



Building a global Rangelands Data Platform: Safeguarding rangelands through data-driven decision making

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Abstract

Rangelands, spanning over half of Earth's land, include ecosystems like grasslands, deserts, savannas, and mountains. They support biodiversity, vital ecosystem services, and the livelihoods of pastoralists, livestock keepers, and farmers. However, rangelands face threats from agriculture, mining, urbanization, and infrastructure expansion, leading to land degradation and increased pressure from rising livestock product demand.

The global Rangelands Data Platform addresses these challenges by serving as a repository for rangeland data, supporting informed decision-making on their management, protection, and restoration. Accessible to the public, the platform raises awareness, supports scientific research, and guides investments in sustainable practices.

By providing data for global advocacy and community resilience, the platform contributes to initiatives like the UN Decade on Ecosystem Restoration and promotes the sustainable use of rangelands. This effort ensures the preservation of their ecosystem services and cultural heritage for millions worldwide.

Introduction

Rangelands, covering over half of Earth's terrestrial surface (Reid et al., 2014), are diverse ecosystems that include grasslands, deserts, savannas, tundra, woodlands, wetlands, and mountainous areas. These landscapes support biodiversity, provide essential ecosystem services, and contribute to food security and poverty alleviation for millions worldwide (Asner et al., 2004). Approximately 91% of rangelands are extensive, characterized by open landscapes with minimal boundaries and limited crop agriculture, while 9% are mixed-use areas combining grazing with cultivation. Communities such as pastoralists, hunter-gatherers, and crop farmers rely on rangelands for livestock production, cultural heritage, and socio-economic activities.

Despite their global importance, rangelands face growing pressures from urban expansion, large-scale agriculture, mining, and climate change. These challenges contribute to land degradation, affecting 25-35% of rangelands globally, and reduce their ability to provide critical ecosystem services. Addressing these threats requires effective governance, restoration, and sustainable management practices. International efforts, such as the UN Decade of

Ecosystem Restoration and the declaration of 2026 as the International Year of Rangelands and Pastoralists, underscore the urgency of protecting these ecosystems.

To address these challenges, the "Sustainable Investments for Large-Scale Rangeland Restoration" (STELARR) project was launched in 2023. Funded by the Global Environment Facility (GEF), STELARR aims to reverse rangeland degradation, enhance productivity, and reduce poverty through sustainable livestock value chains. The initiative prioritizes inclusive benefits for women and youth, fostering resilient livelihoods and economic opportunities. It reinvests profits from sustainable livestock practices directly into rangeland restoration, creating a self-sustaining model for long-term environmental and economic benefits.

Central to STELARR's mission is the development of a global rangelands data platform, led by the International Livestock Research Institute (ILRI) in collaboration with GMV and Vizzuality. This platform serves as a comprehensive repository for rangeland data, enabling the collection, sharing, and analysis of critical information. It supports policymakers, scientists, and local communities in making informed decisions and promotes evidence-based strategies for sustainable management. By highlighting the ecological, economic, and cultural value of rangelands, the platform facilitates targeted investments, monitors changes, and enhances awareness at local, national, and global scales, ensuring the long-term health and sustainability of rangelands worldwide.

Methods

The development of the Rangelands Data Platform employs an iterative methodology that combines user-centred design (UCD) principles with agile practices to meet stakeholder needs and align with the STELARR project's goals. It begins with a discovery phase that gathers and analyses information across business, design, scientific, and technical domains. This phase evolves iteratively, incorporating new insights to ensure the platform remains adaptable.

Business discovery is central to this phase, defining governance structures, identifying stakeholders, and setting objectives and use cases. It also maps needs, analyses existing initiatives, establishes metrics for success, and identifies potential risks. Five key user groups are prioritized: remote sensing and GIS experts, climate and ecosystem management professionals, land management and conservation specialists, community-based approach experts, and agriculture and livestock managers. Their feedback shapes user profiles, use cases, and platform features, ensuring relevance, transparency, and trust.

The design phase adheres to UCD principles, engaging stakeholders to refine platform features through workshops, discovery sessions, and prototype testing. Accessibility is a priority, making the platform inclusive for technical and non-technical users, even those with limited digital literacy or connectivity. Iterative development ensures adaptability to evolving needs.

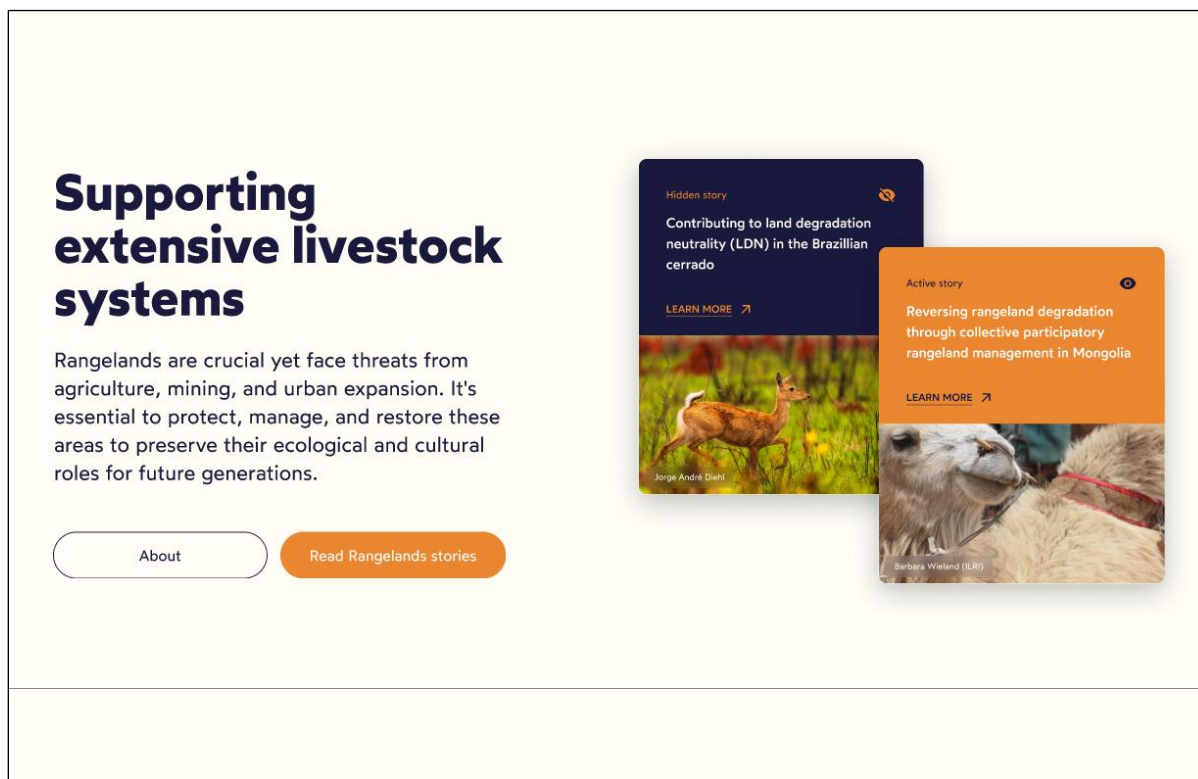


Figure 1 Screenshot of a section of the Rangelands Data Platform landing page.

Simultaneously, the data and technical discovery phases address the platform's data ecosystem, infrastructure, and architecture. Data discovery evaluates existing datasets, identifies gaps, and proposes new sources, while technical discovery focuses on infrastructure, tools, and sustainability strategies. It addresses data formats, processing needs, and storage solutions, mitigating risks to ensure reliable performance in areas with limited connectivity.

Agile methodology underpins development, enabling flexibility and responsiveness. Iterative, time-boxed sprints deliver functional features regularly, guided by continuous stakeholder feedback. A cross-functional team of data scientists, designers, and developers prioritizes a backlog of features and ensures efficient delivery through continuous integration, rigorous testing, and adaptive planning. Post-sprint retrospectives refine processes and align the platform with STELARR's objectives, ensuring it meets diverse user needs.

This structured approach guarantees a user-centric, adaptable, and sustainable platform that addresses the challenges and priorities of rangeland management while remaining aligned with STELARR's broader goals.

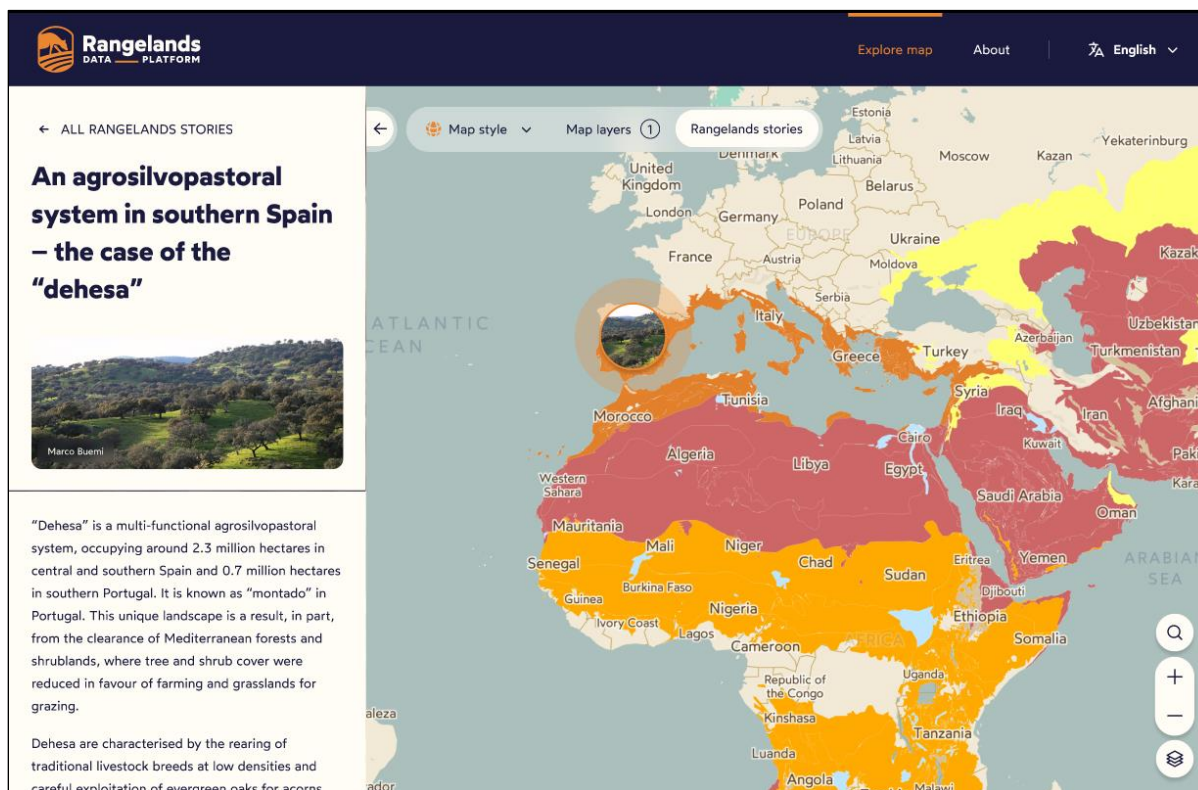


Figure 2 Screenshot of a rangeland story featured on the Rangelands Data Platform.

Results

The Rangelands Data Platform integrates diverse geospatial and contextual datasets within a scalable framework, facilitating comprehensive analysis of rangeland ecosystems. It currently incorporates datasets addressing ecological, productive, and contextual dimensions, with a flexible architecture designed for continuous expansion based on stakeholder feedback and emerging needs. The platform also features case studies that illustrate how changes in rangelands impact local communities, livestock, and natural resources, while showcasing efforts to protect rangelands, wildlife, and the livelihoods dependent on these ecosystems and extensive livestock systems.

The platform is built upon a foundational dataset that defines global rangeland systems by selecting seven of fourteen biomes or rangeland types, based on World Wildlife Fund’s (WWF) classification of terrestrial ecoregions, as defined in the ecoregions layer by Dinerstein et al. (2017). This dataset serves as a spatial mask, enabling users to visualize and explore data specific to rangelands, with the ability to filter by individual biomes or their constituent ecoregions. Building on this foundation, the platform incorporates a range of ecological datasets, such as time-series net primary productivity (NPP) data from Moderate Resolution Imaging Spectroradiometer (MODIS) to capture vegetation dynamics, the Anthropogenic Biomes of the World dataset from Socioeconomic Data and Applications Center (SEDAC) to highlight human impacts on ecosystems, and the World Dryland Areas dataset from UNEP-WCMC to define global dryland boundaries. Additionally, datasets on tree cover loss and tree cover gain from Global Forest Watch provide insights into changes in forest cover over time. Other contextual datasets further enrich the platform, offering valuable information on conservation priorities, threatened species, surface water extent, livestock systems and density, population distribution, pastoralist communities, and indigenous territories. As the platform evolves, the collection of datasets will continue to grow based on ongoing stakeholder feedback, providing a robust foundation for analysing the ecological, productive, and social dimensions of rangelands.

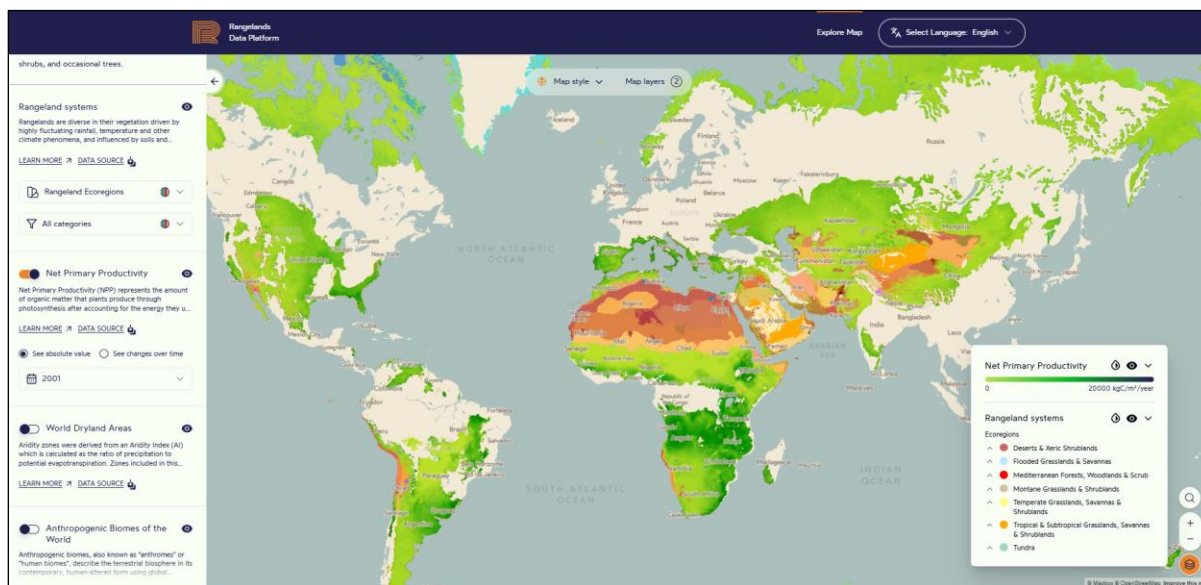


Figure 3 Screenshot of the Rangelands Data Platform, displaying the ecoregions within the rangeland systems and the Net Primary Productivity (NPP) for the year 2001.

The platform’s technical infrastructure is designed for efficient data processing and seamless visualization, enhancing user interaction with diverse datasets. Vector datasets are processed using Python, converted into MBTiles, and hosted on Mapbox to ensure optimized performance. Raster layers are retrieved from Google Earth Engine and processed within Google Cloud Functions, where they are dynamically styled and transformed. This allows the creation of new layers, such as NPP change (calculated from the first and last years of the time series) and total livestock density (aggregating the number of animals per grid cell). The cloud-based processing approach ensures the platform can efficiently handle large datasets and generate real-time, customized visualizations. The system leverages Google Cloud Platform, with containerized applications managing the frontend, backend, and data workflows. Terraform automates resource provisioning for scalability, while Cloud SQL supports relational data storage. Strapi is employed to manage metadata and style configurations for both vector and raster layers, enabling easy updates. Key statistics, such as rangeland metrics, are embedded within the corresponding Mapbox layers, enabling the frontend to retrieve and present this information to users in an interactive and accessible format.

By combining this robust technical foundation with a diverse and expanding set of datasets and case studies, the Rangelands Data Platform offers a flexible, scalable resource for advancing the understanding and management of rangelands. Its ability to incorporate new tools and datasets, driven by ongoing stakeholder feedback, ensures that the platform remains relevant and adaptable to evolving research and policy needs.

Discussion and outlook

The rangelands data platform is design to become a transformative tool for rangeland management, driven by continuous stakeholder interaction and technological advancements. It aims to meet the diverse needs of policymakers, scientists, local communities, and conservationists.

Regular consultations and feedback sessions have been crucial in developing the current version, providing insights into the specific needs of different user groups. However, many more will still be necessary to fully address the platform’s goal. Training programs and workshops are also expected to enhance stakeholders’ capacity to utilize the platform effectively.

Future developments will enhance the platform's capabilities by incorporating more localized data and success stories on rangelands restoration, improving analytics, and fostering greater collaboration among stakeholders. Continuous improvement through stakeholder engagement and technological innovation will ensure the platform remains a vital resource for sustainable rangeland management.

In conclusion, the rangelands data platform represents a significant advancement in rangeland conservation. Its evolution and stakeholder interaction position it as an indispensable tool for promoting sustainable practices, enhancing biodiversity, and supporting resilient livelihoods. As it grows and adapts, it will play a crucial role in achieving global rangeland conservation and sustainable development goals.

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References

- Asner, G.P., Elmore, A.J., Olander, L.P., Martin, R.E., & Harris, A.T. (2004). Grazing Systems, Ecosystem Responses, and Global Change. *Annual Review of Environment and Resources*, 29, 261-299. <https://doi.org/10.1146/annurev.energy.29.062403.102142>
- Archer, S.R. (2010). Rangeland Conservation and Shrub Encroachment: New Perspectives on an Old Problem. In *Wild Rangelands* (eds J.T. du Toit, R. Kock and J.C. Deutsch). <https://doi.org/10.1002/9781444317091.ch4>
- Dinerstein, E., Olson, D., Joshi, A., Vynne, C., Burgess, N.D., Wikramanayake, E., Hahn, N., Palminteri, S., Hedao, P., Noss, R., Hansen, M., Locke, H., Ellis, E.C., Jones, B., Barber, C.V., Hayes, R., Kormos, C., Martin, V., Crist, E., Sechrest, W., Price, L., Baillie, J.E.M., Weeden, D., Suckling, K., Davis, C., Sizer, N., Moore, R., Thau, D., Birch, T., Potapov, P., Turubanova, S., Tyukavina, A., de Souza, N., Pinteá, L., Brito, J. C., Llewellyn, O. A., Miller, A.G., Patzelt, A., Ghazanfar, S.A., Timberlake, J., Klöser, H., Shennan-Farpón, Y., Kindt, R., Lillesø, J.-P.B., van Breugel, P., Graudal, L., Voge, M., Al-Shammari, K.F., Saleem, M. (2017). An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm. *BioScience*. 67 (6), 534-545. <https://doi.org/10.1093/biosci/bix014>