SPACE+ DATA DASHBOARD: EMPOWERING INSTITUTIONS AND CITIZENS WITH SEAMLESS SPACE DATA ACCESS

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ABSTRACT:

This paper presents the Space+ Data Dashboard (SDD), a robust platform developed by the Philippine Space Agency (PhilSA), designed to revolutionize space data access for institutions and citizens. Built using open-source technologies, the SDD seamlessly manages spatial and non-spatial datasets. The SDD is composed of three core components: backend, frontend, and database. The backend uses PostgreSQL with PostGIS for data storage and indexing, Geoserver for vector files, and the Open Data Cube for raster files. Django handles other data types and serves API requests. The front-end uses TerriaMap, a customizable web front-end built on TerriaJS to provide public access and geo-visualization, and ReactJS for user interface and interaction. The SDD is envisioned to fulfill PhilSA's mandate to empower government institutions and the Filipino people using space technologies. It democratizes data access to facilitate the use of space + geospatial data in disaster management, urban planning, environmental monitoring, and informed decision-making. The dashboard also offers direct downloads of various space-derived datasets. In championing data accessibility, PhilSA ensures data-driven decision-making, advancing both national space initiatives and the United Nations' Sustainable Development Goals.

1. INTRODUCTION

As our world becomes more interconnected and our challenges more intricate, the demand for space data continues to grow exponentially (Anderson et al, 2013). Space data proves its effectiveness in disaster management, environmental monitoring, and urban planning (Van Westen, 2000; Ustin, 2004; Wellman et al, 2020). Nevertheless, several obstacles obstruct convenient access to space data, including its complexity, high costs, and limited availability (Kashnitskiy, 2015). The Philippine Space Agency (PhilSA) is mandated to improve public access and resource-sharing in space-related endeavors (Section 8, RA 11363, 2018). This encompasses the development, operation, and management of space facilities for government agencies, stakeholders, and the private sector as well as assisting in utilizing space science, technology, applications (SSTA), and space data to fulfill their respective mandates (Section 8, RA 11363, 2018).

Aligned with the objectives of advancing national space initiatives and promoting data-driven decision-making, a Presidential Directive is currently in effect, directing the Philippine Space Agency (PhilSA) and other concerned agencies to develop a system to ensure that government agencies can access relevant satellite data in a form that the concerned agencies can easily understand and use. In response, a plan of action has been created, which includes the development of the Philippine Space Data and Geospatial Information System (PhilSpace+). This innovative system is designed to facilitate seamless access and ease of use for relevant satellite data benefiting various government entities (Blanco et al, 2022). At its core lies the Space+ Data Dashboard (SDD), a robust platform that empowers both institutions and citizens with comprehensive space data access.

The Space+ Data Dashboard not only represents a technological advancement but also a strategic alignment with the United Nations' Sustainable Development Goals (SDGs). It is aligned with SDG 9 (Industry, Innovation, and Infrastructure) by fostering innovation and inclusivity in data access. It also contributes to SDG 16 (Peace, Justice, and Strong Institutions) by making space data readily available thus, empowering institutions with the tools to make informed decisions and develop sustainable policies. Additionally, the SDD exemplifies the collaborative spirit of SDG 17 (Partnerships for the Goals) by forging partnerships between government agencies, the private sector, and the broader public, all working collectively to harness the power of space data for the betterment of society.

This paper discusses the conceptualization, architecture, and data hosting capabilities of the Space+ Data Dashboard. By incorporating efficient design principles and adopting a user-centric approach, we explore the seamless integration of space data from multiple sources. Data is presented through an intuitive and user-friendly interface as well as free download capability for hazard and climate-related outputs. Moreover, this paper presents various use cases highlighting its envisioned role in supporting government services, public service initiatives, and research applications.

2. MATERIALS AND METHODS

2.1 Space+ Data Dashboard Core Architecture

The development of the SDD is rooted in the utilization of open-source technologies as their use promotes transparency, flexibility, and cost-effectiveness (Simon, 2005). The SDD architecture is inspired by the National Map of Australia and Digital Earth Africa which uses Open Data Cube and Terria Map.

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The difference is that it adds Geoserver and Django to further strengthen the backend and handle other data formats. The SDD is designed to manage extensive spatial datasets that include both raster and vector formats. Its backend architecture facilitates efficient data storage that can accommodate diverse data formats and enables complex queries and analyses.

The SDD is comprised of three (3) key components: database, backend, and front-end. The primary database is PostgreSQL augmented with PostGIS. The backend uses Geoserver to handle and serve vector files, Open Data Cube to manage raster files, and Django to handle other data types and serve API requests. On the front-end, TerriaMap was chosen as it showcases a data catalog and geo-visualization functionality for map layers. Additionally, ReactJS was used to supplement TerriaMap for specific user access levels and advanced functionalities.
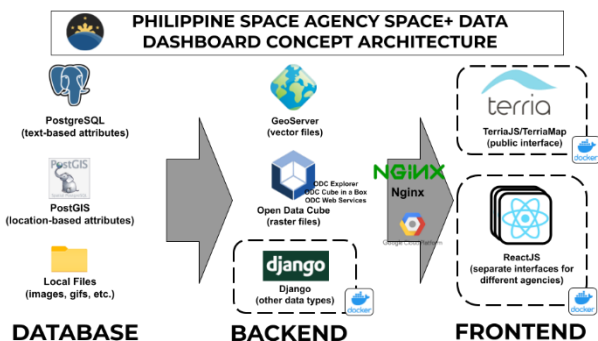

Figure 1. Space+ Data Dashboard Core Architecture

2.1.1   PostGIS: PostGIS is an extender of PostgreSQL used to handle spatial datasets (Obe, Hsu, 2021). PostgreSQL is an object-relational database management system; with PostGIS, spatial datasets can be queried and handled in conformity to industry standards (Obe, Hsu, 2021).

PostgreSQL/PostGIS also serves as the database for handling and indexing datasets in the Open Data Cube. Objects defined by their model schemas in Django are also stored in the same database.

2.1.2   Open Data Cube: The Open Data Cube (ODC) is an open-source software that provides geospatial raster data management and analysis (Open Data Cube, 2021). The Open Data Cube is developed to handle different satellite imagery and their derived datasets.

As of December 2018, there are nine (9) operational Open Data Cubes in the world, eleven (11) under development, and twenty-eight (28) countries with expressed interest (Killough, 2018). The use of Open Data Cube for the SDD is the first for the Philippines on the national level.

2.1.3   Geoserver: GeoServer is a Java-based server that allows users to view and edit geospatial data using Open Geospatial Consortium (OGC) standard (GeoServer, 2023). GeoServer allows users to add, access, and style both vector and raster layers (Youngblood, 2013). It supports Web Map Services (WMS), Web Feature Services (WFS), Web Map Tile Services (WMTS), and Web Coverage Services (WCS) for web mapping and mobile applications. GeoServer also handles GeoWebCache and task automation through REST API; however, does not support raster datasets with Time Dimensions.

2.1.4   Django: Django is a Python-based web development framework that can handle spatial and non-spatial datasets (Holovaty, Kaplan-Moss, 2009). Django also provides a mechanism for handling API requests through the REST framework.

Django was used in the production of the SDD Catalog from the GetCapabilities URL of Geoserver and Open Data Cube. URL Endpoints are also created to handle uploading, deleting, and updating of non-spatial datasets such as legends, images, and icons.

2.1.5   TerriaJS: TerriaJS is an open-source solution for building spatial data federation web platforms. It is a feature-rich customizable web front-end application built on TerriaJS that uses Cesium and WebGL for a full 3D globe in the browser without the need for plugins (Terria, 2020).

TerriaMap was used in creating web interfaces for visualizing spatial data for the National Map of Australia and digital twins in the Philippines (Sta. Ana, Escoto, Fargas et al, 2021). TerriaMap was also used in creating the public-facing interface of the SDD.

2.2   User Interface

The SDD requires the handling of both raster and vector datasets. It requires intuitive functionalities to maximize the use of space data outputs created by the agency. To support these requirements, the following functionalities were identified:

Feature Description	Proposed Solution
Cataloguing of Data Layers	Create a working list of data layers to be added, and method for updating
Display of Metadata and Description of Data Layers	Supply metadata and data description along with data layer
Visualization of Raster Layers	Supported by WMS/WFS, investigate caching, faster loading
Visualization of Vector Layers	Supported by WMS/WFS, investigate caching, faster loading
Display of Legend for Data Layers	Create Style Layer Descriptor (SLD) file that is added with data layer
Basic Map Viewing: Zoom, Pan, and Rotate	Supported by TerriaMap
Choosing of Basemaps	Enumerate basemaps to include in the Dashboard
Uploading of own Data Layers	Supported by TerriaMap
Viewing of Temporal Data Layers	Enable Time Dimensions and add Time Dimension to data layers
Comparison/Differencing of Data Layers	For rasters, ensure same bands/schema; For vectors, consider PyTurf
Viewing of Charts/Graphs to analyse Trends	Add Time Dimension to data layers and add data attribute
Connection to real-time/near real-time data	Consider API requests, and frequent fetching of new data
Feedback mechanism	Create a support email

Table 1. Features needed for the Space+ Data Dashboard

2.3 Space+ Data Dashboard Catalog

The Space Data Mobilization and Applications Division (SDMAD) of PhilSA generates various data layers using both open and commercial imagery sources. Other datasets from various sources may also be included to complete some use cases in the SDD. Some of these examples include the global Google Open Buildings dataset and Microsoft Bing Building Footprints. Data layers from NAMRIA's Geoportal hub may be rehosted in the SDD. Other data layers include the following:

Catalog Category	Data Layer
Agriculture	Maps for different crops
	Flooded Croplands
	Disease-infested croplands
Boundaries	Barangay, Municipal, Provincial, and Regional Boundaries
	Archipelagic and Territorial Boundaries
Climate	Drought Monitoring
	Land Surface Temperature
	Precipitation Data
	Urban Heat Islands
Disaster Risk Reduction and Management	Flood
	Landslide
	Oil Spill
	Volcanic Eruption
Environment	Air Quality
	Night Time Lights
	Soil Type and Classification
	Waste and Pollution Data
	Water Quality
Land Cover and Land Use	Land Cover
	Land Use
	Building Footprints
Marine and Oceans	Satellite Derived Bathymetry
	Benthic Cover
Monitoring	Ship Detection
Satellite Images	Landsat Imagery
	Sentinel Imagery
	DIWATA Imagery
	MULA Imagery
Vegetation	Mangrove Extents
Traffic	Public Transportation
	Traffic Flow

Table 2. Data Layers in the Data Catalog

All of the data present in the SDD Data Catalog are hosted either in Open Data Cube or GeoServer.

3. RESULTS AND DISCUSSION

3.1 Current Features of the Space+ Data Dashboard

This section describes the current features, elements, functionalities, and other architectural components of the SDD.

Figure 2. The Space+ Data Dashboard Interface

3.1.1 Selection of Basemaps: By default, the SDD uses the NAMRIA Geoportal PH Basemap with data labels. Basemaps can be changed by selecting the 'Map Settings' button at the upper right portion of the map view and selecting one of the available basemaps. There are other choices of basemaps like the Natural Earth without labels (ESRI), Positron without labels (CARTO), and Dark Matter without labels (CARTO). The maps can be viewed in 3D via Cesium but need a 3D Access token.
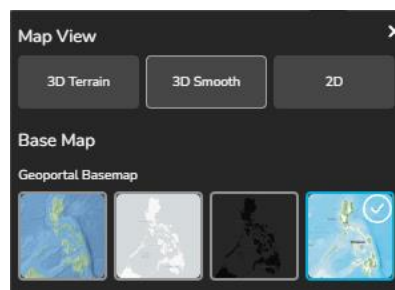
Figure 3. Available Basemaps

3.1.2 Map Navigation Tools: Users can zoom, pan, and rotate the map. It can also be centered at the user's current location. The Zoom can be reset to a viewpoint set at the beginning by clicking on the Home icon. The Measure tool is also available to measure distances (in meters or kilometers). The list of basic functionalities can be found in the Help button.
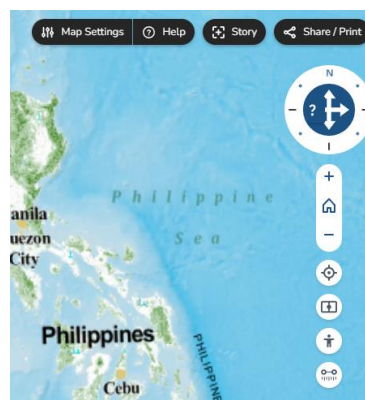
Figure 4. Map navigation tools

3.1.3 Selection of Layers: Layers can be added to the Workbench by clicking the 'Explore Map Data' button. The Data Catalogue will then appear. Users can find a specific data layer using the search bar. Once a data layer is clicked, a preview of the data on the map is shown. Its metadata are also displayed, accompanied with its service link.
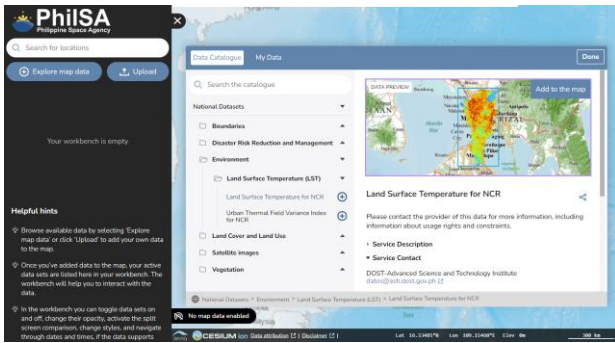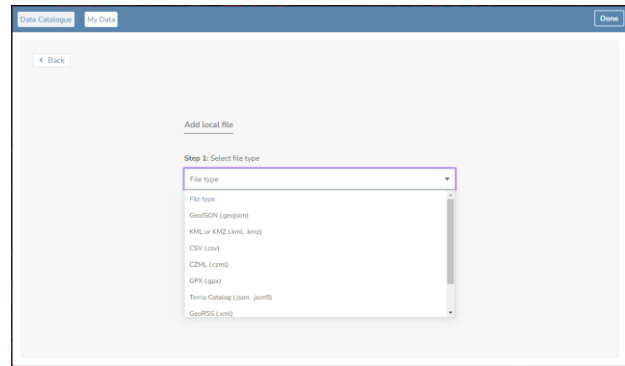
Figure 5. Map navigation tools

3.1.4 Layer Information: Once added to the Workbench, each layer is listed vertically in order of superposition. A checkbox shown beside the title of the layer is used to show/hide the layer on the map. The "Ideal Zoom" button is used to zoom the layer to its extents while the "About Data" button shows the metadata and description of the data layer.

Clicking on the vertical ellipsis icon (also known as "kebab menu") shows different tools available depending on the data layer. These tools may include editing the layer style, comparing two different layers, differencing two different layers, or removing the layer from the workbench. When available, specific vector layers can be exported as a GeoJSON object by clicking the 'Export' button. The opacity of the data layer may also be adjusted on the map. Finally, a legend of the data layer is shown from its Style Layer Descriptor (SLD) file.

Figure 6. Layer Information in the Workbench

3.1.5 Data Upload: Users and organizations can upload their own local vector data to the platform by using the 'Upload' button located in the Workbench. Raster datasets, on the other hand, can only be added through Web Services such as WMS. The uploaded data are only available in the current session and are not uploaded to the SDD's database.

The tool can be used when there are available datasets in the user's local files and want to conduct a simple overlay analysis with SDD's data. In support of SDG 17 (Partnerships for the Goals), the SDD advocates non-duplication of efforts by sharing and rehosting data created by other government agencies and institutions.

Figure 7. Data Upload

3.1.6 Time Slider: Data layers with enabled Time Dimensions may be viewed temporally. By default, layers display the most recent date available. Clicking on the date time button or the left/right icons allows the users to select the date/time of the features visible. Clicking on the Timeline icon shows a time slider panel at the bottom of the map view which can be played/paused to see changes through time.
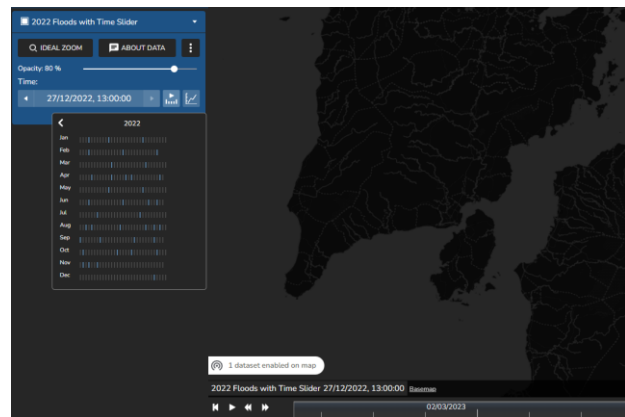

Figure 8. Time Slider Tool

3.1.7 Comparison Tool: The layers can be viewed and compared side by side. This is most beneficial for temporal data, such as pre- and post-event analysis. Further applications include land cover change detection such as agri-urban land conversion.
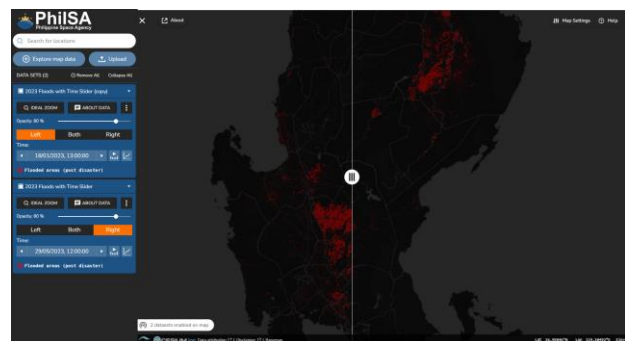

Figure 9. Comparison Tool

3.1.8 Feature Attributes and Charts: Some layer features may further be inspected through charts. Once a feature is clicked, its attributes are displayed through a Feature Information window. Tables and charts can also be viewed through the Charts tool; this feature information can also be downloaded as a CSV or JSON object.
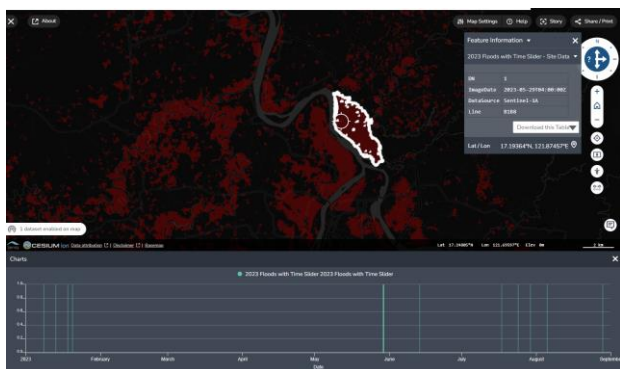
Figure 10. Viewing Charts in the Space+ Data Dashboard

3.1.9   Feedback Mechanism: A Feedback form is included at the bottom right of the SDD. This allows users to suggest features for the development of the SDD or request data layers that may or may not be visible in the Data Catalog. Users may also report bugs/issues in the system for improvement. This automatically includes a current screenshot of the map view display of the users.

Figure 11. Feedback Form

3.2 Available Data Layers/ Data Themes

This section enumerates the different data layers that are currently displayed and can be accessed through the SDD as of October 2023. An initial view of the current Space+ Data Dashboard Data Catalog is shown in Figure 12.
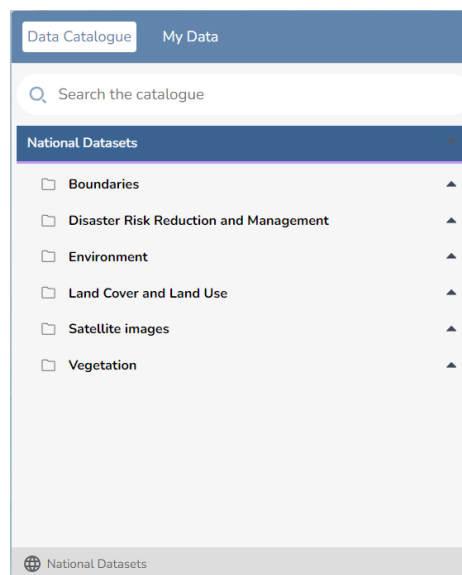

Figure 12. Current SDD Data Catalog

3.2.1   Boundaries: The Boundaries class currently consists of four (4) main data layers: Barangay, Municipal, Provincial, and Regional Boundaries. The 'Edit Style' functionality is enabled for the said data layer, where users can select the attribute that defines the said style and apply a color ramp (for quantitative data) or color palette (for qualitative data).

3.2.2   Disaster Risk Reduction and Management: The Disaster Risk Reduction and Management class currently focuses on the flood data layers. Floods can be viewed as a timeline and can also be compared with other data layers/flood dates. Floods displayed dates from 2018 to the present and are updated regularly. These data can also help in impact assessment and rescue operations.
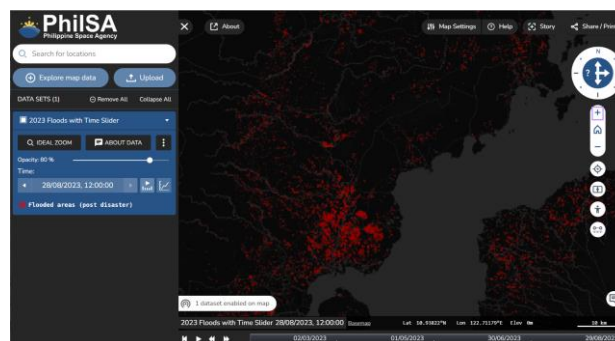

Figure 13. Space+ Data Dashboard: Flood Maps

3.2.3   Environment: The Environment class currently displays two (2) data layers for NCR: Land Surface Temperature (LST) and Urban Thermal Field Variance Index (UTFVI). These layers show visualization of rasters of continuous data values.
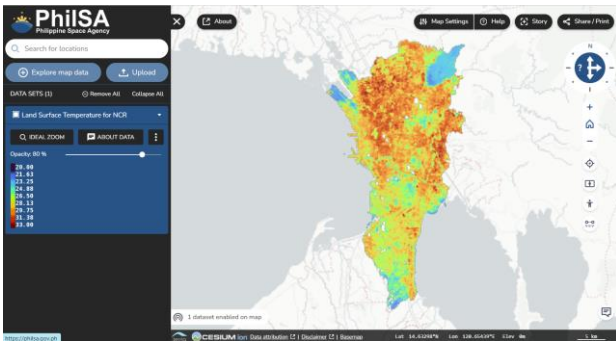
Figure 14. Space+ Data Dashboard: Land Surface Temperature

3.2.4   Land Cover and Land Use: The Land Cover and Land Use class currently displays Land Cover for the entire country for 2022. These layers best show visualization of rasters of discrete data values. The benefit of land cover maps also extends to change detection between multiple dates, as well as, planning based on current land cover.
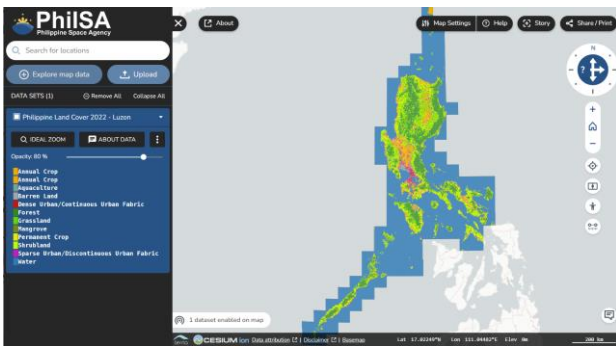

Figure 15. Space+ Data Dashboard: Land Cover (Luzon)

3.2.5   Vegetation: The Vegetation class currently displays Mangrove Extents for the entire country for 2022. These layers best show visualization of rasters of discrete data values.
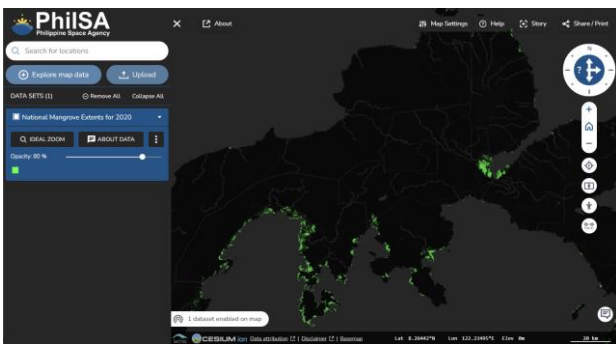

Figure 16. Space+ Data Dashboard: Mangrove Extents (2020)

3.3   Other Applications of the Space+ Data Dashboard

3.3.1   Sharing and Printing of Maps: Users can print or download a copy of the current map view for further presentation and recording. Further improvements to the Print Map feature would automatically include other map elements such as a Title, North Arrow, Scale, Legend, and other Map Information.
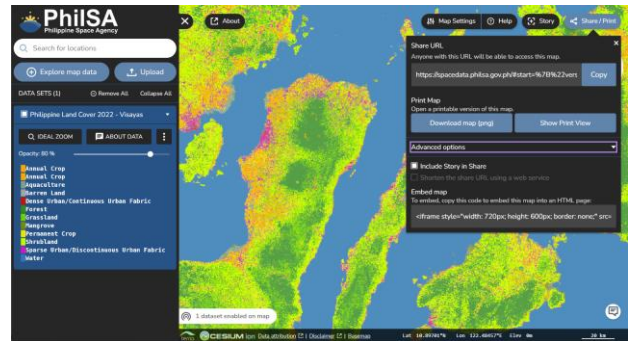

Figure 17. Printing and Downloading Maps

3.3.2   Map Stories: Users can also save different scenes in succession and preview them as a map story. This story can also be shared over the internet as a URL link that can be shared on other platforms including social media. For each scene, a map extent, a title, and a description are included.
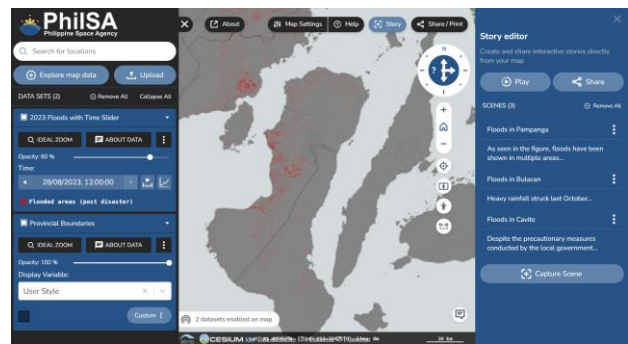

Figure 18. Map Stories

3.3.3   Using Geoserver and Open Data Cube within QGIS: For further processing and analysis, Geoserver and Open Data Cube can be connected and streamed to QGIS using the Open Geospatial Consortium (OGC) Web Map Services (WMS) and Web Feature Services (WFS). Figure 19 shows an example of loading the Land Cover data layer from Geoserver in QGIS.
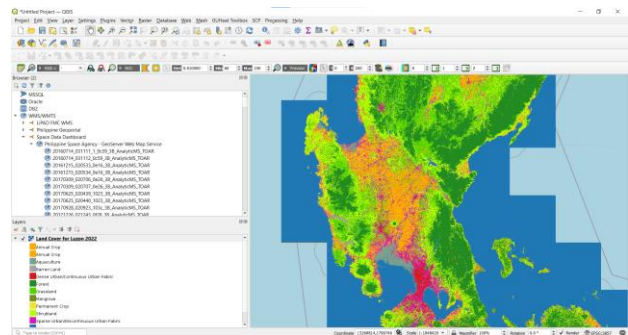

Figure 19. Geoserver with QGIS

4.   CONCLUSION

In conclusion, the Space+ Data Dashboard (SDD) has been successfully developed using open-source technologies. Most of the proposed features of the User Interface have been implemented, although further refinement is needed for real-time data connectivity and chart display. The SDD data catalog is regularly updated, both self-generated and re-hosted. It is important to emphasize that as new data layers are added to the catalog, standardization, metadata supplementation, and Style Layer Descriptor (SLD) integration are required.

The development of the SDD is still ongoing and additional features are in the pipeline. These include the implementation of quick analytics and reports based on the presented data, as well as enhanced streaming and feature processing capabilities. Furthermore, the ingestion and display of 3D data are considered for future exploration. Future functionalities include user-level access and integration with citizen science applications like the PhilSA Open Data Kit (ODK).

It is worth noting that PhilSA's implementation of the SDD aligns seamlessly with SDG 16 (Peace, Justice, and Strong Institutions) as it empowers informed decision-making through space data. Moreover, it fosters collaboration with other government agencies, reflecting a shared commitment to serving the public, which resonates with the spirit of SDG 17 (Partnerships for the Goals). Lastly, the SDD, coupled with the Open Data Cube, enables the creation of innovative products and automation of satellite-derived offerings in support of SDG 9 (Industry, Innovation, and Infrastructure).

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