# Development of a Geoportal for the integrated management of cartographic information in the Llanganates-Sangay Connectivity Corridor

**Wilson Eduardo Chipantashi Aneloa, Juan Gabriel Mollocana Lara, César Iván Álvarez Mendoza, Andrea Cecilia Mancheno Herrera, Andy Ronny Lema Jacho**

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# DEVELOPMENT OF A GEOPORTAL FOR THE INTEGRATED MANAGEMENT OF CARTOGRAPHIC INFORMATION IN THE LLANGANATES-SANGAY CONNECTIVITY CORRIDOR

**Wilson Eduardo Chipantashi Aneloa**[1]
**Juan Gabriel Mollocana Lara**[2]
**César Iván Álvarez Mendoza**[3]
**Andrea Cecilia Mancheno Herrera**[4]
**Andy Ronny Lema Jacho**[5]

## ABSTRACT

**Objective:** The objective of this research was to develop a GeoPortal using the ArcGIS Online platform for the Llanganates-Sangay Connectivity Corridor (CELS) to enhance its management and conservation.

**Theoretical Framework:** The CELS in Ecuador is a key area for ecological connectivity between two protected areas. Due to its extension across different provinces, the geographic information of the area is dispersed, highlighting the need for a tool that unifies and centralizes these data.

**Method:** This research adopts a mixed-method approach, integrating qualitative and quantitative data from a Geodatabase with geographic information. Meetings were held with the involved stakeholders to agree on the standards and base layers of the GeoPortal. The created platform was evaluated through surveys conducted with the CELS Research Network and entrepreneurs.

**Results and Discussion:** The results revealed that the created platform received an approval rating of 4.33 out of 5, indicating a need for better dissemination of the platform's usage and benefits.

**Research Implications:** The research addresses the efficiency and importance of creating a GeoPortal for managing an ecologically significant area.

**Originality/Value:** This study contributes to the literature by addressing a problem in an ecologically rich area and providing a solution through the creation of an appropriate tool. The relevance and value of this research are demonstrated in the creation of the GeoPortal and its positive reception.

**Keywords:** Information, CELS, Cartography, Biodiversity, Maps.

## DESENVOLVIMENTO DE UM GEOPORTAL PARA A GESTÃO INTEGRADA DE INFORMAÇÕES CARTOGRÁFICAS NO CORREDOR DE CONECTIVIDADE LLANGANATES-SANGAY

## RESUMO

**Objetivo:** O objetivo desta pesquisa foi desenvolver um GeoPortal utilizando a plataforma ArcGIS Online para o Corredor de Conectividade Llanganates-Sangay (CELS), a fim de aprimorar sua gestão e conservação.

[1] Universidad Politécnica Salesiana, Quito, Ecuador. E-mail: wchipantashi@est.ups.edu.ec
Orcid: https://orcid.org/0009-0001-1666-6814
[2] Universidad Politécnica Salesiana, Quito, Ecuador. E-mail: jmollocana@ups.edu.ec
Orcid: https://orcid.org/0000-0002-2430-8400
[3] Universidad Politécnica Salesiana, Quito, Ecuador. E-mail: calvarezm@ups.edu.ec
Orcid: https://orcid.org/0000-0001-5629-0893
[4] World Wildlife Fund, Quito, Ecuador. E-mail: andrea.mancheno@wwf.org.ec
Orcid: https://orcid.org/0009-0000-5525-1665
[5] World Wildlife Fund, Quito, Ecuador. E-mail: ronnylema@hotmail.com
Orcid: https://orcid.org/0009-0007-1687-7084

**Referencial Teórico:** O Corredor de Conectividade Llanganates-Sangay no Equador é uma área-chave para a conectividade ecológica entre duas áreas protegidas. Devido à sua extensão em diferentes províncias, as informações geográficas da área estão dispersas, ressaltando a necessidade de uma ferramenta que unifique e centralize esses dados.

**Método:** Esta pesquisa adota uma abordagem mista, integrando dados qualitativos e quantitativos a partir de uma Geodatabase com informações geográficas. Foram realizadas reuniões com os atores envolvidos para acordar os padrões e camadas base do GeoPortal. A plataforma criada foi avaliada por meio de questionários dirigidos à Rede de Pesquisa e empreendedores do CELS.

**Resultados e Discussão:** Os resultados revelaram que a plataforma criada recebeu uma aprovação de 4,33 em 5, destacando a necessidade de melhor divulgação do uso e dos benefícios da plataforma.

**Implicações da Pesquisa:** A pesquisa aborda a eficiência e a importância da criação de um GeoPortal para a gestão de uma área de relevância ecológica.

**Originalidade/Valor:** Este estudo contribui para a literatura ao abordar um problema em uma área de grande riqueza ecológica e oferecer uma solução através da criação de uma ferramenta adequada. A relevância e o valor desta pesquisa são evidenciados na criação do GeoPortal e na sua recepção positiva.

**Palavras-chave:** Informação, CELS, Cartografia, Biodiversidade, Mapas.

## DESARROLLO DE UN GEOPORTAL PARA LAGESTIÓN INTEGRAL DE INFORMACIÓN CARTOGRÁFICA EN EL CORREDOR DE CONECTIVIDAD LLANGANATES-SANGAY

### RESUMEN

**Objetivo:** El objetivo de esta investigación fue desarrollar un GeoPortal mediante la plataforma ArcGIS Online para el Corredor de Conectividad Llanganates-Sangay (CELS) potenciando la gestión y conservación del mismo.

**Marco Teórico:** El Corredor de Conectividad Llanganates-Sangay en Ecuador es una zona clave para la conexión ecológica entre dos áreas protegidas. Debido a su extensión en diferentes provincias, la información geográfica del área se encuentra dispersa, lo que resalta la necesidad de una herramienta que unifique y centralice estos datos.

**Método:** Esta investigación adopta un enfoque mixto, integrando datos cualitativos y cuantitativos, a partir de una Geodatabase con información geográfica. Se llevaron a cabo reuniones con los actores involucrados para acordar los estándares y capas base del Geoportal. La plataforma creada fue evaluada mediante encuestas dirigidas a la Red de Investigación y emprendedores del CELS.

**Resultados y Discusión:** Los resultados obtenidos revelaron que la plataforma creada tiene una aprobación del 4.33 sobre 5, siendo necesario una mejor difusión del uso y beneficios de la plataforma creada.

**Implicaciones de la investigación:** La investigación realizada aborda la eficiencia y la importancia de la creación de un Geoportal para la gestión de un área de importancia ecológica.

**Originalidad/Valor:** Este estudio contribuye a la literatura al abordar una problemática de un área con riqueza ecológica y darle solución a la misma con la creación de una herramienta adecuada. La relevancia y valor de esta investigación se evidencian en la creación del Geoportal y la recepción positiva del mismo.

**Palabras clave:** Información, CELS, Cartografía, Biodiversidad, Mapas.

## 1 INTRODUCTION

According to Ecuador's National System of Protected Areas (SNAP), a biological corridor is a vegetation strip that facilitates species movement, promoting connectivity, ecological stability, and migration between habitat fragments. (Ministerio del Ambiente Ecuador, 2015). A connectivity corridor, or ecological corridor, is considered a strategy for biodiversity conservation, supported by the thematic information collected (Braga et al., 2024). Initiated in 2002 with support from the World Wildlife Fund (WWF), the CELS project aims to connect two key protected areas, facilitating genetic exchange and ensuring ecosystem continuity between them. (World Wildlife Fund, 2023). The CELS involves a variety of stakeholders, including government agencies, NGOs, academic institutions, and foundations. This diversity requires an efficient platform to manage and share geospatial data, enabling collaboration and informed decision-making.

Geoportals can help organize and understand natural areas. Ongoing research explores accessing real-time data using only free tools for managing geospatial big data, without relying on servers. (Bebortta et al., 2020). Additionally, research has been developed to incorporate geoportals with "metageosystems," which are complex systems that integrate multiple interconnected geographic and geospatial systems (S. Yamashkin et al., 2023). Geoportals are used to address problems such as the identification of risk areas, the location of endemic species, and the control of forest fires (Yamashkin et al., 2024). They are also employed in nature conservation, as in Romania, where they facilitate the documentation of natural habitats and wildlife species (Oana & Staiculescu, 2011).

Currently, research is being conducted to enhance these services by incorporating advanced visualization, integrating layers without geometric conflicts, and standardizing data (Toomanian et al., 2013). Additionally, real-time data access using free tools for managing geospatial big data is being explored (Bebortta et al., 2020), along with the integration of geoportals with metageosystems, complex systems that connect multiple geospatial sources (Yamashkin et al., 2023). A recent study highlights the relevance of geoportals in smart urban governance in countries like Spain, South Africa, Denmark, and Japan, emphasizing the importance of the ISO 19100 standard for geospatial data management (Ugeda & Fonseca, 2023). In Russia, geoportals have been key in resolving visualization and data dissemination issues within regional metageosystems. For instance, in Mordovia, web-based geoportals have improved access to spatial data infrastructure and play a crucial role in the management of Russia’s National Geospatial Information Systems (Yamashkin et al., 2024). Geoportals have

also been developed to integrate spatiotemporal cultural landscapes (Anatoliy et al., 2020).

Other examples include marine geoportals, which support Marine Spatial Planning (MSP), and the development of agricultural geoportals in Spain, such as for real-time monitoring of rice crops (Granell et al., 2017). In Latin America, Brazil has advanced in creating a collaborative catalog of open-access geoportals (da Silva & Camboim, 2021).

A Geographic Information System (GIS) is a tool that enables the capture, storage, analysis, and presentation of geographic information. Its development responds to the need for quick access to data to solve problems and make decisions in various fields, such as biodiversity studies (Von, 2006). Geographic Information Systems can be adapted to various environmental needs, as in the case of the geomorphology of the Catu River basin in Brazil, where specialized software was used (Silva et al., 2024). A review of studies on geotechnology applied to sanitation determined that the use of Geographic Information Systems for adequate mapping improves the visualization of issues (Corrêa et al., 2024). Efforts are also underway to develop and promote innovative geographic tools like SIGFIS, a geographic information system for monitoring water resource use in Pernambuco, Brazil. (Ferreira et al., 2024).

ArcGIS Online, developed by ESRI, is a web-based GIS system that enables collaboration and sharing of maps, apps, and geographic data. It complements ArcGIS Desktop and Enterprise, offering an accessible platform for users, even without GIS experience. Through subscriptions, users can create and publish maps as web layers and manage content, customize the platform, and set security policies. (Arias, 2017). This tool has proven to be user-friendly and has contributed to climate change education, as observed in high school students in Spain (Gil et al., 2024). Since the software meets usability standards and integrates well with the CELS collaborating entities, it has been selected for developing the Geoportal.

The development of a GeoPortal for CELS using ArcGIS Online is proposed to enhance its management and conservation. The project's objectives include analyzing cartographic data in collaboration with stakeholders to ensure accurate data selection, implementing a geoservice for better data understanding through web applications, and disseminating results to CELS stakeholders, fostering new research and strengthening corridor conservation.

## 2 METHODOLOGY

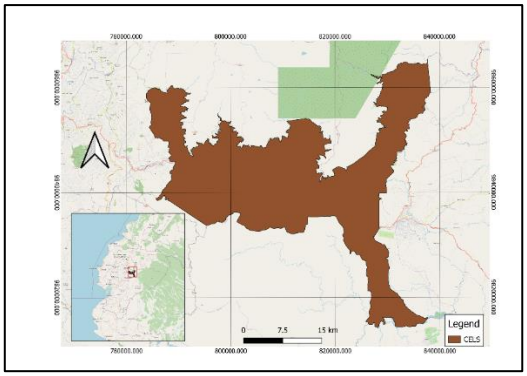
### 2.1 DESCRIPTION OF THE STUDY AREA

In Ecuador, the formalization of ecological corridors in public policy began in 2013, with further regulations in 2020. These corridors are designated as conservation areas aimed at maintaining connectivity between protected areas under a sustainable landscape management approach. While initially focused on protected areas, the policy allows for corridors in various contexts. The CELS, established in 2002, focuses on ecological, social, and economic connectivity between Llanganates and Sangay National Parks, supported by detailed studies to identify key connectivity areas. The participation of local stakeholders is essential, the CELS proposal incorporates ecosystem criteria to ensure integrated watershed management, aiming to sustain social, economic, cultural, and political dynamics in the landscape. (Gobierno Provincial de Pastaza, 2019).

The CELS, situated in the central Ecuadorian Andes and extending into the Amazon region, is vital for ecological connectivity between Sangay National Park to the south and Llanganates National Park to the north. According to WWF (2014), it is one of the 65 priority conservation sites in the Northern Andes. (Yaguache, 2014). The CELS covers the provinces of Tungurahua, Pastaza, and Morona Santiago, integrating various provincial, cantonal, and parochial jurisdictions. This diverse area includes high-biodiversity regions such as Machay and Las Estancias in Baños, and Madre Tierra in Mera, where human access is restricted. Studies have recorded 101 mammal species, including key species like the spectacled bear (Tremarctos ornatus) and the jaguar (*Panthera onca*), highlighting the corridor's ecological importance (WWF, 2023).

**Figure 1**

*Study area map.*



## 2.2 DATA COLLECTION

Geographic information was obtained from official data sources provided by decentralized autonomous governments, the National Information System (SNI), the Military Geographic Institute (IGM), and data generated by non-governmental organizations within the CELS (WWF, Ecominga, Waska Amazonía, etc.). Similarly, these non-governmental organizations are responsible for collecting information about the territory, including specific details such as research networks, tourism networks, and resources for the PDOT (which consist of detailed information for land use planning, CELS information regarding the territory of each province, canton, or parish). This information, being of a territorial nature, was deemed relevant for inclusion in the geoportal after discussions with CELS stakeholders.

**Table 1**

*Geodatabase data collection.*

| Classification | Examples | N | Source |
|---|---|---|---|
| Geographic layers | Rivers, roads, population, territorial divisions, etc. | 75 | SNI, IGM |
| Environmental layers | Hydrographic basins, Isohyets, Soil type, Isotherms, etc. | 79 | MAATE, Ecominga, WWF |
| Projects at CELS | Proctective forest, ecotourism, biofactories, etc. | 49 | WWF, Ecominga |

N = number of layers

During the data inquiry, 203 layers were identified within a geodatabase. As a result, data cleansing is required, as these layers include sectoral division cut layers, duplicate layers shared by different organizations containing the same information, and outdated layers.

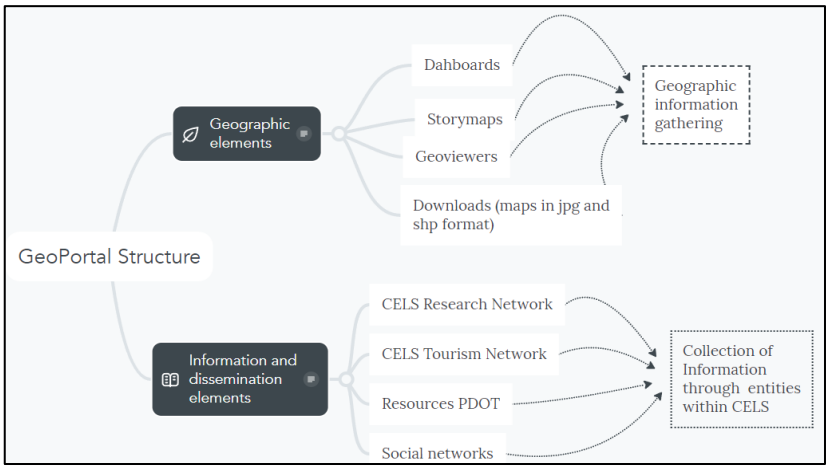
## 2.3 GEOPORTAL STRUCTURE

The research design employs a mixed-methods approach, integrating qualitative and quantitative data through maps, storymaps, and dashboards. This descriptive method aims to enhance understanding of the CELS. An exploratory analysis focused on representative CELS stakeholders and specific cartographic data for the GeoPortal. The research utilizes ArcGIS Online to manage various variables, including geographic data, territorial divisions, project area polygons, strategic points, and stakeholders' perceptions of satisfaction and interface usability. The procedure started with information collection and needs assessment, guided by a methodological diagram to validate data through stakeholder meetings, ensuring quality.

Strategic meetings with key CELS agents, facilitated by a Nonprofit organization as an intermediary, enabled collaborative data gathering for the geospatial service. This involved interviews and regular project progress presentations. For the geoportal creation, we considered gathering available geographic information within the CELS to support dashboards, story maps, geo-viewers, and map downloads. Contributions from CELS organizations will enrich the geoportal's content. The tourism network includes sustainable tourism projects, while the research network involves researchers generating new data. The PDOT toolkit provides territorial data for CELS municipalities' land-use planning. Social networks and contact methods are included for disseminating information and receiving suggestions about the geoportal.

**Figure 2**

*Geoportal structure diagram.*




The collected data was processed using ArcGIS Online, applying layers and tools to create web maps and dashboards for dynamic visualization and interpretation. Files in "Shp." format were integrated as hosted feature layers, allowing collaborative modifications and data refinement. To ensure accessibility, the files were hosted publicly on the platform for viewing and use, while the original files remain under the owner's supervision for specific uses. The GeoPortal's virtual environment was created using the "ArcGIS HUB" tool, integrating layers, maps, dashboards, and other accessible tools. A key feature is the GeoViewer, which provides intuitive and comprehensive information visualization, setting it apart from conventional GIS. Additionally, a data download system was included to facilitate data manipulation.

### 2.4 GEOPORTAL EVALUATION

Finally, meetings were held to introduce the tool and the use of the GeoPortal to stakeholders in the CELS, collecting suggestions to improve the platform. A dissemination group was established on the ArcGIS Online platform, which facilitated communication and information exchange among participants, highlighting Nonprofit organization's GLOBIL platform as an effective means for project dissemination. The results regarding the creation of the platform were measured through surveys focused on the main stakeholders of the CELS, including some members of the Decentralized Autonomous Governments, members of the research network, members of the sustainable tourism network, and members of the nonprofit organization. For the evaluation, Likert scale questions (rated from 1 to 5) will be used to gather user feedback. The surveys were initially intended to target primarily the research network, as these professionals are expected to make the most use of the platform, covering 30% of the network, or approximately 10 respondents. However, a significantly higher number of 18 respondents was reached.

## 3 RESULTS AND DISCUSSIONS

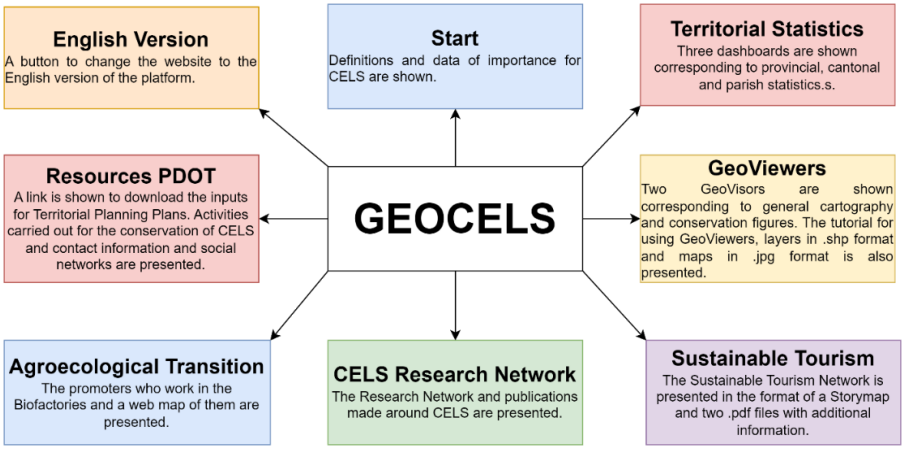
### 3.1 GEOCELS CREATION

The GeoPortal is built using ArcGIS Hub, a cloud platform that enhances data interconnection among research groups. Within ArcGIS Online, ArcGIS Hub allows for the creation and design of web pages with predefined templates. For greater design flexibility, the ArcGIS Hub Premium license is required, which provides access to customized templates and full control through the ARCADE language, based on JavaScript and HTML.

Since the project's goal is to facilitate the dissemination of cartographic files and represent the Llanganates-Sangay CELS projects, and considering that no additional software beyond ArcGIS Online will be used, predefined templates have been chosen. Although these limit aesthetic customizations, the created virtual environment meets the project requirements efficiently, resulting in the GEOCELS platform.

**Figure 3**

*GEOCELS platform diagram.*



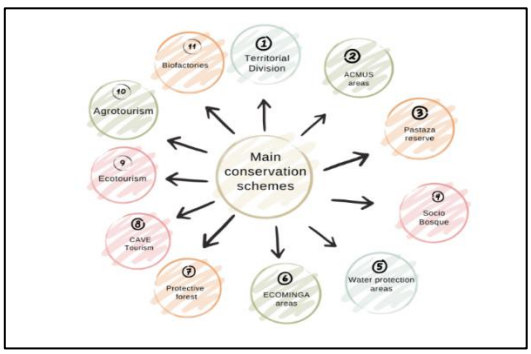

Note: link of the created tool https://geocels-upsq.hub.arcgis.com

GEOCELS was created based on the concept of the planned structure (Figure 2), where dissemination elements were combined with geographic elements in tools such as the tourism network story map and the research network story map. Within GEOCELS, there are two tools created based on geographic elements: the geo-viewers and dashboards for territorial statistics.

To improve information management, the data repository of the CELS was explored with the support of Nonprofit organization. A geodatabase with 203 layers was obtained, including general information, specific data on cantons and provinces, and physical and climatic aspects of the area. A data cleansing process was necessary to select the most relevant layers for the project, removing duplicates and areas not related to the CELS. As a result of this analysis, 11 main conservation schemes within the corridor were identified, enhancing the clarity and usability of the geospatial data. These conservation schemes were used as the base cartography for the creation of the geo-viewers and dashboards.

**Figure 4**

*Diagram of the main conservation schemes.*

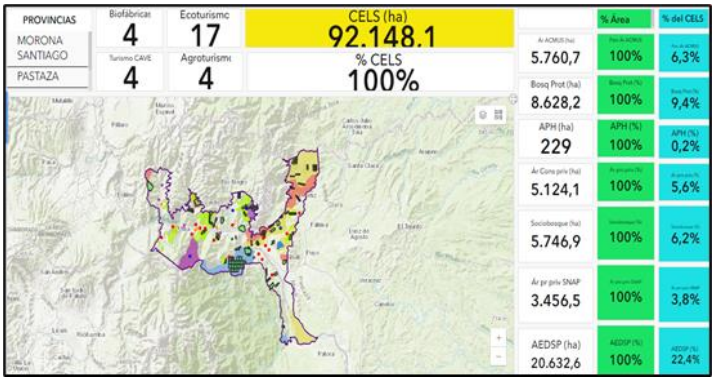


Additionally, the study's limitations and potential directions for future research are discussed. It is essential that both the results and the discussion are based on solid evidence and contribute significantly to advancing knowledge on the addressed topic. Within the CELS, Municipal Conservation Areas (ACMUS) are managed by Decentralized Autonomous Governments (GAD) and are located in the cantons of Mera, Baños, and Palora, covering specific areas designated for local conservation. The Pastaza Provincial Reserve, under the jurisdiction of the Decentralized Autonomous Government of Pastaza, constitutes a large protected area of over 20,000 hectares. It primarily extends around the parishes of Shell, Madre Tierra, and Mera. The Socio Bosque areas within the CELS cover approximately 5,700 hectares. These areas are distributed across most parishes in the CELS, except for four: Sucre, Baños, Madre Tierra, and Sangay. Water Protection Areas (APH) in the CELS are territories designated for the protection of public water sources. The main of these is the water protection area of the Pindo River, which plays a crucial role in conserving water resources. The ECOMINGA Foundation's reserve system, covering the parishes of Ulba, Baños, Río Verde, Río Negro, and Mera, encompasses approximately 5,000 hectares. These areas focus on the conservation of herpetofauna, birds, and flora. Protective forests in the CELS include the Habitagua, Moravia, and Cerro La Candelaria Protective Forests, totaling around 8,600 hectares. These forests are located in rugged terrain and are crucial for conserving water resources and biodiversity. CAVE tourism, which refers to scientific, academic, volunteer, and educational activities, is represented in four areas within the CELS: The Private Protected Area of the Zuñag River, the Private Protected Reserve Cerro de la Candelaria, the Sumak Kawsay in Situ Reserve, and the Adela Crystal Frog Reserve. Ecotourism in the CELS includes 17 points dedicated to activities such as bird watching, hiking, and adventure tourism, located in various areas of the corridor. Agrotourism is present in the CELS with four locations: Urku Allipacha, Finca Orgánica Vizcaya, Finca Orgánica El Placer, and Café Gallo de la Peña. These sites offer experiences related to agriculture and rural life. Finally, the biofactories in the CELS, located in the parishes of Río Verde, Río Negro, and Ulba, focus on the creation and transformation of living organisms, with four active facilities: El Placer, La Floresta, San Jorge, and Vizcaya.

The main conservation schemes, in addition to being represented in geoviewers, were also used for the creation of two tools: storymaps and dashboards.

**Figure 5**

*Provincial dashboard.*




Within the dashboard tool, statistics for each of the main conservation schemes are displayed, where tourism points are counted, areas are measured in hectares, and the percentages of each zone are provided. In the case of Figure 5, territorial divisions by province are shown. Various navigation buttons are integrated, allowing users to select a specific province and display the conservation scheme statistics for the chosen province. Dashboards have been created for three different territorial divisions: parish, canton, and province levels.

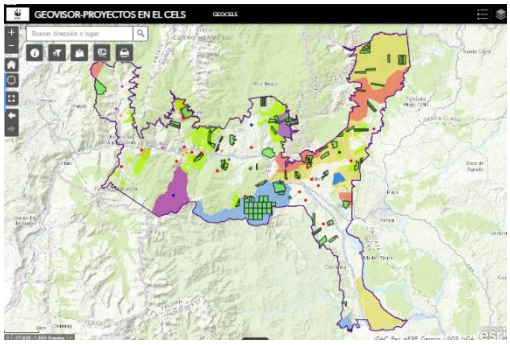
**Figure 6**

*Story map of the sustainable tourism network.*


Story maps are presentations that include information and maps to provide a better understanding of the territory. In the case of Figure 6, a story map of the sustainable tourism network is presented, where as you navigate through the presentation you can see each tourist spot that is currently within the CELS, its location on the map, information about the activities offered and contact information for the enterprise. Similar story maps have been created for: information about CELS recognitions, the research network, promoters of the enterprises and activities carried out by the actors in the territory.

**Figure 7**

*Conservation schemes geoviewer.*




Two geoviewers were developed as the main tools. The one shown in Figure 7 corresponds to the conservation schemes geoviewer, which includes support tools such as a button to add more information, either by the user or from the atlas offered by ESRI. You can view attribute tables, a collapsible legend, a layer list that can be modified, filters to navigate through the different territorial divisions, and an option to print the map. In addition, the second geoviewer includes additional data beyond the conservation schemes, such as land use, ecosystems, roads, rivers, etc.

## 3.2 GEOCELS EVALUATION RESULTS

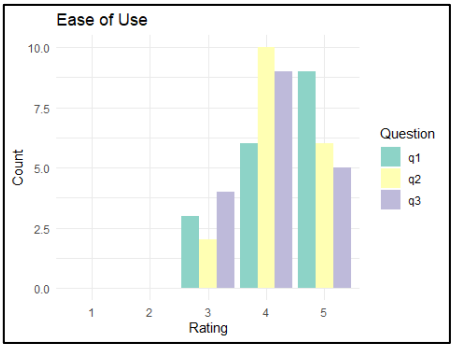
For the questions, a total of 9 questions were asked, which can be divided into three sections: consideration of use, satisfaction, and ease of use. A total of 18 people from all the key entities that make up the CELS were surveyed. Surveys in general reveal that GEOCELS has been well received by users, although specialized training is needed to optimize its use and evaluation. All respondents have worked directly in the CELS territory, which suggests a positive perspective from local stakeholders but limits the understanding of the perceptions of external users.

### 3.2.1 Ease of use

It is important for GEOCELS to be user-friendly. To evaluate this, we assessed the navigation through the interface, the use of tools such as the geovisor and dashboards, and overall ease of use. While the results are positive, this is the aspect that is most in need of improvement within GEOCELS, as users may find it difficult to adapt to new tools.

**Figure 8**

*Ease of use results.*



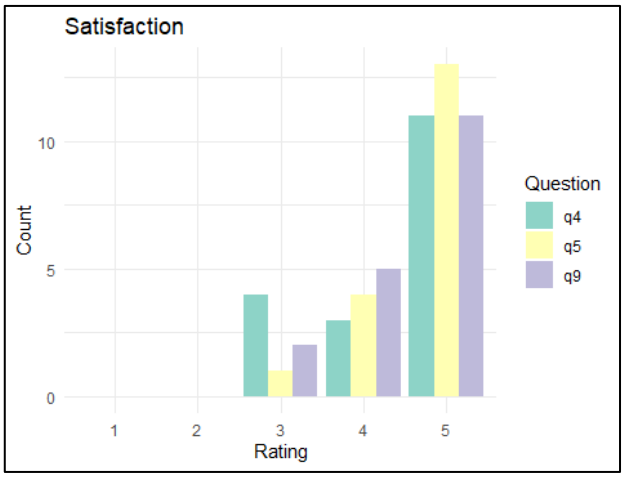

q1 = overall ease of use; q2 = navegation; q3 = tools.

### 3.2.2 Satisfaction

User satisfaction with GEOCELS was measured by asking about the platform's structure, organization, and clarity, the relevance of the presented information, and overall user satisfaction. Unlike ease of use, this aspect received a more positive reception from users, indicating that despite some initial difficulties, users are satisfied with the creation of GEOCELS.

**Figure 9**

*Satisfaction results.*



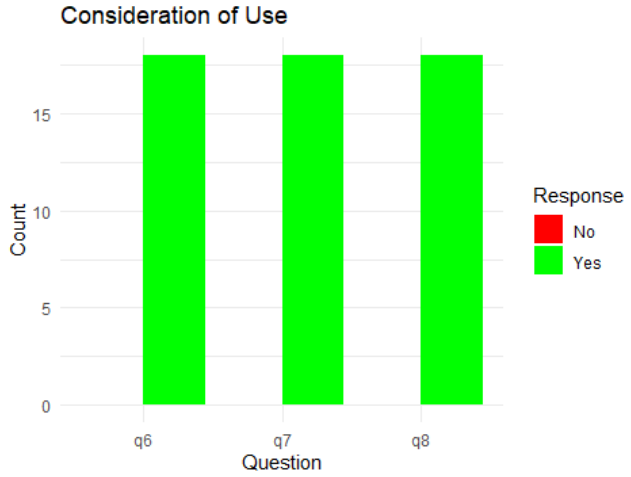

q4 = structure; q5 = relevance; q9 = overall satisfaction.

### 3.2.3 Consideration of use

For the considerations of use, dichotomous questions of 'yes' and 'no' were used to evaluate whether respondents would use GEOCELS for research or work within the territory, if they would recommend the platform to a colleague, and if they want to learn more about the created platform. Very positively, there is a 100% consideration of use; all consulted users approve GEOCELS as a platform designed for use within the territory.

**Figure 10**

*Consideration of use results.*




q6 = personal use; q7 = learn about GEOCELS; q8 = recommendation to others.

On average, satisfaction reaches a score of 4.33 out of 5, suggesting that the platform has a broad acceptance margin. The platform developed for CELS is effective in disseminating cartography, though there are areas for improvement, especially in its aesthetic design. The use of the standard version of ArcGIS Hub limits customization options, but overall functionality is not compromised. Integration with GLOBIL and access to ArcGIS Hub Premium is expected to enhance the design and add additional features. While the platform meets its objectives using ArcGIS Online tools, future tools for real-time mapping and other functionalities could be incorporated.

GEOCELS has been well received, with an average rating of 4.33 out of 5. It is recommended to conduct dissemination campaigns, training, and continuous improvements. Surveys suggest good acceptance among corridor users, but additional interactive materials and training are needed to improve understanding. Is suitable for dissemination and potential implementation in other research. Compared to other national geoportals, GEOCELS offers a

more accessible interface and diverse tools. Future improvements could include real-time data collection and other innovations.

## 4 CONCLUSION

The developed GeoPortal is effective in managing cartographic resources for the CELS region and shows notable potential to drive research in this area.

Thanks to the collaboration of various organizations, a cartographic information standard has been established that effectively meets the needs of CELS. The interface, designed to be intuitive and visually straightforward, enhances user access to and interaction with the geographic data of CELS.

The choice of ArcGIS Online has proven suitable for the CELS context, as its integration with the GLOBIL platform optimizes data dissemination and management efficiently for users.

Surveys conducted with CELS stakeholders indicate that the introduction of tools in GEOCELS presents an intermediate level of difficulty. It is recommended to complement the platform with training and video tutorials to improve accessibility and user understanding, as the current format may be less instructional.

It is crucial to move beyond the creation of the platform by implementing specialized training and collaborating with the Research Network to enhance the tool. This will allow the GeoPortal to become a valuable resource for dissemination and support for future research.

The dashboard confirms that Tungurahua holds the largest portion of CELS territory, covering 52.5%. However, it also reveals the need for conservation efforts in Morona Santiago, which has only 3 ecotourism sites, indicating potential for biofactory or agrotourism development. Despite its smaller CELS territory and fewer conservation initiatives, Morona Santiago is significant, as it contains 100% of the ACMUS areas within CELS.

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