibility.

Governmental stakeholders prioritised georeferenced and structured formats (e.g., Excel, PDF) to support practical decision-making in urban planning, agricultural management, and environmental conservation. Visualisation tools, particularly maps and charts, were regarded as essential for spatial analysis and effective communication with varied audiences. To address usability challenges, government stakeholders frequently called for GIS training and online tutorials. They also advocated for simplified metrics, such as traffic-light indicators, to make complex datasets more accessible for local policymakers. A recurring need was the development of centralised repositories offering multi-tiered information and metadata to ensure alignment with policy and operational objectives.

Industry stakeholders focused on integrating soil data into existing workflows to advance precision agriculture, sustainability practices, and business decision-making. Preferred formats such as Excel, CSV, and APIs were considered crucial for enabling seamless interoperability with digital systems. While geospatial layers and graphs were valued for visualisation, raw data was often preferred for advanced analytics and custom modelling. Mobile applications were noted as particularly useful for fieldwork, while web-based platforms facilitated the integration of soil data with other key variables such as weather patterns and biodiversity indicators. Industry representatives underscored the importance of GIS training and access to reliable repositories, as well as targeted case studies to demonstrate the practical value of soil data in industry settings.

Civil society stakeholders placed a strong emphasis on user-friendly formats such as Excel and PDF, recognising their accessibility for grassroots mobilisation, sustainability initiatives, and educational projects. Maps and infographics were especially appreciated for engaging non-expert audiences and fostering broader awareness. Although desktop and mobile platforms were commonly used, limited familiarity with formal data repositories was observed. Civil society stakeholders highlighted the critical need for technical support, including accessible tutorials and flexible training sessions. They also stressed the importance of fostering collaborations with educational institutions, local governments, and community groups to amplify the societal impact of soil data. Simplified, actionable insights were seen as key to enhancing public awareness and engagement with soil health.

Cross-cutting insights reveal recurring themes across all stakeholder groups. Flexible and accessible formats such as CSV, Excel, and PDF were universally preferred for their compatibility with analytical tools, while georeferenced data was particularly prioritised by academia and government. Industry stakeholders emphasised APIs for digital workflow integration, while civil society valued simplified formats for community-based initiatives. Visualisation tools, including maps, graphs, and charts, were widely appreciated, with geospatial tools frequently mentioned for spatial analysis. However, civil society often noted a preference for simple and intuitive visualisations to engage non-expert audiences effectively.

Some participants across groups highlighted limitations in existing visualisation tools, particularly regarding access to raw data for advanced analytics or the availability of simplified solutions for non-expert use. Training resources, including GIS training, video tutorials, and user manuals, were consistently identified as critical needs across all stakeholder groups. Several interviewees called for centralised repositories with multi-tiered information and comprehensive metadata to improve data integration and interoperability

5. Discussion

The findings from both the surveys and the interviews contribute to comprehensively understand end-user needs and preferences, shedding light on both sector-specific demands and overarching requirements. These results identify critical areas of focus for the project and provide actionable insights for future development, ensuring alignment with user expectations and broader project objectives.

The classification of end-users in ECHO underscores the diversity of stakeholders engaging with soil health data. By organising users into **distinct groups**, such as agricultural soil health, urban and peri-urban soil health, ecosystem services, and forest soil health, the project has effectively addressed different data requirements and operational contexts. The integration of the Quadruple Helix model (academia, industry, government, and civil society) further illustrates the multidimensional nature of soil data applications and the cross-sectoral opportunities for collaboration. This classification also allowed the project to identify specific gaps, such as the underrepresentation of certain sectors, which can guide targeted engagement in future efforts. This approach enables ECHO to tailor its tools, services, and communication strategies to meet the specific needs of each group, ensuring that all stakeholders are adequately represented and supported.

Survey responses offer significant insights into how end-users interact with soil health data, including their preferred formats, platforms, and technical support needs. These findings underpin ECHO's strategy to deliver practical, user-focused solutions, enhancing the utility of citizen-generated data across sectors. The survey also confirms the versatility of soil health data, which is applied to scientific research, policy development, educational initiatives, and community engagement. For example, the strong focus on research (**47.1%** of respondents prioritised Excel as a data format) underscores the importance of providing high-resolution data formats tailored for analysis, while policymakers require clear, actionable datasets to inform regulatory frameworks**.** By capturing the specific practices of stakeholders, ECHO is well-positioned to adapt its offerings to meet these varied demands.

A user-centred approach to data presentation is helpful, as highlighted by end-users' preference for formats such as Excel, CSV, and GIS-compatible files like shapefiles and GeoTIFF. These formats ensure compatibility with analytical tools and workflows, enabling users to manipulate and integrate data efficiently. Visualisation tools, such as charts and maps, are also pivotal in simplifying complex datasets and enhancing interpretability, particularly for educational and outreach purposes. ECHO must continue to prioritise these formats while exploring innovative visualisation options that address the unique needs of educators and policymakers. For instance, enhancing dashboard functionality for real-time data visualisation could better serve community engagement and environmental monitoring.

The analysis of platform preferences reveals a clear demand for adaptability in data access. Desktop applications and online portals remain essential for research and analysis, while mobile applications and APIs represent areas for growth, particularly for field-based users and younger, tech-savvy audiences. By addressing these preferences, ECHO can ensure interoperability across platforms, fostering seamless integration with existing workflows and enhancing the accessibility of soil health data. This aligns with the project's commitment to providing inclusive, user-friendly tools for diverse technical and operational needs.

The demand for structured training sessions, user manuals, and online tutorials highlights the importance of accessible and practical support resources. For instance, **31.6%** of respondents indicated that they did not use formal repositories, underscoring a potential gap in data literacy. To bridge this gap, ECHO should prioritise the development of user-friendly training materials and real-time assistance tailored to underrepresented groups. These efforts will empower end-users to effectively utilise soil health data, bridging gaps in data literacy across sectors.

The preference for established repositories such as the European Soil Data Centre (ESDAC), the FAO Soil Information System, and LUCAS Soil underscores the importance of maintaining interoperability with widely used data sources. By aligning with both regional and international standards, ECHO can maximise the relevance and applicability of its data, supporting comparative analyses and policy development at multiple levels. For example, integrating soil health data with other environmental datasets, such as climate or hydrological information, could enhance its practical utility for stakeholders engaged in cross-sectoral projects.

While the survey results and heatmaps provide useful insights, several opportunities for improvement have emerged. These include enhancing mobile and API-based access to support on-the-go data usage, integrating soil data with broader environmental datasets to provide a holistic view, and tailoring support materials for diverse user groups. Addressing these areas will ensure that ECHO remains a flexible and comprehensive resource for its end-users, strengthening its relevance across sectors.

The surveys and interviews conducted in Task 4.1 were designed to capture general and specific insights into the needs and preferences of end-users regarding soil health data, rather than focusing directly on links to certification schemes, land-use planning, or policy strategies. However, the findings provide a crucial foundation for addressing these areas in future project phases. By identifying stakeholder needs and challenges, ECHO has taken an initial step towards aligning its outputs with policy-relevant initiatives and decision-making processes. For instance, the alignment of survey findings with stakeholders' demand for actionable data formats highlights a clear pathway for incorporating citizen-generated data into policy frameworks. This deliverable lays the groundwork for developing targeted tools and guidelines, enabling the integration of citizen-generated soil data into certification schemes, land-use planning, and practical frameworks for landowners, ensuring that future deliverables remain user-focused while advancing towards more specific and impactful applications.

The interviews revealed both shared priorities and distinct challenges in the use of soil data across diverse stakeholder groups. Common needs, such as flexible data formats, effective visualisation tools, and robust technical support, point to opportunities for unified strategies that could maximise impact. At the same time, addressing specific gaps, such as the industry's focus on digital workflows, civil society's call for greater public engagement, and academia's emphasis on metadata and training, will be key to tailoring solutions for each group's unique requirements. By addressing these challenges, the ECHO project can better align its outputs with end-user expectations, enhancing the scientific, societal, and policy relevance of its soil data initiatives.

Finally, the findings suggest broader implications for the future of citizen science in soil health monitoring. By addressing the identified gaps and aligning with user priorities, ECHO has the potential to set a benchmark for how citizen-generated data can drive cross-sectoral collaboration, foster environmental stewardship, and inform sustainable land management practices. By ensuring that the recommendations reflect the key insights from surveys and interviews, ECHO can further enhance its impact on stakeholders, building a robust foundation for future phases of the project. This approach will enhance the credibility and impact of the project, ensuring that the data generated is both scientifically robust and practically valuable.

6. Conclusions

The ECHO project has successfully gathered valuable insights into the preferences and needs of end-users, providing a clear set of priorities for improving data accessibility, usability, and relevance. By addressing these needs—such as delivering flexible data formats, comprehensive metadata, and tailored support—ECHO is well-positioned to become a trusted resource for citizen science generated soil data across Europe. This deliverable has established a foundation for meaningful engagement with stakeholders, ensuring alignment with their requirements and expectations.

These findings directly support and inform other tasks and work packages within the ECHO project, enabling a cohesive approach to achieving project objectives:

Task 4.2. Uses of citizen-generated data: the detailed insights into user preferences for data formats, visualisation tools, and platforms will guide the practical application of soil health data. These results ensure that data solutions developed in task 4.2 align with user needs and operational contexts, enhancing the relevance and usability of citizen-generated data.

Task 4.3. Evaluating the interest and utility of citizen-generated data: the stakeholder mapping conducted in task 4.1 provides the framework for assessing the utility and impact of ECHO's data outputs. By understanding the diverse needs of end-users, task 4.3 can systematically evaluate how effectively the data supports research, policy-making, and operational decisions across sectors.

Task 4.4. Deriving value for farmers, landowners, and local authorities: the categorisation of end-users into detailed groups, including farmers, local governments, and landowners, lays the groundwork for identifying how these groups can derive the greatest benefit from ECHO's data. The findings from task 4.1 enable targeted strategies for improving data accessibility and promoting its use in land management and agricultural practices.

Task 4.5. Policy implications and guidelines: the feedback on data accessibility, interoperability, and repository preferences will inform the policy frameworks and guidelines to be developed in task 4.5. This ensures that ECHO's outputs align with user expectations and contribute effectively to policymaking at both regional and European levels.

The deliverable also contributes to the broader objectives of other work packages as follows:

WP3. Citizen engagement and mobilisation: the detailed end-user profiles generated in task 4.1 will enhance strategies for engaging and mobilising citizens in soil health monitoring activities. By understanding the motivations and needs of end-users, WP3 can refine its approaches to maximise participation and impact.

WP5. Digital infrastructure for soil data: the user preferences for platforms, APIs, and visualisation tools identified in task 4.1 are crucial for the design and development of the ECHO digital infrastructure. These insights will help ensure that the platform meets the technical and functional requirements of a diverse user base, from researchers to field practitioners.

7. Acknowledgements

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Appendix 1: Structure of the end-user matrix

ECHO partner	Free response (FR)
End-User / Organisation name	
User group	Drop-down options of response (DOR): Group 1: agricultural soil health/Group 2: urban and peri-urban green soil health/Group 3: ecosystem services and food quality initiatives/Group 4: forest soil health
Stakeholder type (Quadruple-Helix)	DOR: Academia/Government/Industry/Civil Society
Country	DOR: Italy/Poland/Germany/Portugal/Spain/Finland/ Greece/Romania/Austria/Belgium/Bulgaria/Croatia/Republic of Cyprus/Czech Republic/Denmark/ Estonia/France/Hungary/Ireland/Latvia/Lithuania/ Luxembourg/Malta/Netherlands/Slovakia/Slovenia/Sweden/Scotland/Europe
Region or city	FR
Interest for end-user (focus areas and motivation)	
Interest for ECHO (Description of relevant activities or projects in which the end-user is involved)	
Additional comments	

Appendix 2: Survey and interview questions

Survey questions

1. **Could you provide your name and the name of your organisation?**
   Short free text
2. **For what purposes or goals do you typically use soil data in your activities or projects?**
   Multiple choice
3. **What format do you usually prefer for receiving soil data?**
   Multiple choice
4. **What types of data visualisations help you the most when analysing soil data?**
   Multiple choice
5. **What platforms or tools do you typically use to access and work with soil data?**
   Multiple choice
6. **What kind of technical support would make it easier for you to use soil data in your work or projects?**
   Multiple choice
7. **What official data repositories do you currently use to access soil data, if any?**
   Multiple choice
8. **Do you know other professionals or communities that could benefit from using soil data?**
   Yes/No
9. **Please provide details of the professionals or communities you know.**
   For each new end-user, please provide at least the name of the organisation and a contact (email). If you have more information, feel free to include relevant details such as their interest areas, country, or any specific activities they are involved in.
   Input on demand
10. **Additional comments**
11. **As part of the ECHO project, a citizen science initiative focused on collecting and utilizing soil health data, we are reaching out to better understand how you use soil health data, ensuring that the data generated by ECHO is valuable and relevant to you. We will handle your personal information, specifically your name, with complete confidentiality and use it solely for the purpose of enhancing soil data and its application within the ECHO project. Your information will not be shared with any third parties without your explicit consent. All personal data is processed in accordance with the General Data Protection Regulation (GDPR) (EU) 2016/679, ensuring your rights to access, rectify, delete, restrict, and exercise other rights granted by law. To exercise these rights, please contact the Ibercivis Foundation at rgpd@ibercivis.es.**
    Please select one of the following options:
    I accept/I don't accept

Interview questions

Introduction:

The interview begins with an explanation of the ECHO project and the purpose of the discussion.

Current usage of soil data:

- Could you tell me a bit about how you currently work with soil data in your projects or daily activities?
- Follow-up (if necessary): For what purposes or goals do you typically use soil data in your activities or projects?

Preferred data format:

- When it comes to receiving soil data, what format works best for you?
- Follow-up (if necessary): Is there a specific reason why you prefer that format?

Data visualisation needs:

- Are there any types of data visualisations that you find particularly helpful when analysing soil data?

Tools and platforms:

- What tools or platforms do you usually use to access and work with soil data?
- Follow-up (if necessary): Are there any features or integrations in these tools that are especially useful for you?

Technical support and assistance:

- What kind of technical support would make it easier for you to use soil data more effectively in your work or projects?

Official data repositories:

- Are there any official data repositories you currently use to access soil data?

Networking and collaboration:

- Do you know of any other individuals or organisations that could benefit from the soil data we're generating in the ECHO project?
- Follow-up (if necessary): Would you be comfortable introducing us or sharing their contact details?

Final comments and suggestions:

- Do you have any other suggestions or ideas on how we can improve how soil data is shared and accessed?
- Follow-up (if necessary): Is there something specific you'd like to see from the ECHO project's soil data resources that would be especially helpful for you?