Project: Building Resilience in Rangeland Communities with Big Data

Proposed outline of a global Rangelands Data Platform

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ESA	European Space Agency
FMT	Flood mapping tool
GEOGLAM	Group on Earth Observations Global Agricultural Monitoring
GFW	Global Forest Watch
ILC	International Land Coalition
IUCN	World Conservation Union
LULC	Land use, land cover
RAPP	Rangeland and pasture productivity
WWF	World Wide Fund for Nature

REFERENCE WEBSITES AND DOCUMENTS

The following websites and documents have been referenced in the text, according to the codes (RD.'x'] in column 1:

Table 1-1 - Reference Documents

Ref.	Title	Date accessed
[RD.1]	https://earthmap.org/	13/04/2021
[RD.2]	https://map.geo-rapp.org/	13/04/2021
[RD.3]	http://www.openforis.org/tools/collect-earth.html	16/04/2021
[RD.4]	http://www.fao.org/dryland-assessment/en/	16/04/2021
[RD.5]	https://gardian.bigdata.cgiar.org/#!/	17/04/2021
[RD.6]	http://earthobservations.org/geoglam.php	17/04/2021
[RD.7]	http://trends.earth/docs/en/	17/04/2021
[RD.8]	https://www.globalforestwatch.org/map/	15/06/2021
[RD.9]	https://app.climateengine.com/climateEngine	05/10/2021
[RD.10]	https://floodmapping.inweh.unu.edu/	20/10/2021
[RD.11]	https://map.drought.gov.au/	22/10/2021

1.0 INTRODUCTION

1.1 Objectives of the project

54% of the world's land surface is classified as rangeland[1], and the health and productivity of this land are directly critical to the livelihoods, cultures, and resilience of more than 500 million people around the world, many of whom are indigenous peoples, who depend on rangelands. Rangeland ecosystems are critical for achieving food and water security, as well as resilient local and national economies, and for improving environmental conditions.

However, there are significant data gaps and inconsistencies on the distribution, status, risks, changes, and opportunities for restoring or building resilience in rangeland communities. Rangeland monitoring often occurs at the local level, using various terminology, tools, indicators, and frameworks, and without global storage of data. This has led to poorly planned investments, particularly in pastoralist areas which, in many cases, has damaged rather than strengthened the resilience of communities.

The project ***Building Resilience in Rangeland Communities with Big Data***, led by ILRI and technologically supported by GMV, was selected as a pilot project winner in the CGIAR's Inspire Challenge 2020 and provided with an award of US$100,000. This project planned to establish the first-ever online global Rangelands Data Platform, agreed upon by global actors, for monitoring rangelands and consolidating rangeland data, including ecosystem health, change, risks, and restoration opportunities. It is anticipated that this **Rangelands Data Platform** will serve as *the* "go-to" information source on rangelands, with data made publically available. The information on land use change and restoration will be particularly important for guiding global and national investments in rangelands better building the resilience of communities to shocks and stresses, and for global and advocacy work related to this. Such global data are vital for use in global processes and initiatives such as the UN Decade on Ecosystem Restoration, the anticipated International Year of Rangelands and Pastoralists as well as for development agencies such as IFAD and advocacy networks such as Livestock Data for Decisions (LD4D).

The primary and end beneficiaries of this project are pastoralists and agro-pastoralists who will benefit from more informed, better planned and better value-for-money investments in rangelands. It is also anticipated that eventually pastoralists and other rangeland users will benefit from and use the data itself, though how to best present the data for such use needs to be further developed. National governments, national research centres and local pastoralist networks are also key partners.

In the early months of the project, concerns were raised by those involved in the project about setting up a Platform without confirmed funds for upkeep and maintenance of that Platform, which is not yet the case. As such, we decided to go as far as possible with developing the

[1] www.rangelandsdata.org/atlas

structure and content of the Platform without actually setting it up on line though a domain and website would be created, and part developed for a Rangelands Atlas. This aim was to do this in the most inclusive and informative way working with different stakeholders so all would be aware of the impending Platform and be able to contribute to its development. At the same time effort would be invested in identifying and securing funds for long-term support to the Platform (discussed more in Section 6.0).

1.2 This report

This report summarises the activities that have taken place as part of the project ***Building Resilience in Rangeland Communities with Big Data*** from January-December 2021. Each section will describe a step in the process towards developing the anticipated global Rangelands Data Platform. The final section will give the current status of the Platform, together with challenges incurred, and future plans for further development of the Platform.

2.0 ANALYSIS OF EXISTING GEOSPATIAL PLATFORMS

The first step in establishing the Rangelands Data Platform was a review of existing geospatial platforms with potentially similar objectives to those of the Rangelands Data Platform. This has helped to consider whether any of these would be suitable for hosting the Rangelands Data Platform; to identify best current technologies for the development of the Platform; and to select the most interesting from which to learn. Meetings have been held with the owners of some of these to learn more about their architecture and understand the decisions they made when building their platforms.

The list of platforms and applications was initiated by ILRI and associated partners and complemented by GMV with few more platforms relevant for the study. A brief summary of the results of the analysis is presented in the table below. The references used for links to the websites is found in the Table on page ii.

Table 2.1 Existing platforms

Platform	Description	Features
Earth-Map [RD.1]	Earth-Map is a tool for quick historical environmental and climate analysis based on Google Earth Engine and developed within FAO's Open Foris Initiative with the support of the Government of Germany through The International Climate Initiative (IKI) from the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety.	■ Web-based visualization map. ■ Variety of collections to visualize ■ Allows data processing.
RAPP [RD.2]	The RAPP Map is the spatial data platform for the Rangeland and Pasture Productivity activity which is part of the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative. This online tool gives access to information about the state and condition of global rangelands. It provides time-series data on vegetation and environmental conditions, allowing national and regional tracking of the resources which sustain livestock production	■ Web-based visualization map. ■ Variety of collections to visualize ■ Allows data processing. ■ Allows user data upload for local analysis

Collect Earth [RD.3]	Tool that enables data collection through Google Earth. In conjunction with Google Earth, Bing Maps and Google Earth Engine, users can analyse high and very high resolution satellite imagery for a wide variety of purposes.	■ It works as a tool over Google Earth. ■ It is a desktop application (plugin). ■ Does not provide web-based data visualization.
Dryland Global Assessment [RD.4]	Website that collects the results of different analyses carried out on drylands in the world. The analysis used Collect Earth [RD.3] and draws on information from 213,782 sample plots located across the world's drylands.	■ The way the data is presented is engaging. ■ Contains relevant information about drylands. ■ Does not provide web-based data visualization.
GARDIAN [RD.5]	Global Agricultural Research Data Innovation & Acceleration Network, is a one-stop shop for data and publications, but it also allows users to visualize and analyse data, propelling the CGIAR System farther in an increasingly digitized, data science-driven agriculture for development sector.	■ Search engine for agriculture publications and datasets. ■ It also provides map visualization.
GEOGLAM [RD.6]	Website with information and links on the different participants of the GEOGLAM initiative.	■ It provides access to relevant platforms. ■ It does not provide web-based data visualization.
Trends Earth [RD.7]	Trends Earth (formerly the Land Degradation Monitoring Toolbox) is a platform from Conservation International for monitoring land change using earth observations in a desktop and cloud-based system.	■ It is a desktop application. ■ Does not provide web-based data visualization

Global Forest Watch [RD.8]	Online platform that provides data and tools for monitoring forests. By harnessing cutting-edge technology, GFW allows anyone to access near real-time information about where and how forests are changing around the world.	■ Provides map visualization and analysis of the data ■ Allows user input for areas of interest ■ Focused on forest.
Climate Engine [RD.9]	Web application for visualize and process satellite imagery focused on early warning of drought, wildfire, and crop-failure risk. Build thanks to partnerships between the Desert Research Institute, University of California Merced, and Google.	■ Web-based visualization map. ■ Variety of collections to visualize ■ Allows data processing.
Flood Mapping [RD.10]	Tool that address flood-related information for early warning and risk management of floods. The FMT generates inundation maps for significant floods from 1984 till the present using open Earth data. The tool applies a water classification algorithm to 'stacks' of historical satellite imagery derived from Landsat to reveal inundation patterns over space and time.	■ Web-based visualization map. ■ Variety of collections to visualize or download ■ It does not allow data processing.
Australian National Drought Map [RD.11]	The National Drought Map helps users find a range of information on drought conditions and associated support measures for affected communities. It provides access to spatial data from Australian Government agencies involved in drought prevention and management.	■ Web-based visualization map. ■ Focussed on droughts. ■ It allows uploading data ■ It provides national data aggregated per region.

After conducting the analysis on the web-based platforms and tools. The most relevant platforms for the design of a Rangelands Data Platform were identified. ILRI and GMV contacted the owners/developers of the most interesting platforms to better understand the IT architecture and further understand the motivations behind the critical decisions in their design. The two fruitful meetings held with FAO and GEOGLAM are here below briefly described.

The meeting with FAO was with Danilo Mollicone, Alfonso Sanchez-Paus Diaz and Daniel Dionisio, leads of the FAO's Earth Map platform [RD.1] developed within FAO's Open Foris Initiative. In this meeting ILRI and GMV learned about the technologies used in the platform backend (Google Earth Engine) and got to know more in depth how their platform integrates with Google technologies. Considering that CGIAR and FAO have on-going agreements, FAO offered to potentially deploy the frontend of the future Rangelands Data Platform under their existing environment. This option has great advantages (in cost and effort) but also important limitations with respect to the customization of the platform that should be further analysed. Earth Map is open-source and will be uploaded to GitHub, so it could be also possible to develop the rangelands data platform using FAO's developments as baseline upon getting successful agreement between CGIAR/ILRI and Google to get their in-kind support under their Google Cloud for Researchers program.

The second meeting was held with Juan Guerschman (RAPP project leader from CSIRO) and Ian Jarvis (Program Director of the GEOGLAM initiative), about the RAPP Map platform [RD.2] under GEOGLAM. GMV and ILRI learned more about RAPP's architecture and the tools and technologies in use. The open-source tool Terria.js stands out as a possible solution for the Rangelands Data Platform's frontend. RAPP's data catalogue is supported by in-kind collaborations with several large research institutions. That means that to replicate the approach in rangelands data platform we would need to develop our own solutions in terms of data storage and data access. GEOGLAM welcome the possibility to include the Rangelands Data platform as an associate.

3.0 RANGELANDS ATLAS

3.1 Development and launch of a Rangelands Atlas

A key input to the development of the Rangelands Data Platform has been the production of sets of maps on rangelands, combining a rangelands basemap made up of rangeland-type terrestrial ecoregions drawn from WWF's categorisation of these at global level with other publically available large data sets on different themes/issues including global protected areas, key biodiversity areas, land degradation neutrality indicators, climate change modelling and other. See: https://www.worldwildlife.org/biome-categories/terrestrial-ecoregions

These maps and the data developed from the mapping process were compiled in the first-ever global Rangelands Atlas together with local case studies and facts and figures drawn from the data. This Atlas was launched in May, in the week leading up to the launch of the UN Decade of Ecosystem Restoration. The Atlas was presented as a collaboration between ILRI, FAO, IUCN, WWF, UNEP and the ILC Rangelands Initiative, as well as the Livestock and PIM CRPs, and the Big Data Platform and contributing to the UN Decade of Ecosystem Restoration.

The Atlas is also on line, as a project of the global Rangelands Data Platform. In order to set this up the web domains have been purchased and are ready for use for the Rangelands Data Platform, with the domain address: www.rangelandsdata.org. The address www.datarangelands.org was also purchased so that no-one else will be able to use this very similar address. The address of the Atlas is www.rangelandsdata.org/atlas

The launch received significant publicity, with the Atlas presented several times at different events in June including as part of the official programme of the UN Decade (see below). Maps and data will continue to be added and the website developed as we move towards developing the data platform itself. A list of some of the significant publicity received by the launch of the Atlas is provided in Appendix 1. The Atlas was announced on the Big Data Platform: https://bigdata.cgiar.org/inspire/inspire-challenge-2020/big-data-in-resilience-of-rangeland-communities/

https://bigdata.cgiar.org/blog-post/%E2%80%8B%E2%80%8B%E2%80%8B%E2%80%8B%E2%80%8B%E2%80%8B%E2%80%8Bnew-atlas-reveals-climate-critical-rangelands-cover-half-the-worlds-land-surface-supporting-millions-of-people-and-critical-ecosystems/

4.0 SURVEY TO GATHER INFORMATION ON USER REQUIREMENTS

As part of the process of getting stakeholder input into the design of the Rangelands Data Platform an online survey was undertaken.

4.1 Results of the survey

The questionnaire "Requirements gathering for Rangelands Data Platform" was disseminated in English, French and Spanish through several networks to receive user feedback and develop the most useful data platform for the rangelands community. We requested to the potential user of this platform to answer a short 14-question survey on what they would like from such a platform. Few more optional technical questions were also provided in addition to better define the IT design of the platform.

The networks contacted include the AfriCultuReS community, the Grassland Dialogue Platform, IFAD GeoGroup, IFAD country directors, FAO EarthMap developers, GEOGLAM RAPP developers, the FAO Pastoralist Knowledge Hub and FAO, ESA and IFAD staff directly involved in rangelands management. The questionnaire and the summary of responses is provided in Annex 2. The responses tailored by the most represented user groups are also provided as reference Annex 3.

The survey received 77 responses (by 10th November 2021). 40% of the responses came from academia. Government bodies, NGOs and international agencies cover almost equally other 30% of the total responses.

The questionnaire offered a long list of services that could be available in the future platform. The greatest interest was on **having global datasets to assess the current status and trends in rangelands**. In particular, data to monitor **environmental trends and land use dynamics in rangelands** were the most demanded. According to the statistics the information about **trends in livestock numbers** is also very relevant for the respondents. 70-80% of the responses to the survey cover those topics.

Worth noting that 60% of the respondents are also interested in a **repository of information** about rangelands, and in **having the possibility to self-process data and maps**.

It is remarkable that **all** the options receive support from at least 35% of the participants.

Together with the already mentioned, highest preferences for governmental employees also include **verification of national datasets** and **data for improvement reporting** for international/national commitments. NGOs find also of interest **advocacy and lobbying**, and **crowd-sourcing of data**.

These needs are reinforced by the answers given by the participants to the question on their willingness to use certain datasets from a list of pre-selected ones. 90% of the participants respond that they would use information on **livestock distribution and routes**, and **land use**

land cover (LULC) current status and trends. Data on **climate projections** were also of interest for near 65% of respondents. Worth noting that **soil erosion** is of great interest for governments and **conflicts** relevant for NGOs and international agencies.

All responses were selected by, at least, 20% of the participants.

Potential users demand data and information to be available in the platform at **country level**. Information at **regional administrative boundaries in-country and across country** are also relevant for more than half of the participants.

Regarding the question about the highest interest questions to be answered for understanding rangelands, many respondents mentioned **changes in land use** in rangelands, analysing **degradation** in rangelands due to **overgrazing** and **climate**, how **climate change is impacting** rangelands and livestock, information about **livestock population and carrying capacity**, and **where the rangelands are**.

About the trends to follow, again **dynamics of livestock and land use** are the most repeated answers. Worth also mentioning **climate change impacts** and trends **of vegetation cover, rangelands degradation, demography and biomass**.

On the data to be provided by the platform, there are many different requests for very different purposes. The key words are: trends, change, livestock, regular updates, land use, soil, degradation, rehabilitation, maps. That might be synthetized in a platform **hosting geospatial data (maps) to analyse trends, changes and degradation on livestock, land use and soil with regular updates for rehabilitation** purposes. However, note that many other applications are requested. Flexibility is a must in the platform in order to respond to the needs and expectations from the different rangelands communities.

The most mentioned uses for the data and services requested in the previous questions are for policy development, research, impact analysis, education, investment planning and advocacy.

The question regarding the data to be collected at national level to consolidate global products follows the previous responses. **Trends on LULC, livestock and land degradation**. **Land productivity, biomass and vegetation cover** have also relevance in the answers.

Half of the participants would have interest in **uploading local data** to the platform. That includes photos, reports and national datasets in **tabular, raster or vector data**.

Most of the respondents do not use any web-based platform to get information about rangelands. The answers including platforms refer to national catalogues or multi-purpose geospatial platforms.

The platform design should focus in computer-based deployment. Near all the answers requested support for computers. 30% request a mobile visualization too.

Short films are not of interest for the community, **however local case studies, guidelines and facts/figures** are all requested.

No conclusive answer with respect to the rangelands bulletin subscription.

Data from weather stations network and/or in-situ measurements are relevant for nearly all the participants.

Near 60% of the respondents accepted to continue with the technical questions.

Regarding the preferred visualization in the platform, the most common answer is **maps**. On the visualization options there is no consensus. All the pre-defined options seem to be of interest for the community, but the preference is the **trend analysis**. Note that this is linked to the requirements stated in previous questions where analysis of trends, dynamics or changes were highly demanded.

The most requested **frequency updates** for the data hosted in the platform are **6-months and annual**.

The community requested data, at least, from the beginning of the century in order to assess changes (**last 20 years**). If possible **30 years** or more.

On the spatial aggregation the participants indicate their interest in averages at **district and catchment level,** and information at either **10m or 1km** depending on the product. This is very relevant to design the platform because having **very high resolution products at global level for long time series** drives the platform concept selection. The storage capability of the platform server is then one of the deciding factors.

All options presented to query data are well received by the rangelands community.

Not very demanding time response for data visualization and processing. Majority voted the most conservative option.

The feature to download data is a must for the potential users of the platform. They mostly requested **tabular data and maps**. A third of the respondents would like to download raster data.

More than 80% of the responses indicate their preference to be able **to process their own products**. **Results disaggregated by user group offer the same numbers**. This feature is not only of interest for academia, but also relevant for Governmental members, NGOs and international agencies. Processing capabilities should then be available in the platform to do, at least, **statistical processing and data layer merging**. Pre-processing maps instead of trends and dynamics of different variables do not seem to be a good option. **Fast-processing on-the-fly** via integrated applications, toolboxes or notebooks to cope with the user needs is required.

Users are not particularly interested in joining through a user login.

4.2 User requirements

After analysing collectively and individually the answers to the questionnaire, the team transformed the needs into IT requirements and the most informant features for the design are presented here.

On the data catalogue:

- Datasets from the catalogue shall be updated every 6 months
- Spatial resolution shall be reported at 1km at national level and 10m at regional level
- At least 20 years of data is requested
- Geospatial data
  - To be available at country and regional level
  - Spatial aggregations available per district and catchment
  - Lot of different datasets and products are of interest, with priority for
    - Climate projections
    - Time series of LULC
    - Time series of biomass
    - Global and local rangelands
    - Time series of rangelands condition
    - Time series of livestock population
    - Livestock routes
    - Livestock carrying capacity
    - Time series of vegetation cover
    - Time series of demography
    - Time series of soil erosion
    - Conflicts
- Non-geospatial data
  - Reports and documents
  - Photos

On the features:

- It shall be possible to download data in a variety of formats (both geo and non-geo data)

- It shall be possible to upload data in a variety of formats (both geo and non-geo data)
- Users shall be able to process data
  - To create customized trends and change maps from the time series data
  - To customize aggregated data (spatial/temporal)
  - To combine datasets

On the visualization:

- The platform shall allow visualizing trends, changes and dynamics.
  - As jpg/png maps and graphs for assessments
  - As xls statistics for reporting
- It shall be possible to query datasets per sector, location, parameter, type of data and time period.

5.0 OUTLINE AND STRUCTURE OF THE RANGELANDS DATA PLATFORM

The analysis performed on the user requirements highlights the need for the platform to allow visualising and processing geospatial data in a flexible manner. There is no quorum in the main objectives and purposes the Platform should follow, being in addition all the services and datasets proposed by ILRI and GMV of interest for the users. Some conclusions can be extracted by summarising the results, but the key issue to be addressed in the platform design is the platform capability to satisfy as many needs as possible. Worth noting that this would be only possible by giving the user sufficient options and features to customize the visualization and data creation to fit their daily-work needs.

When designing a web-based geospatial platform there are several decisions to be taken and that will briefly covered in this chapter. Note that both the study of the existing platforms [**Error! Reference source not found.**as well as the IT user requirements extracted from the responses of the questionnaire [**Error! Reference source not found.**were considered for the solutions proposed.

An important characteristic to address is the **data storage**. As presented in [**Error! Reference source not found.**rangelands communities demand, at least, long time series of several climate/biophysical/hazard/socio-economic datasets at national/regional level at high spatial resolution and with frequent updates. Since geospatial data already require large storage capability due to their nature, the demanding data catalogue requested by the users exacerbate this issue.

There exist, however, different solutions to deal with this requirement. One solution consists of hosting the data on **local machines** so that the owner/developer of the platform has complete control of the data available in the catalogue, therefore ensuring rapid access to these data since no data queries are needed to external servers. This solution, local storage, presents some very important drawbacks. It requires purchasing, setting up and maintaining servers with large storage capacities which is very pricy. These servers also require updates when the platform needs more storage or the hardware becomes obsolete. That will happen at a certain point because the steady increase of the data at every data update. In addition, the Platform developers will have to manually upload to the local servers the new data produced by the third party collaborators or the new collections requested by the users so that the data can be duly and timely available on the Platform. Daemons (computer program that runs as a background process) could be installed in the servers of the data producers to check the availability of new data. But this is not always possible and requires specific permissions that might be not granted.

Another option for the data storage is the use of a **cloud-based storage**. This solution consists of renting storage on external servers to host the data requested for the platform. In this approach the issues discussed for local servers are not applicable. The rented capacity can be

expanded or reduced so that it can be adapted to the needs of the platform as it grows. In addition, there are already commercial cloud services that present geospatial data in their offer. That is the case of Google Earth Engine, Microsoft Azure or Amazon Web Services. These cloud providers host in their servers geospatial data collections that are of interest for rangelands communities. Note that data not present in their catalogues can be requested to be added or uploaded following the approach described in the local servers.

In summary, in order to comply with the requirements regarding the data availability, the platform should have great variety of collections at different resolutions with high periodicity updates as well as the possibility to upload data in different formats. Additionally, at least 20 years is needed. All these reasons result in the conclusion that the optimum approach for the platform relies on the usage of cloud services. Among the possible solutions, **Google Earth Engine** (GEE) stands out because it is currently the service with the largest number of collections incorporated in its catalogue. On top of this, most of the successful and with the most optimized performance geospatial platforms employ GEE as backend, including Earth Map as discussed with FAO's during our meeting [**Error! Reference source not found.**].

Another relevant topic is the requirement on the processed data. The platform could include data **pre-processed** on its catalogue and this would include time series statistics, combined data or spatial aggregations. These data can be processed off-line and added to the catalogue by the platform owner so it can be directly visualized and downloaded by users. This might be an interesting option when a scientific team that knows well the user community needs is behind the platform so they can create and validate the processed data relevant for the users (e.g. [RD.10]). Nevertheless, based on the questionnaire responses, each group of users has different expectations on the platform design. To be as compliant as possible with the user demands the best solution is to provide the user with the capability of processing their data via integrated applications, toolboxes or notebooks. It would not necessarily imply users having programming skills to develop their own application, instead the platform developers can install pre-configured applications on the platform giving the user possibility to process what they need in a friendly interface for non-scientific / non-technical users.

The processing algorithms will run on either the local servers or cloud services. The advantages of a cloud solution mentioned in the storage section holds here too: easily scalable to the demand and discarded the need to purchase and maintain local machines. Moreover, some services that offer cloud processing, already implement efficiently some of the most common functions for geospatial data processing (e.g. layer combinations, temporal and spatial mean) further increasing the preference to implement these services on the platform.

In conclusion, a commercial **cloud processing solution** stand out as the best option according to the meetings held with the platforms' owners [**Error! Reference source not found.**] and to the requirements discussed in [**Error! Reference source not found.**. A variety of the platforms analysed use GEE as their processing tool (e.g. [RD.1], [RD.8], [RD.9] and [RD.10]) which is a solution that implements many functionalities aimed at geospatial processing and solves the storage solution, therefore it is the most powerful option available for the Rangelands Data

Platform's backend. At the time of writing the GMV team has had contacted with Rebecca Moore, director of Google Earth and Google Earth Engine, to explore the possibility of partnering in this initiative.

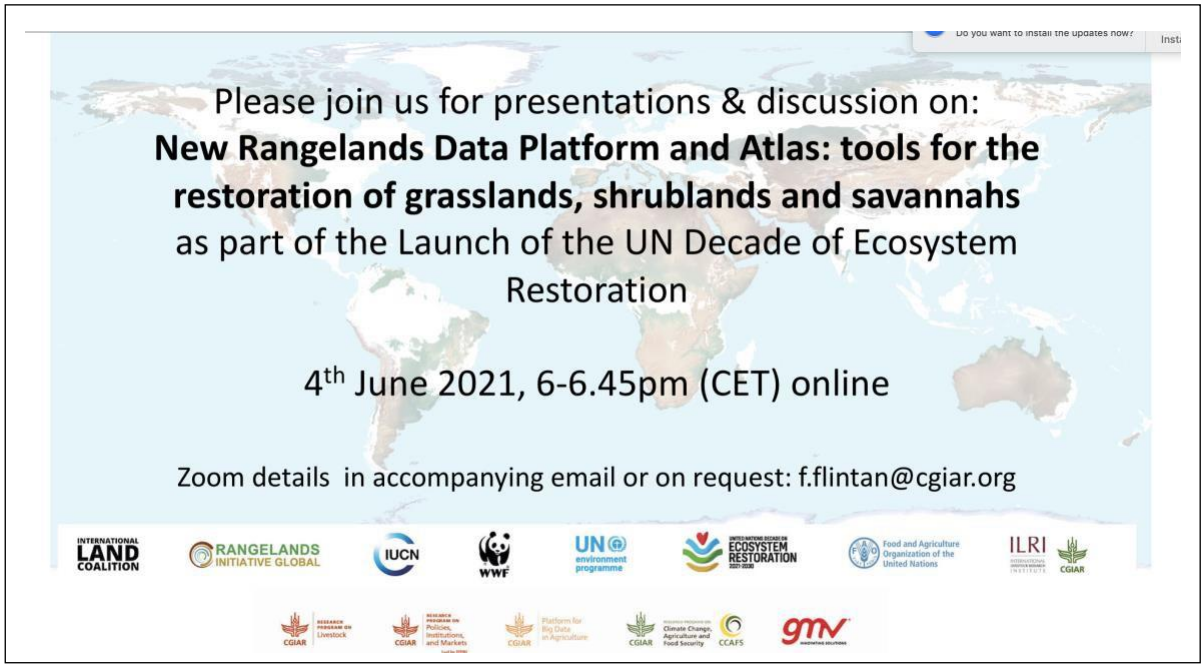
To address the challenges posed by the rangelands user community in the visualization of the data, it is required a frontend with enough functionalities to integrate all the tools mentioned in the data processing discussion. Our analysis revealed that, currently, the best options are MapBox and TerriaJS. MapBox stands out as the best private option and offers highly customizable map solutions for geospatial websites. It is implemented as frontend solution on [RD.8] and [RD.10]. On the other hand, TerriaJS is the best open-source solution, consisting on a framework for web-based geospatial catalogue and it is implemented, for instance, on [RD.2] and [RD.11]. MapBox is a relevant option when focusing on the frontend customization, allowing the developer to build its own customized dashboard and thus better adjusting to the user's needs. TerriaJS is significantly more limited with respect to the customization. Worth noting that integrating the MapBox solution in the Rangelands Data Platform will require either purchasing a licence or getting in-kind support under the umbrella of their Education program.

As a final remark it is important to reinforce the idea of the need for a flexible platform that includes a large storage capacity to host a wide variety of collections as well as the addition of processing tools for users. The conclusion extracted from the study of state-of-the-art platforms and solutions indicates that the architecture that better adapts to these needs is a platform whose backend is based on GEE with a Mapbox frontend. This solution implies a partnership with Google under their Google Cloud for Researchers program and with MapBox under their Education program.

6.0 FINAL REMARKS

There is a clear demand for a global Rangelands Data Platform, and this project has gone a significant way to developing the Platform and realising it. An extensive consultation taken place over the last year by ILRI and GMV which has allowed us to identify what we believe to be the best structure and modality for the Platform. The website is set up, and currently has the Rangelands Atlas already available on it (highlighting the support provided from the Big Data Platform). The very successful launch of the Rangelands Atlas as a first step towards the Rangelands Data Platform highlighted strong international organisation support for filling the gaps in big data (partners on the Atlas were ILRI, FAO, IUCN, WWF, UNEP and ILC Rangelands Initiative), as well extensive media coverage.

At the same time, we/ILRI have been involved in a number of events where we have firstly raised awareness on the demand for big data on rangelands, and secondly shared the plans to launch the Platform. The Rangelands Data Platform was presented at an international meeting held as an official side event of the launch of the UN Decade of Ecosystem Restoration on 4th June 2021 (Presentations being put on CGSpace and recording on YouTube). Presentations on the Atlas and the Rangelands Big Data Platform were also presented at the Livestock Data for Decisions (LD4D) Summer Session, August 2021.



Remaining tasks include looking at the alignment of the proposed structure and modality with two case study countries – Kenya and Kyrgyzstan – and this is underway through consultations with key stakeholders there. Following this, some adjustments may be needed to ensure that the proposed Platform best supports and links with government platforms as much as possible. In addition, at least one brief will be produced on current available data on rangelands and remaining gaps.

The next step will be to finalise the design of the Rangelands Data Platform and to launch it. However, for this we want first to ensure that secure funding is available for the Platform for at least 2-3 years to allow for further development, updating and maintenance – there is no point launching a Platform that we cannot keep updated. As such, we have decided not to launch the Rangelands Data Platform until this is confirmed. Happily, the Platform has been included in the 1CGIAR Initiative Livestock Climate and System Resilience as an activity, and once budgets are confirmed for the first year we can assess when it would be best to launch the Platform. We are also looking to some of the international partners to provide financial support.

Appendix 1: Selection of media coverage of launch of the Rangelands Atlas

Date	Headline	URL	Source	Country	Language	Reach
5/28/21 2:34	La mitad de la superficie terrestre del mundo está formada por pastizales	https://www.vertigopolitico.com/bienestar/medio-ambiente/notas/la-mitad-de-la-superficie-terrestre-del-mundo-esta-formada-por-pastizales	Vértigo Político	Mexico	Spanish / Castilian	46.952
5/28/21 2:08	Los pastizales naturales son esenciales para enfrentar el cambio climático y revertir la pérdida de biodiversidad	https://www.virtualpro.co/noticias/los-pastizales-naturales-son-esenciales-para-enfrentar-el-cambio-climatico-y-revertir-la-perdida-de-biodiversidad	Revista Virtual PRO	Argentina	Spanish / Castilian	58.489
5/27/21 19:00	¿Cuál es el valor de los pastizales naturales para enfrentar el cambio climático?	https://www.elnuevosiglo.com.co/articulos/05-27-2021-cual-es-el-valor-de-los-pastizales-naturales-para-enfrentar-el-cambio	El Nuevo Siglo Bogota	Colombia	Spanish / Castilian	248.749
5/27/21 17:49	Nuovo Atlante delle praterie: ricoprono la metà della superficie terrestre e sono fondamentali per il clima	http://www.alternativasostenibile.it/articolo/nuovo-atlante-delle-praterie-ricoprono-la-met%C3%A0-della-superficie-terrestre-e-sono	Alternativa Sostenibile	Italy	Italian	8.503
5/27/21 17:30	New atlas reveals rangelands cover half the world's land surface, yet often ignored despite threats	https://www.westwaleschronicle.co.uk/blog/2021/05/27/new-atlas-reveals-rangelands-cover-half-the-worlds-land-surface-yet-often-ignored-despite-threats/	West Wales Chronicle	United Kingdom	English	8.966
5/27/21 10:52	Nuevo atlas muestra importancia de pastizales para manejo de la crisis climática	https://www.eleconomista.com.mx/arteseideas/Nuevo-atlas-muestra-importancia-de-pastizales-para-manejo-de-la-crisis-climatica-20210526-0159.html	El Economista	Mexico	Spanish / Castilian	4,731,858
5/27/21 9:28	La superficie terrestre del mundo está formada por pastizales, una oportunidad para abordar la crisis climática y de biodiversidad	https://www.enfoquemonterrey.com.mx/site/?new=66322&text=la-superficie-terrestre-del-mundo-está-formada-por-pastizales-una-oportunidad-para-abordar-la-crisis-climática-y-de-biodiversidad	Enfoquemonterrey	Mexico	Spanish / Castilian	503

5/27/21 8:28	La mitad de la superficie terrestre del mundo son pastizales	http://www.periodismoyambiente.com.mx/2021/05/26/la-mitad-de-la-superficie-terrestre-del-mundo-son-pastizales/	Periodismo y Ambiente	Mexico	Spanish / Castilian	632
5/27/21 2:29	Rangelands atlas	http://www.indiaenvironmentportal.org.in/content/470636/rangelands-atlas/	India Environment Portal	India	English	49.638
5/27/21 1:34	WWF: Áreas de pastagem devem ganhar importância no combate às alterações climáticas	https://greensavers.sapo.pt/wwf-areas-de-pastagem-devem-ganhar-importancia-no-combate-as-alteracoes-climaticas/	SAPO	Portugal	Portuguese	11,635,751
5/27/21 1:34	Áreas de pastagem devem ganhar importância no combate às alterações climáticas, diz ANP/WWF	https://www.cmjornal.pt/sociedade/clima/detalhe/areas-de-pastagem-devem-ganhar-importancia-no-combate-as-alteracoes-climaticas-diz-anpwwf	Correio da Manhã	Portugal	Portuguese	4,294,064
5/27/21 1:19	Áreas de pastagem devem ganhar importância no combate às alterações climáticas – organização ambientalista	https://www.agroportal.pt/areas-de-pastagem-devem-ganhar-importancia-no-combate-as-alteracoes-climaticas-organizacao-ambientalista/	Agro Portal	Portugal	Portuguese	66.515
5/27/21 0:47	Livestock can play a very important role': New atlas hopes to push 'climate-critical' rangelands up the global agenda	https://www.foodnavigator.com/Article/2021/05/26/Livestock-can-play-a-very-important-role-New-atlas-hopes-to-push-climate-critical-rangelands-up-the-global-agenda	Food Navigator	United Kingdom	English	252.608
5/26/21 22:21	WWF, il 54% delle terre emerse sono praterie	https://www.ansa.it/canale_ambiente/notizie/natura/2021/05/26/wwf-il-54-delle-terre-emerse-sono-praterie_06efe510-f444-430e-a608-8dbda2f634d8.html	ANSA.it	Italy	Italian	15,073,239

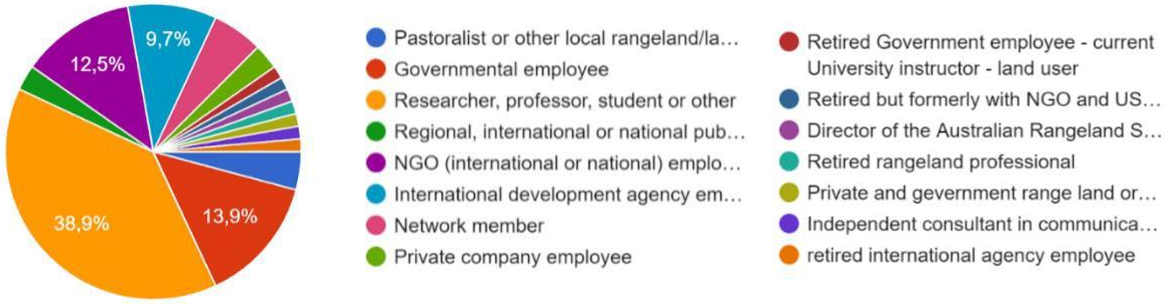
5/26/21 21:33	New Data Shows Rangelands Make Up Half the World's Land Surface – and Present a Severely Underutilized Opportunity to Address the Climate and Biodiversity Crises	https://www.worldwildlife.org/press-releases/new-data-shows-rangelands-make-up-half-the-world-s-land-surface-and-present-a-severely-underutilized-opportunity-to-address-the-climate-and-biodiversity-crises	World Wildlife Fund	United States	English	1,539,073
5/26/21 21:14	New Data Shows Rangelands Make Up Half World's Land Surface – and Present a Severely Underutilized Opportunity to Address Climate	https://www.miragenews.com/new-data-shows-rangelands-make-up-half-worlds-566692/	Mirage News	Australia	English	406.927
5/26/21 20:45	Em Portugal, 31% do território está de fora do plano de combate às alterações climáticas	https://jornaleconomico.sapo.pt/noticias/em-portugal-31-do-territorio-esta-de-fora-do-plano-de-combate-as-alteracoes-climaticas-743690	SAPO	Portugal	Portuguese	11,635,751
5/26/21 20:24	Pubblicato il "Rangeland atlas", il nuovo Atlante mondiale delle praterie	https://www.greenreport.it/news/aree-protette-e-biodiversita/pubblicato-il-rangeland-atlas-il-nuovo-atlante-mondiale-delle-praterie/	Greenreport	Italy	Italian	96.427
5/26/21 19:45	Em Portugal, 31% do território está de fora do plano de combate às alterações climáticas	https://www.agroportal.pt/em-portugal-31-do-territorio-esta-de-fora-do-plano-de-combate-as-alteracoes-climaticas/	Agro Portal	Portugal	Portuguese	66.515
5/26/21 19:41	Pubblicato il "Rangeland atlas", il nuovo Atlante mondiale delle praterie	https://www.youfeed.it/news/4981.9426626-pubblicato-il-rangeland-atlas-il-nuovo-atlante-mondiale-delle-praterie	YouFeed It!	Italy	Italian	17.814
5/26/21 17:40	PRATERIE, NUOVO ATLANTE WWF: COPRONO LA METÀ DEL PIANETA	https://www.nelcuore.org/?p=54059	Nelcuore.org	Italy	Italian	11.58

5/26/21 17:25	L'Atlante della biodiversità	https://www.vanityfair.it/news/approfondimenti/2021/05/26/atlante-biodiversita-wwf-fao-pascoli	Vanity Fair	Italy	Italian	5,688,771
5/26/21 9:01	New atlas reveals climate-critical rangelands cover half the world's land surface, supporting millions of people and critical ecosystems— yet often ignored despite threats	https://news.cision.com/wwf-international/r/new-atlas-reveals-climate-critical-rangelands-cover-half-the-world-s-land-surface--supporting-millio,c3353672	News Cision	United States	English	578.877
5/26/21 8:21	WWF, il 54% delle terre emerse sono praterie	https://www.altoadige.it/ambiente-ed-energia/wwf-il-54-delle-terre-emerse-sono-praterie-1.2921614	Alto Adige	Italy	Italian	634.401
5/26/21 8:21	WWF, il 54% delle terre emerse sono praterie	https://www.giornaletrentino.it/ambiente-ed-energia/wwf-il-54-delle-terre-emerse-sono-praterie-1.2921614	Trentino	Italy	Italian	343.463
26/5/21	Il nuovo atlante delle praterie	https://www.wwf.it/news/?58241/Il-nuovo-Atlante-delle-praterie	WWF ITALY	Italy	Italian	
27/5/21	NEW ATLAS REVEALS CLIMATE-CRITICAL RANGELANDS COVER HALF THE WORLD'S	https://marcopoloexperience.com/green/new-atlas-reveals-climate-critical-rangelands-cover-half-the-worlds	MARCO POLO EXPERIENCE-Global views and business strategies	Italy	English	
26/05/2021 h 18:34	Areas de pastagem devem ganga importância no combate as alterações climáticas, diz ANP/WWF	https://www.cmjornal.pt/sociedade/clima/detalhe/areas-de-pastagem-devem-ganhar-importancia-no-combate-as-alteracoes-climaticas-diz-anpwwf	cm Jornal	Portugal	Portuguese	

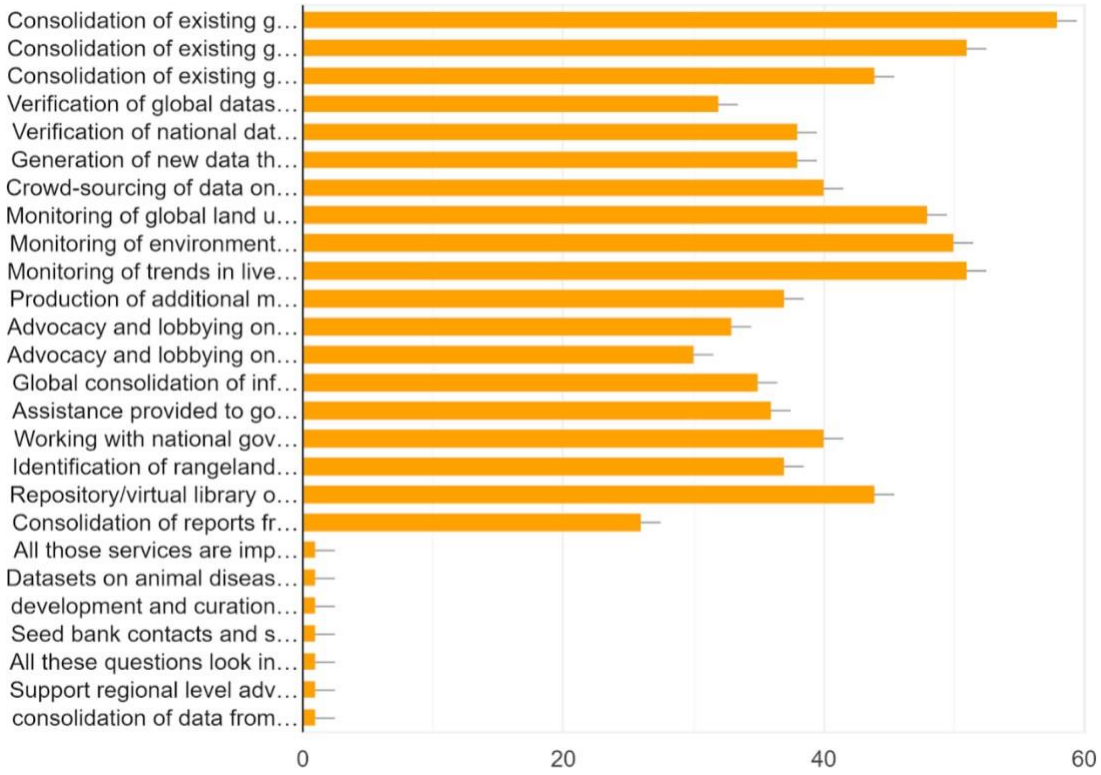
28/5/21	Atlas shines light on world's vulnerable and critical rangelands	https://www.engineeringnews.co.za/article/atlas-shines-light-on-vulnerable-and-critical-rangelands-2021-05-28/rep_id:4136	Creamer Media's Engineering news	South Africa	English	
28/5/21	WWF presenta il Rangeland Atlas l'atlante dei pascoli	https://www.ilgiornaledellaprotezionecivile.it/attualita/wwf-presenta-il-rangeland-atlas-latlante-dei-pascoli	Il giornale della Protezione civile	Italy	Italian	
26/5/21	New Atlas reveals climate-critical rangelands cover half the world's land surface, supporting millions and critical ecosystems- yet often ignored despite threats	https://knowledge.unccd.int/publications/new-atlas-reveals-climate-critical-rangelands-cover-half-worlds-land-surface	Knowledge hub- United nations convention to combat Desertification	WW	English	

Appendix 2 Questionnaire results

Q2.1 Which type of user group would you best categorize yourself as?



Q2.2 Which of the following services would you like a Rangelands Data Platform to provide? Please tick the boxes:



Q2.3 What are the three questions that you consider are most important in understanding rangelands at global or national levels that we do not have adequate data for?

Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

Q2.4 What do you consider to be the three most important trends in rangelands that the global data platform could follow?

Visual representation of the most mentioned terms:

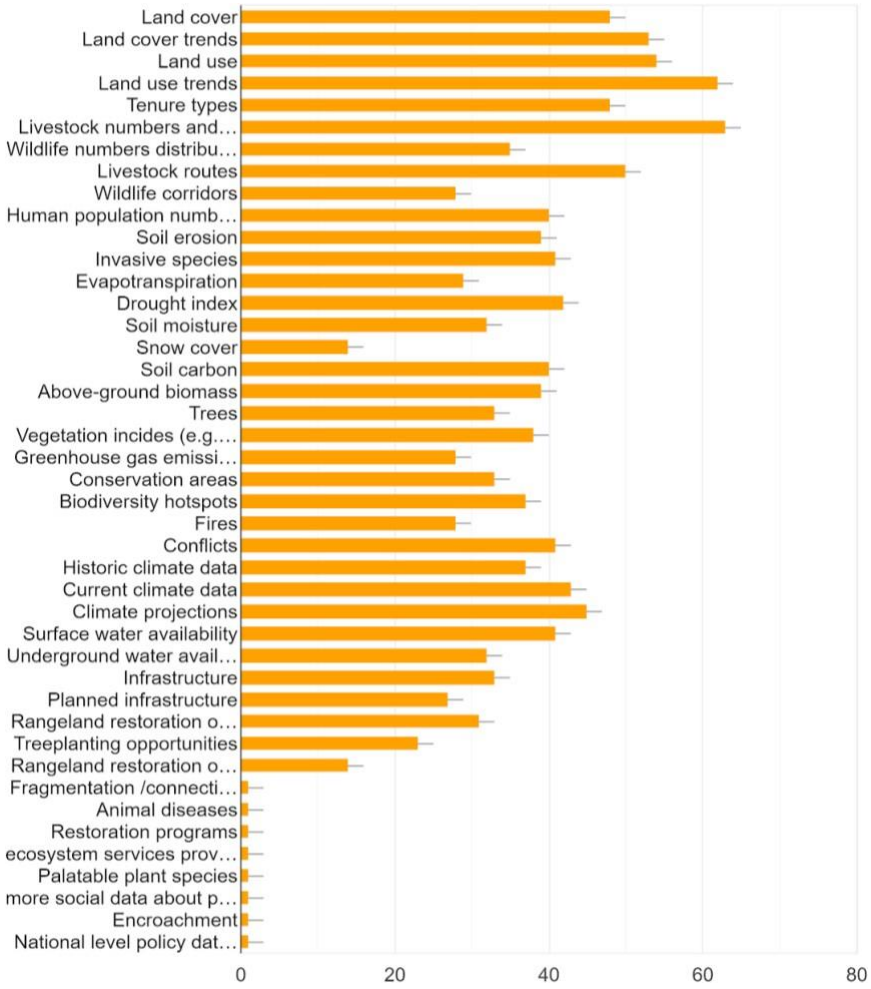
Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

Q2.5 What data would you like to see provided by a global Rangelands Data Platform? Please be specific as possible, give emphasis on the application linked to the need, and list as many types of data as you want. E.g. "I would like detailed information on rangelands degradation updated yearly for rangelands rehabilitation planning"
Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

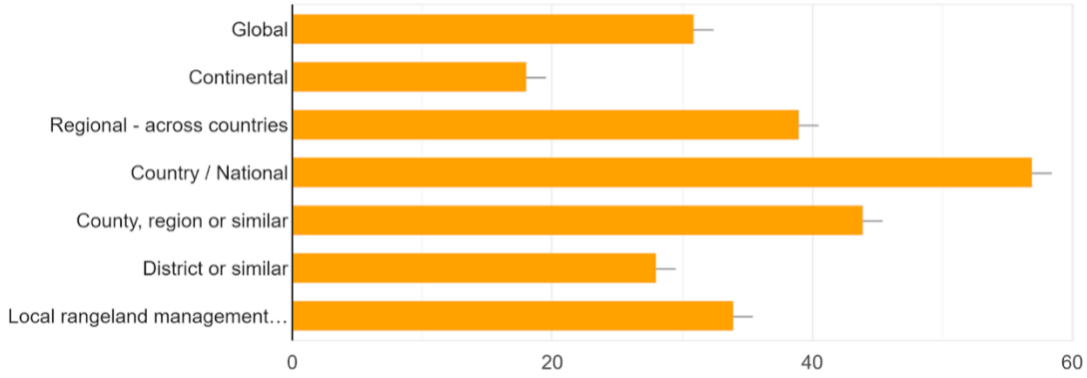
Q2.6 What are the three most common purposes that you will use this data for?
Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing



Q2.7 If the Rangelands Data Platform provided information on the following would you use this data? [Check the ones that you would use]

Q2.8 What level of data are you most interested?



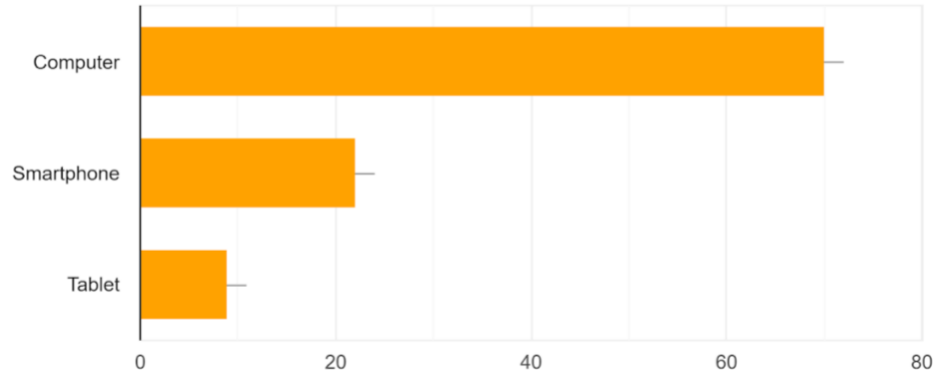
Q2.9 What do you consider to be the three most important data that should be collected at national level for a national level Rangelands Data Platform and then which could be consolidated globally?
Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

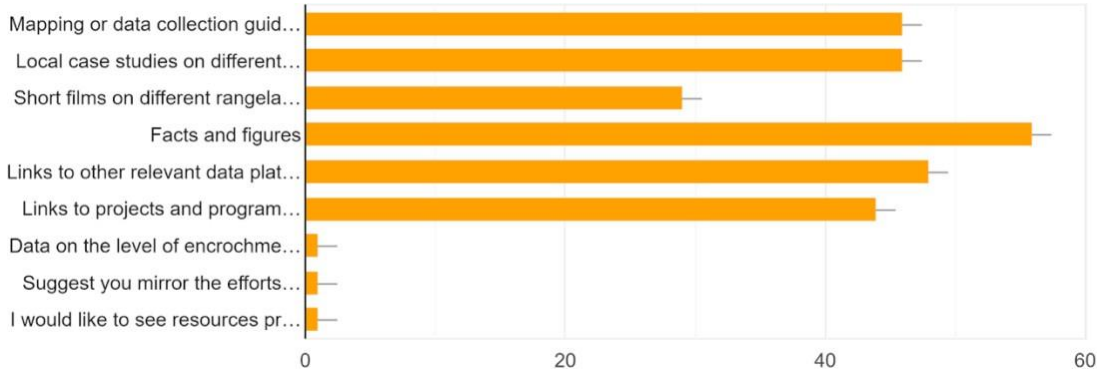
Q2.10 Do you have data to share with the rangelands data platform? If yes, what is this data and in what format is it (e.g., JPG, GeoTiff, XML, Json, XLS, etc.)? If possible please estimate how much data storage capacity you would need for this shared data.
Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

Q2.11 Are you currently using any web-based data platforms providing information on rangelands? If yes, what are these platform(s) and what are you using them for?
Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

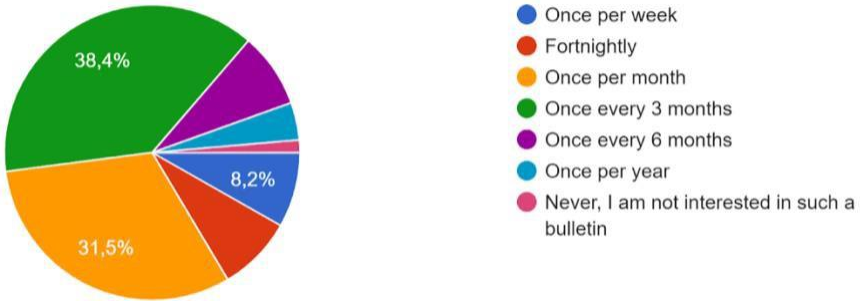
Q2.12 Once established, from where would you mainly access the global rangelands data platform?



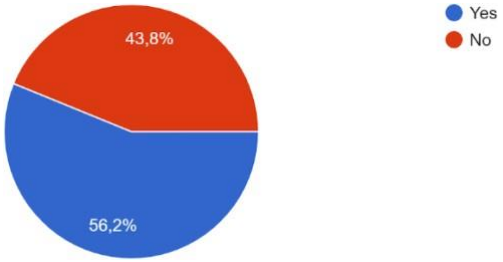
Q2.13 What other support material would you like to see on the rangelands data platform apart from data and maps?



Q2.14 If the global rangelands data platform published a short (no more than 4 page) bulletin of new data on rangelands from data generated, how often would you like to receive this:

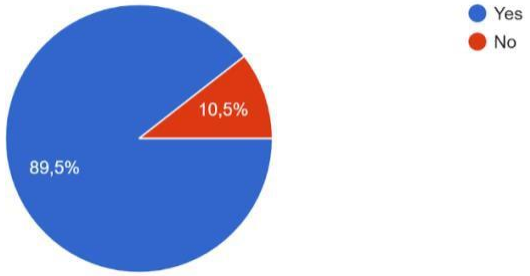


Thank you for providing us with information about your needs and preferences related to data on rangelands. Now we would like to ask you a few more additional questions linked to data storage, visualization, processing and other that we will use to help define the technical specifications of the data platform. Do not feel obliged to answer all questions but rather, provide what information you can. Would you like to respond the extra technical questions?



Technical questions

Q3.1 Are data from weather stations or gathered from in-situ measurements usually of interest for you?



Q3.2 What is your preference with respect to the data visualization (any data) in the Rangelands Data Platform?
Visual representation of the most mentioned terms:

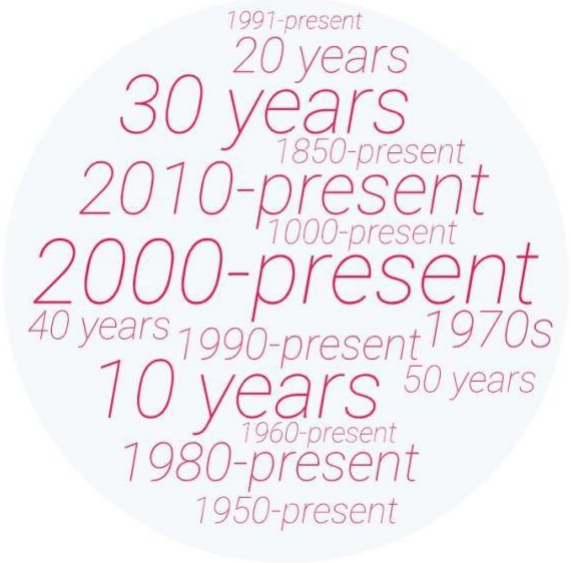
Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

Q3.3 For instance, in case you want to assess/visualize changes how would you like to do it?

Q3.4 Which update frequency do you need? (E.g. if you need Land degradation updated every 6 months, the answer here would be "6 months")
Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

Q3.5 Which temporal coverage do you need? (The temporal coverage refers to the time period available for the product. E.g. I want to assess the changes in rangelands over the last 20 years, the answer would be 2000 - present)
Visual representation of the most mentioned terms:

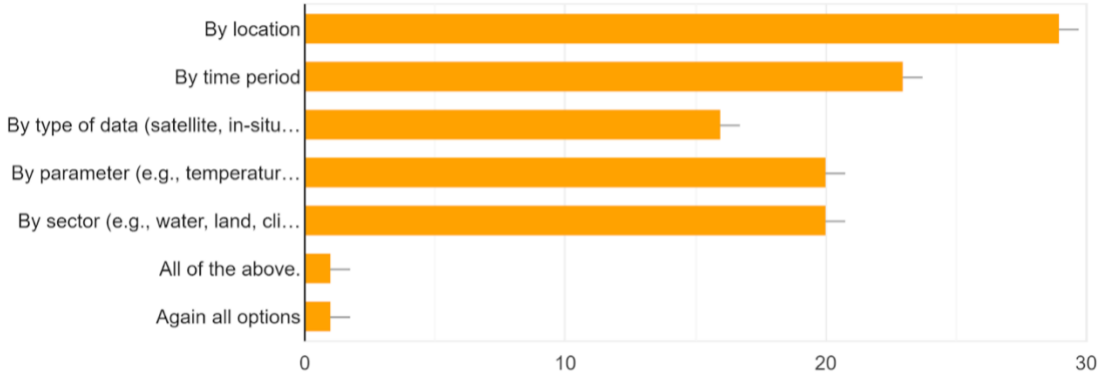


Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

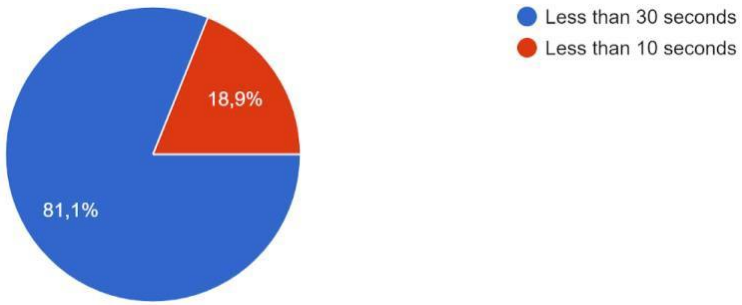
Q3.6 What is the spatial resolution or aggregation you would need? (E.g. 10m, 1km, per county, per catchment, per district, etc.)
Visual representation of the most mentioned terms:

Individual responses are available in the link below.
https://docs.google.com/document/d/1ykyF6M3v7eq4BGVdG8BdM_G-jksGGVz-Lj_pZTw2wos/edit?usp=sharing

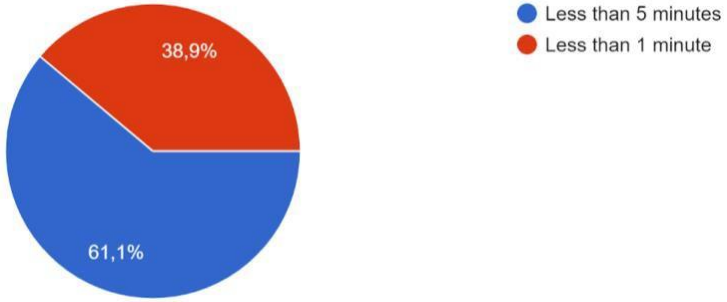
Q3.7 What are your preferred option to search datasets?



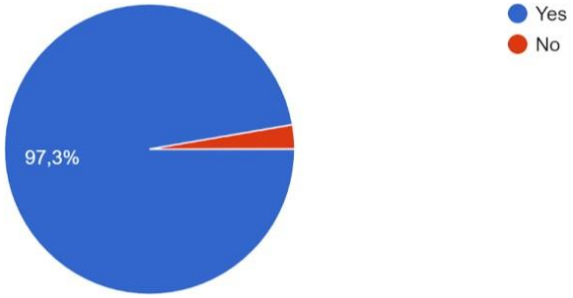
Q3.8 How much loading time would be acceptable for data visualization?



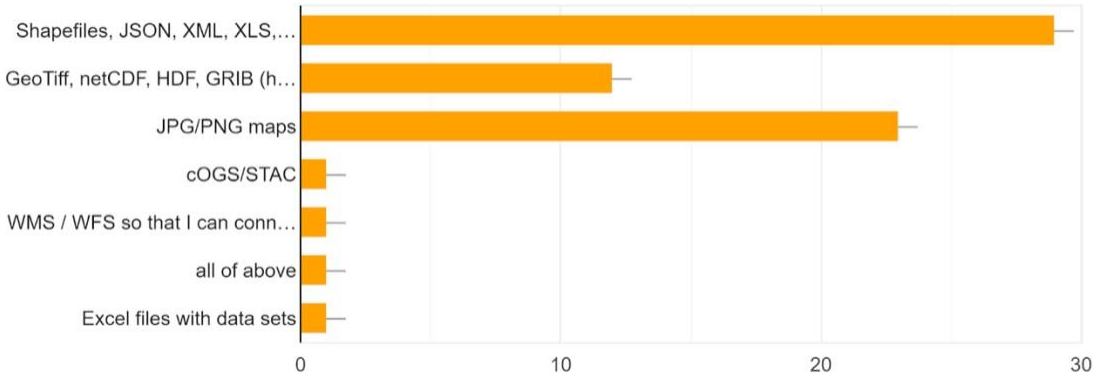
Q3.9 How much loading time would be acceptable for data processing?



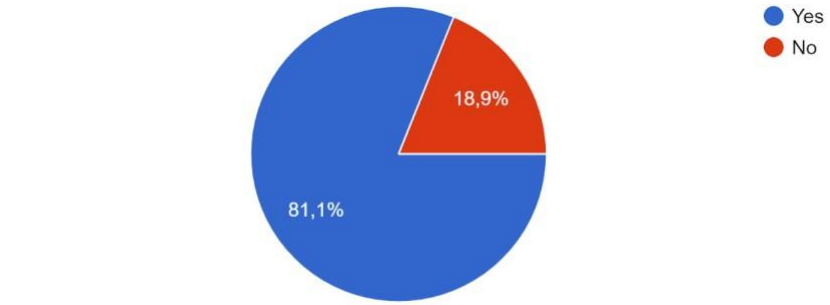
Q3.10 Would you like to download data from the data catalogue, or maybe processed by you?



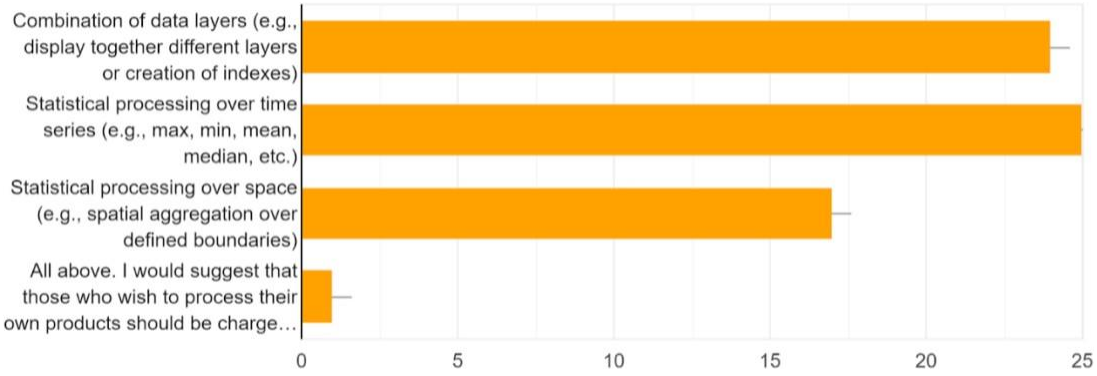
Q3.11 If yes, which file formats would you like to have available for download?



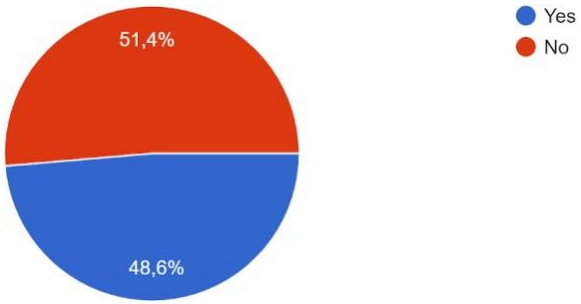
Q3.12 Would you like to have the possibility to process your own products?



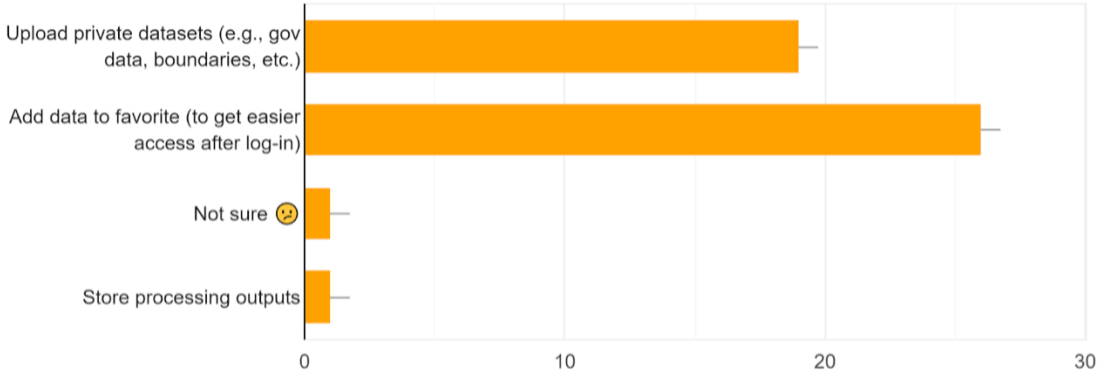
Q3.13 If the answer to the previous question is yes, what type of processing would you perform? E.g. merging livestock numbers with rangeland degradation to spot areas at risk from overgrazing



Q3.14 Would you like to have the possibility to use the platform without user login?



Q3.15 If you want to login with your own user profile, which features should each user have?



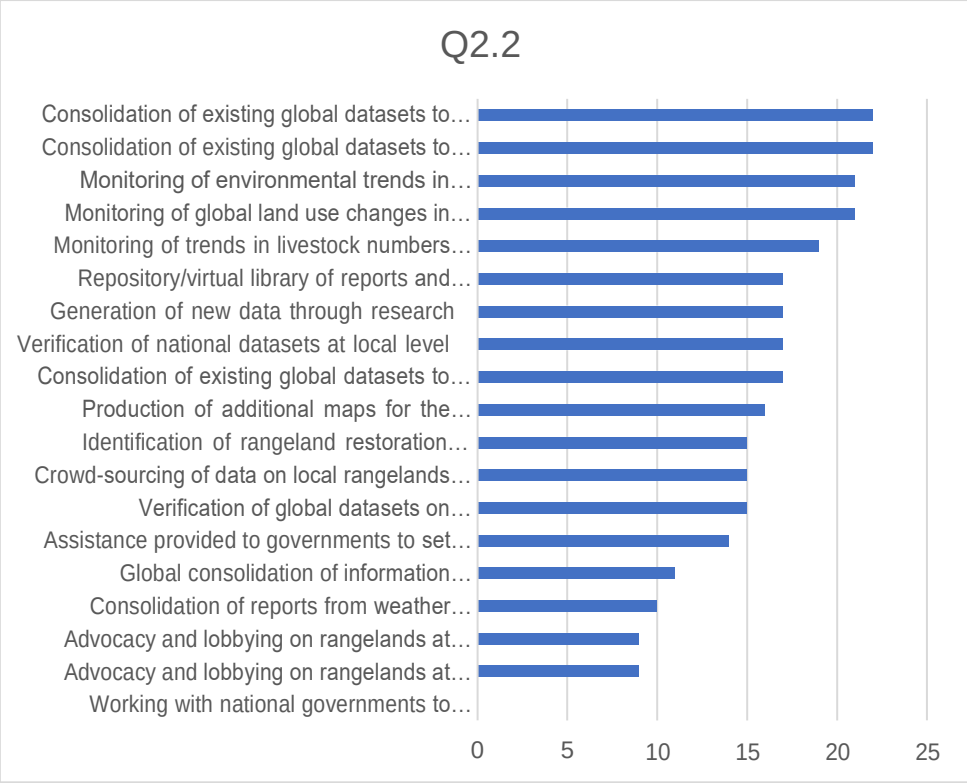
Questionnaire results tailored by group taxonomies

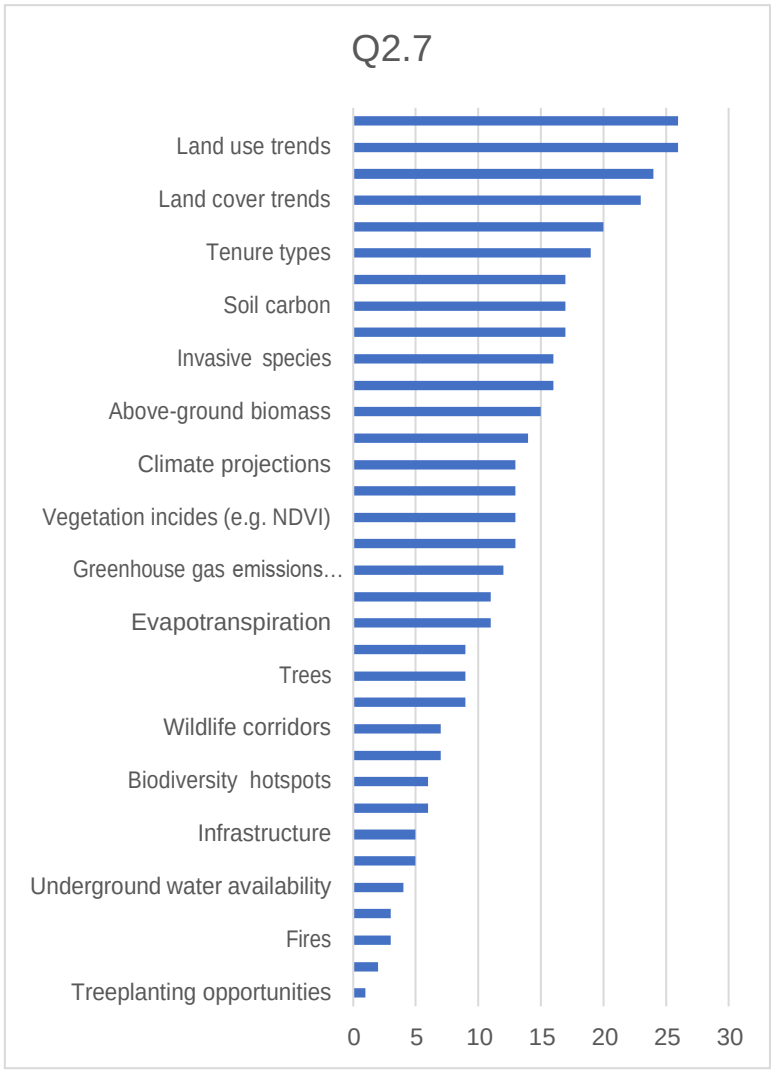
The groups of users with the greatest representation have been selected. Researcher, professor student or other (38.7%), governmental employee (13.5%), NGO (international or national) employee (12.3%) and international development agency employee including UN (9.6%).

Furthermore, the questions selected to analyse are the most critical for the platform design. These are questions 2.2, 2.7, 3.10 and 3.12.

Researcher, professor, student or other

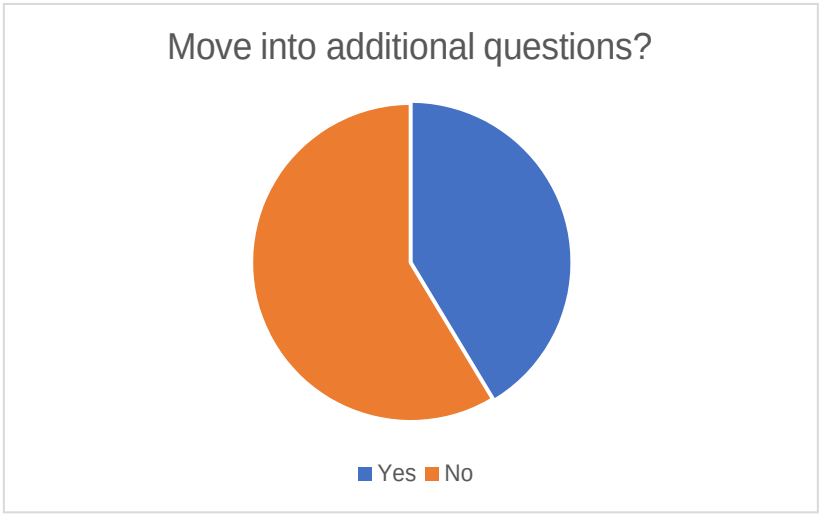
Q2.2 Which of the following services would you like a rangelands data platform to provide?



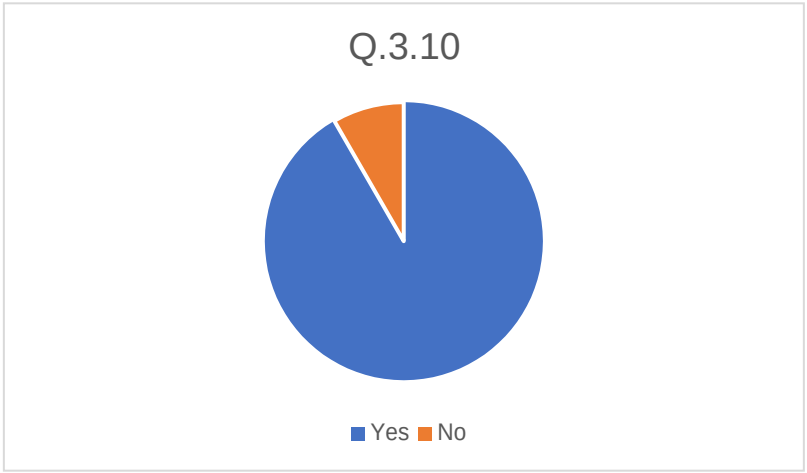


Q2.7 If the Rangelands Data Platform provided information on the following would you use this data?

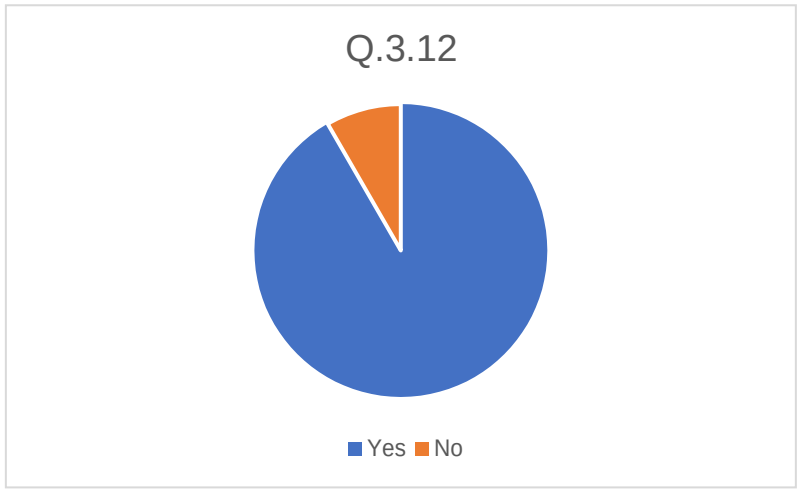
Inside this group, 40% opted for answering technical questions60% no.



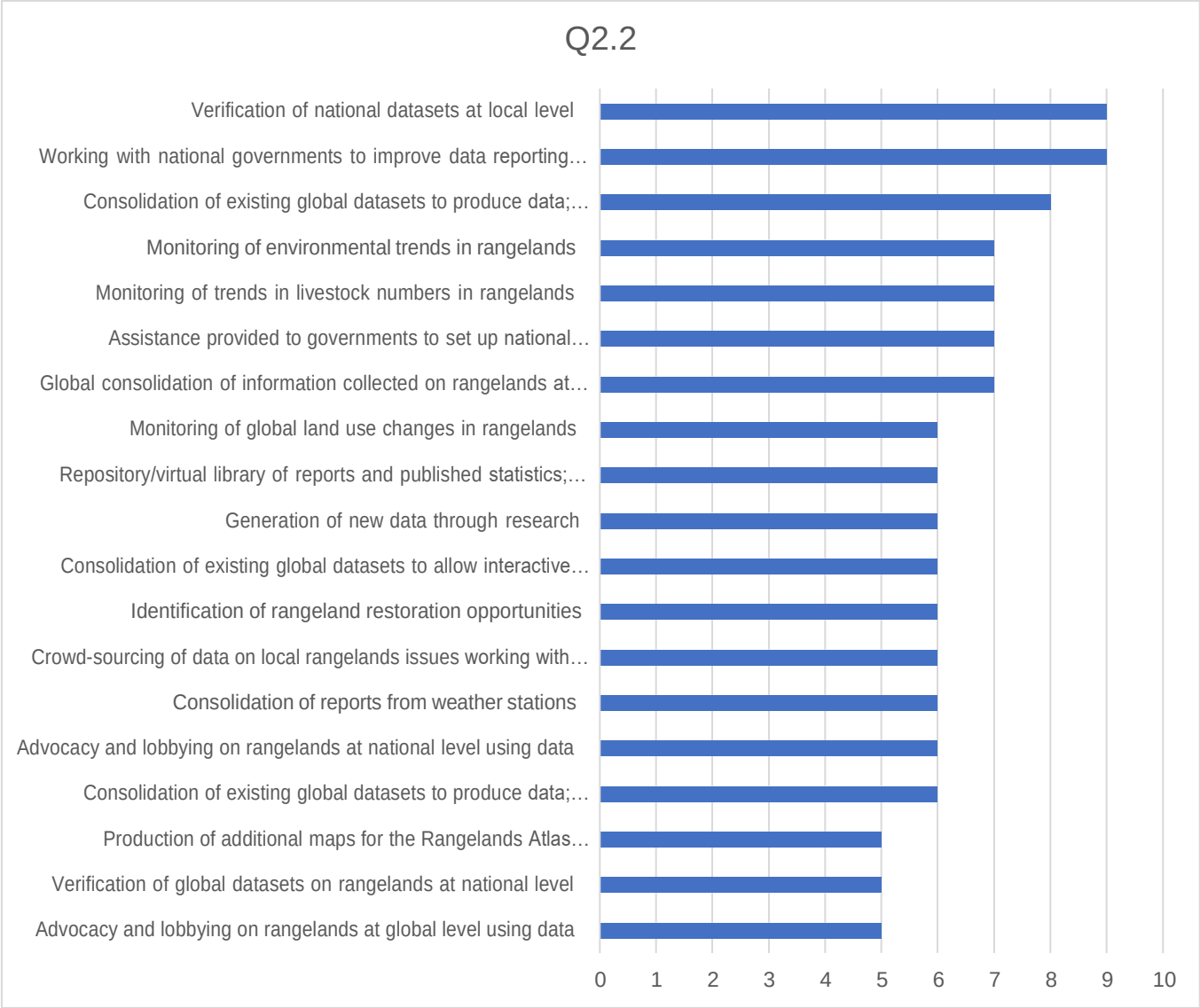
Q3.10 Would you like to download data from the data catalogue, or maybe processed by you?

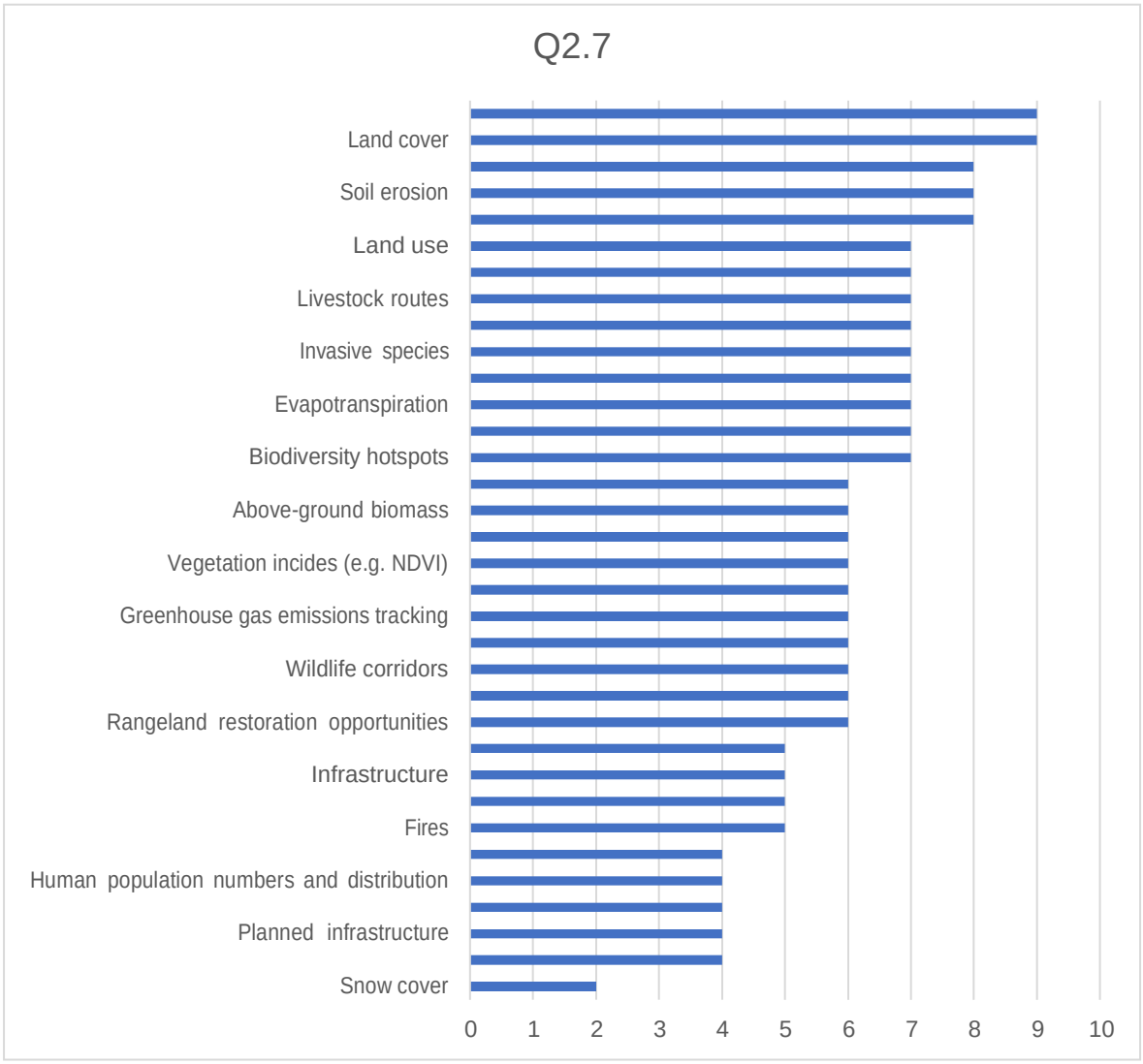


Q3.12 Would you like to have the possibility to process your own products?



Government employees

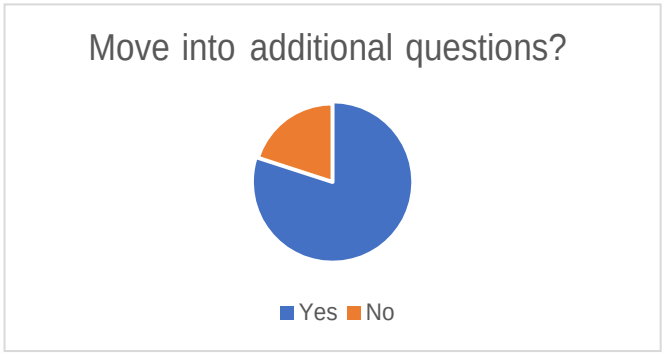




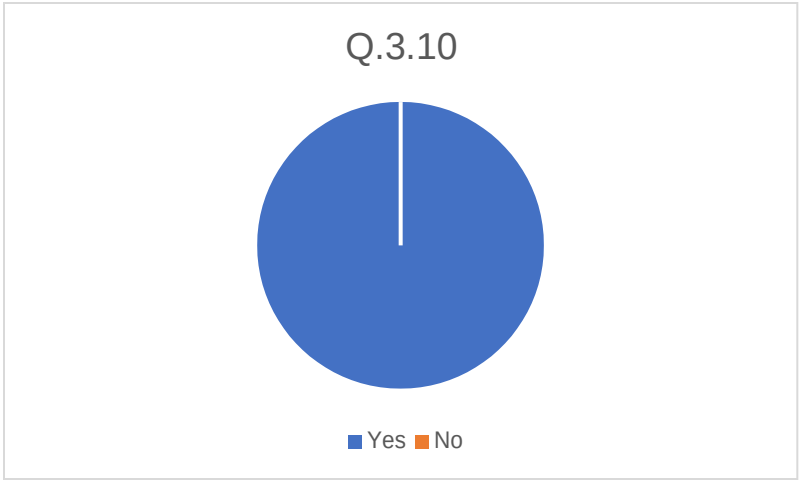
Q2.2 Which of the following services would you like a rangelands data platform to provide?

Q2.7 If the Rangelands Data Platform provided information on the following would you use this data?

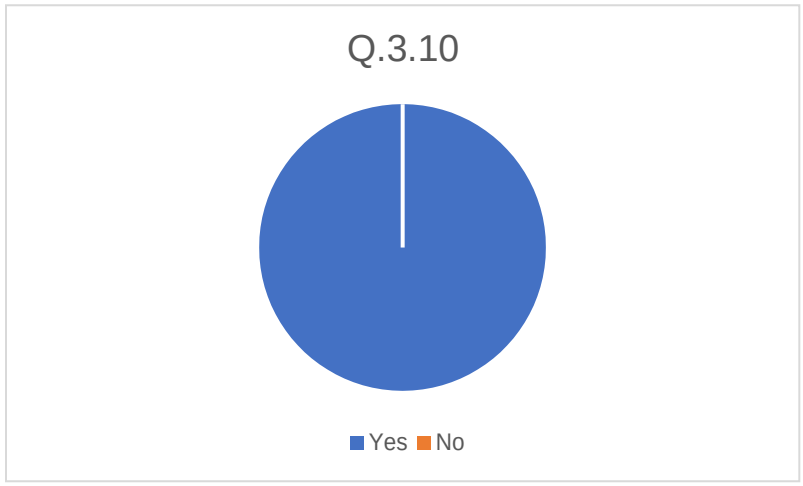
Inside this group, 80% opted for answering technical questions while 20% opted for finishing the questionnaire.



Q3.10 Would you like to download data from the data catalogue, or maybe processed by you?



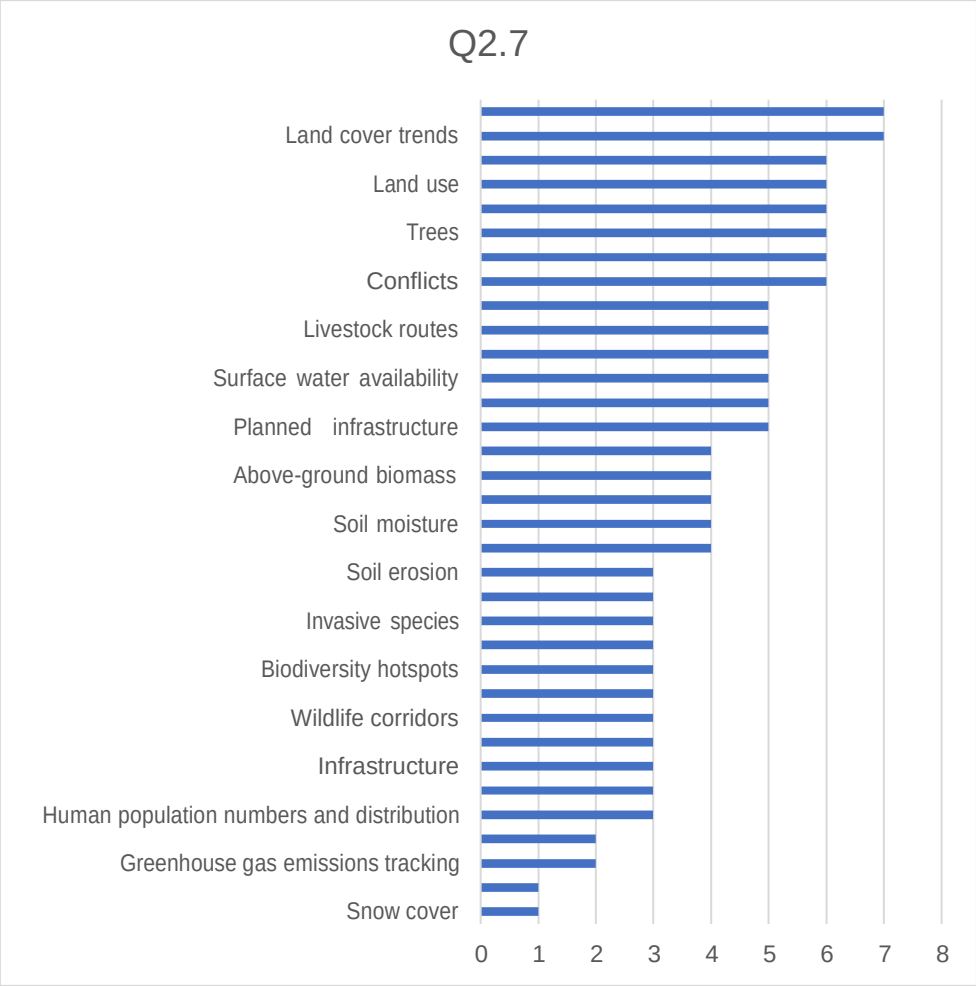
Q3.12 Would you like to have the possibility to process your own products?



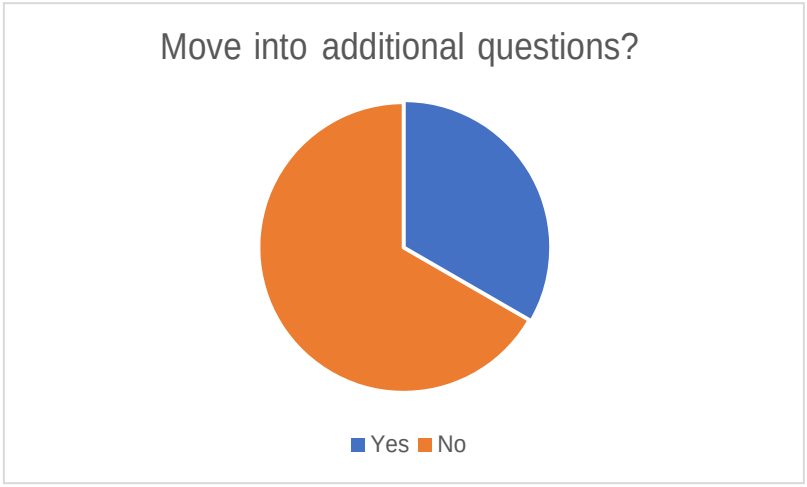
NGOs and development workers

Q2.2 Which of the following services would you like a rangelands data platform to provide?

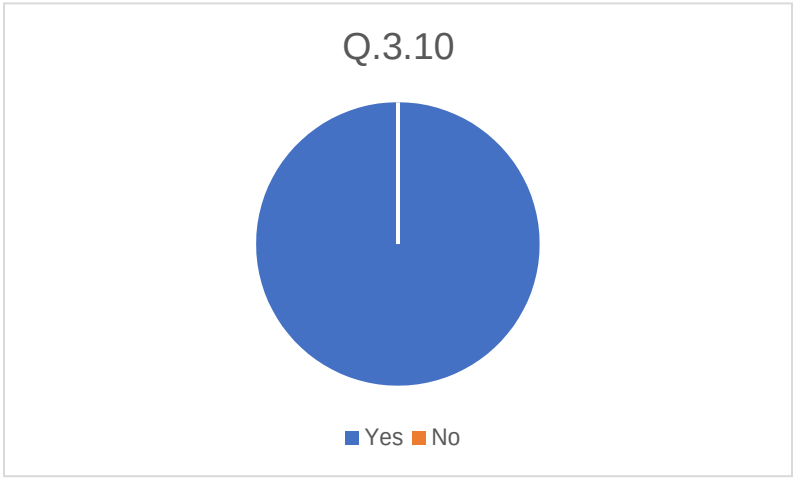
Q2.7 If the Rangelands Data Platform provided information on the following would you use this data?



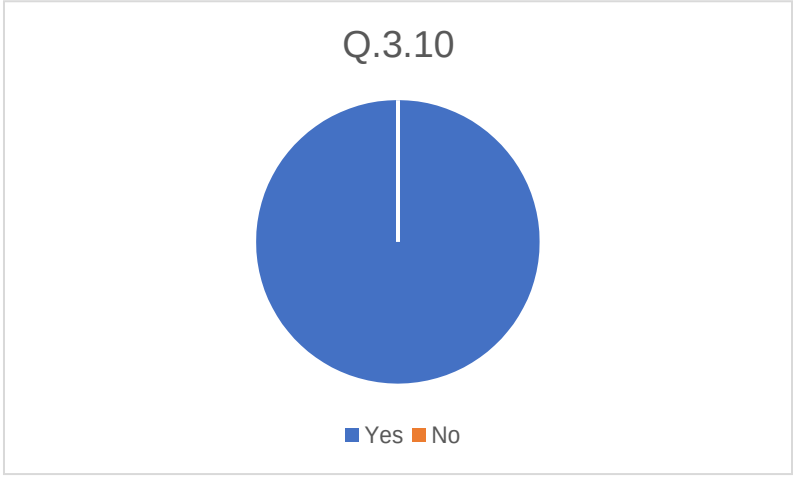
Inside this group, 33% opted for answering technical questions while 66% opted for finishing the questionnaire.



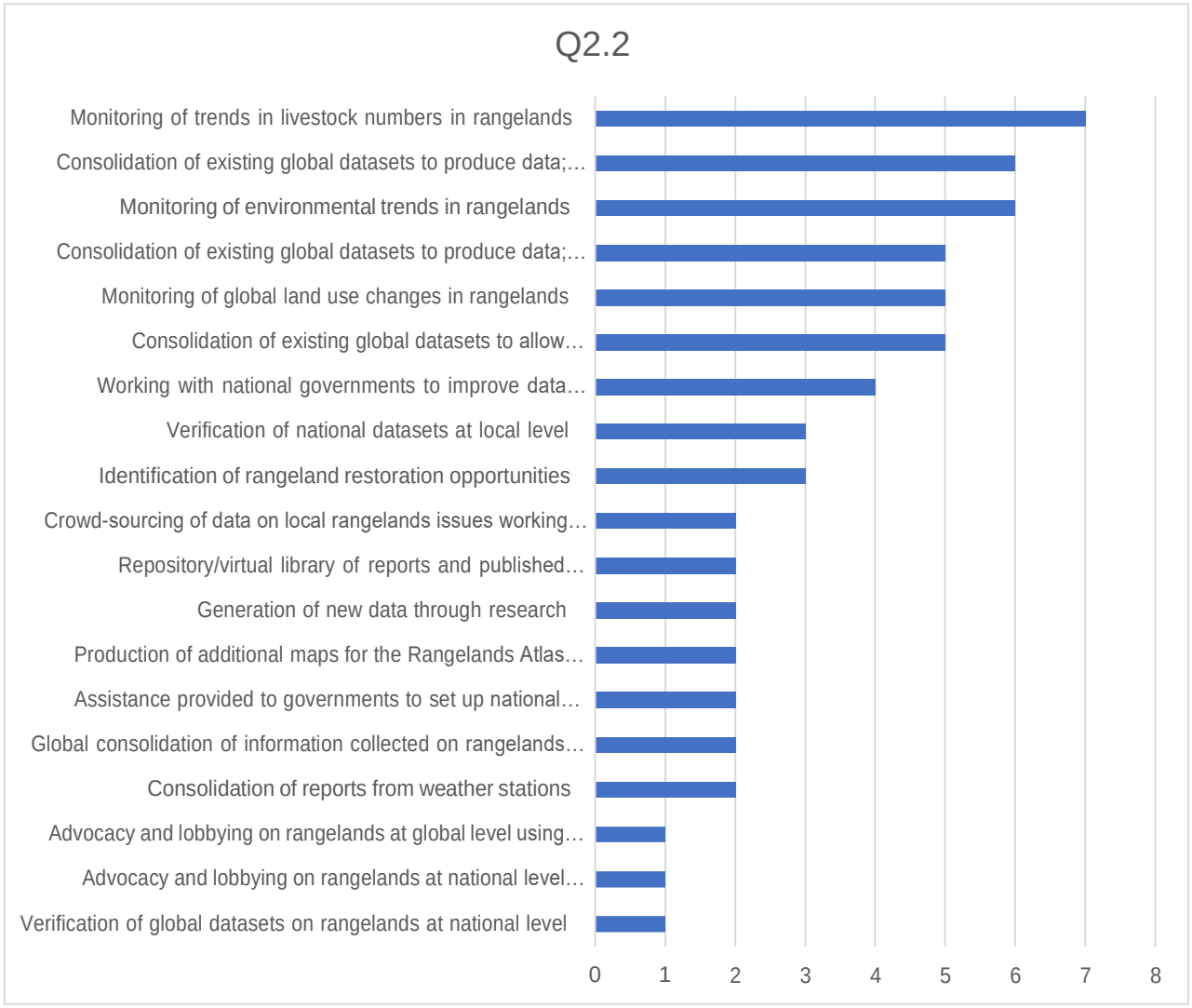
Q3.10 Would you like to download data from the data catalogue, or maybe processed by you?



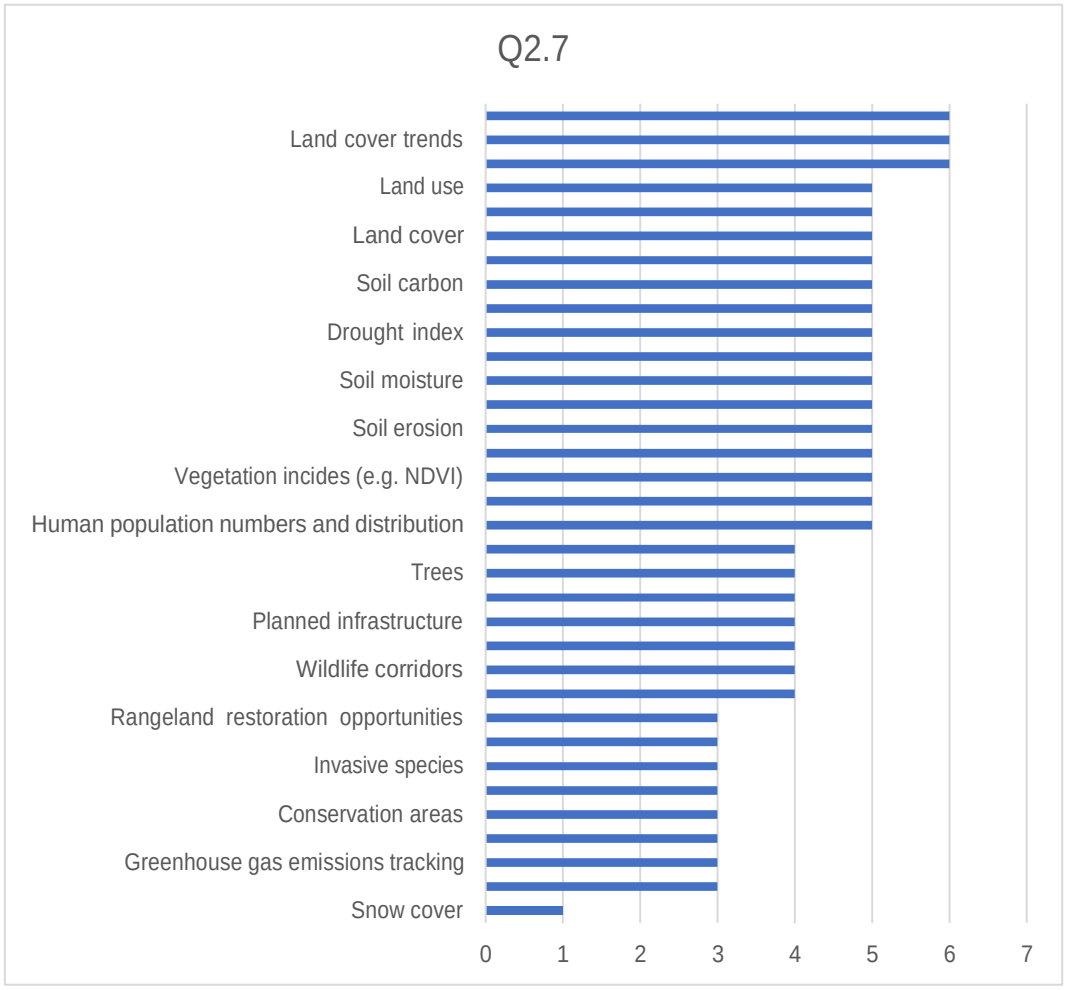
Q3.12 Would you like to have the possibility to process your own products?



International development agency

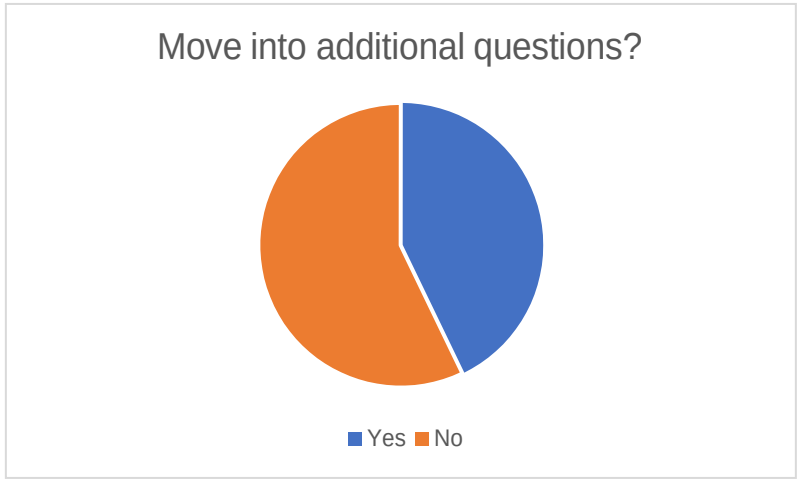


Q2.2 Which of the following services would you like a rangelands data platform to provide?

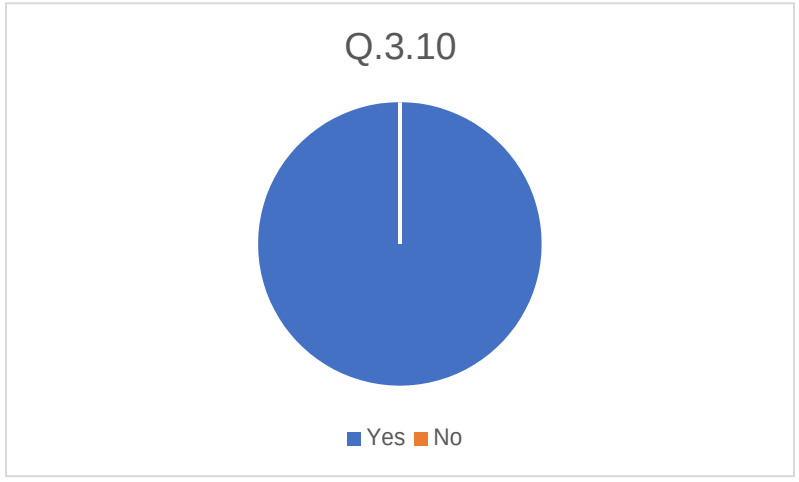


Q2.7 If the Rangelands Data Platform provided information on the following would you use this data?

Inside this group, 43% opted for answering technical questions while 57% opted for finishing the questionnaire.



Q3.10 Would you like to download data from the data catalogue, or maybe processed by you?



Q3.12 Would you like to have the possibility to process your own products?