

Data and Services Roadmap 2024



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Executive Summary

This Data and Services Roadmap lays out the necessary and potential developments for the technical Earth observation components of DE Africa Phase-III, focussed on achieving *Uptake and Impact*.¹

The components in this Roadmap are grouped into Input Datasets, and Services. Components that are currently being progressed and those that can potentially be developed are both included. Each component is assigned a 'Tier' which considers the technical, logistical, and resourcing difficulty of its development. Specifically:

- Input Datasets are the foundational Datasets, including Earth observation data (CEOS² analysis ready data 'pipelines'³) and other geographic datasets and ancillary data that are required to derive output services and to support users. They are listed in Section 4.
- **Services** are the information products derived from Input Datasets. An operational Service is continuously updated as required Input Datasets become available. Services may be updated, based on user feedback, to incorporate new sensors, new algorithms and auxiliary data. Potential services are listed in Section 6 and ordered according to their relevant Thematic Areas.

The **DE Africa Platform** is **not** covered in this Roadmap. The Platform includes the software infrastructure and tools that support data visualisation, discovery and analysis and enable users to interface with DE Africa data and services. This Roadmap is an important driver for the Platform, and these dependencies are included in **Appendix 1**.

¹ Previous versions of the Roadmap informed the Establishment Phase of DE Africa (Phase-II), from August 2019 to June 2022.

² Committee on Earth Observation Satellites

³ A key strategy for DE Africa is that these will in future be provided 'ready to use' by CEOS agencies, however, in practice there is considerable expertise and effort required to ensure these data pipelines.

1. Introduction

Governance context

The Data and Services Roadmap is a central document in the governance of DE Africa. During the August 2019 Committee meeting held in Nairobi, Kenya, the Digital Earth Africa (DE Africa) Technical Advisory Committee agreed to the development of a Technical Roadmap that would articulate what products are to be generated and prioritized through DE Africa. This is the first major revision of the Technical Roadmap since 2019, including the change of name to Data and Services Roadmap. The revision corresponds to the completion of Phase II (the Establishment Phase) and the needs of Phase III, with particular reference to national / country focus.

Phase III requirements

Phase III of DE Africa is focussed on creating additional value from the science, technology (and institutional arrangements) established in Phase II, by driving the uptake of the DE Africa program and delivering impact. Aligned with the long-term program goal to **improve the lives of African people through access to tailored information for decision making**, the Phase III outcomes are:

- **Sustainment:** DE Africa is on-track to be sustained in Africa, with key African stakeholders invested to achieve this end-point;
- **Uptake and Impact:** DE Africa information is consistently used by key stakeholders governments, academia, researchers, communities, private sector and individuals, to drive environmental, social and economic impacts.

Direct funding for Phase III is provided by the Australian Government and the Helmsley Charitable Trust. These funding partners have also indicated areas for DE Africa to focus work. Significant indirect funding comes as in-kind contributions from supporters (in particular Amazon Web Services and Esri) and from program Implementing Partners (IPs).

Country engagement approach

During Phase III, it will be essential to align DE Africa services with country-level use cases and products, and to position DE Africa capabilities to address specific requirements and national priorities in order to both build support from countries for the sustainment of DE Africa and to expand impact. To maximise relevance to key stakeholders who are vital to the sustainability of DE Africa, future services will continue to be continental but with a focus on country-level use-cases and workflows.

Successfully engaging with National Governments has been identified as vital to the success of DE Africa Phase III, and the development of a country engagement approach is a specific requirement of funders. Through this, and in order to have impact at government level, we will engage directly with national governments to understand each country's government context, the key problems to be addressed, the information gaps that DE Africa can fill, the capacity building requirements, and the modalites to work in a particular country.

Commitments to Funders

The Technical road-map for Phase III must address commitments to funding partners and others as well as advance the DE Africa vision and mission more broadly, including strategic alignment to Global and African Agendas (UN 2030 Agenda, Sendai Framework, the Paris Agreement, the New Urban Agenda and Agenda 2063) and alignment with African regional programmes using EO (such as SERVIR, GMES & Africa, ORLOA⁴, & etc.)

Data and Services

The Data and Services Roadmap indicates the developments to be undertaken to:

- Bring data (including Earth observation data, other necessary geographic and ancillary datasets) into DE Africa, and;
- Deliver the thematic services that will be built and delivered based on those datasets and their analysis. The Roadmap also includes 'potential' datasets and services.

2 Approach

This section outlines the separate components of the Roadmap (Input Datasets and Services), the key considerations for addressing these during Phase III, and the role of partnerships in delivering new capabilities.

2.1 Components of the Data and Services Roadmap

This Data and Services Roadmap outlines existing and potential **Input Datasets** to be included in DE Africa, and the existing and potential **Services** to be produced by DE Africa.

Input Datasets are the datasets (satellite Earth observations (EO), other geographic and ancillary data), that can be used to derive output Services. Input Datasets that are coming from satellite data streams are typically updated constantly, as satellite operators acquire and make available new observations. These 'EO data pipelines' will ideally provide Analysis Ready Data (ARD) meeting CEOS specifications, however in some cases further processing is necessary. Establishing and maintaining high-frequency EO data pipelines is a significant undertaking and one of the unique strengths of DE Africa.

Not all Input Datasets are EO datasets or have a high frequency of update. Key datasets such as elevation models and soil property grids are essentially static or updated infrequently. These require fewer resources to maintain.

A subset of Input Datasets are hosted by other parties but are made accessible through DE Africa. One such example is the ERA5 gridded climate data. Code examples in open source notebooks show technically advanced users how to load and use this and other such datasets.

⁴ West African Regional Coastal Observatory

⁽https://ocean-climate.org/en/west-african-regional-coastal-observatory-orloa/)

Services are continental scale outputs which are produced within DE Africa, from various combinations of the Input Datasets along with models, ground-truth data & etc. The label 'Services' is used to retain a user and beneficiary focus. A Service is provided with specified levels of update and latency, and may be continuously updated as input datasets become available. Services may be updated to incorporate new sensors, new algorithms and auxiliary data.



Figure 1 illustrates the conceptual relationships between Input Datasets and Services.

Figure 1: Observations from satellites (and other sources) provide PetaBytes of Analysis Ready Data (ARD). The ARD is processed by the Platform, which is based on the Open Data Cube (ODC), to provide Services. The Services are designed to support users by providing information to enable data-driven decision making.

The **Technical Platform** includes infrastructure and tools that support discovery, visualisation, analysis, and download, so that users can interface with DE Africa Input Datasets and Services. Whilst Platform development is not part of this Roadmap, the requirements for the Platform, in order to deliver the Roadmap, are covered in Appendix 1.

2.2 Guiding Principles

DE Africa is a public-good data infrastructure guided by a set of Governing Principles⁵. The principles imply that DE Africa will develop and host Input Datasets that are consistent with:

Accountability and Transparency

- Input Datasets must be identified in conjunction with stakeholders, ensuring responsiveness to priorities
- The Data and Services Roadmap, in line with other aspects of DE Africa, will be responsive to change through regular review by the Advisory Committee and DE Africa Governance Bodies

Diversity and Inclusion

⁵ https://www.digitalearthafrica.org/about-us/our-principles/governing-principles

• DE Africa will have an eye toward diversity and inclusion in choosing which datasets and services are to be developed, and in the manner in which the work is done. This will reflect our ambition to be an exemplar of diversity and inclusion as well as our understanding of the practical advantages of an inclusive approach.

Sustained Operational Services

- EO datasets that conform to CEOS ARD⁶ standards will have greater impact and lower management overheads, and are critical to sustainability.
- Datasets are progressed to have the maximum benefit, leading to greater support for operational continuity. Continental coverage datasets have the potential to reach a wider user-base and this was a key rationale during DE Africa Phase II. However, Phase III must engage with national decision makers, and national datasets or services may be essential to meet the needs of policy makers (national and sub-national levels) in order to support the right decision at the right scale.
- Other relationships and partnerships that maximise the reliability and capability of DE Africa and reduce the costs and risks of maintaining DE Africa operations.

Open and Free Data

- Datasets that can be readily shared under free and open licences, with high levels of interoperability, remove the need for DE Africa to manage licences and dramatically lower barriers to use, leading to greater use and greater impacts and benefits for users.
- These principles do not prevent DE Africa users from accessing other datasets, for example high resolution imagery that is available from commercial providers or under other international frameworks.

2.3 Priorities and drivers for new input datasets and services

DE Africa embarked on Phase III from 1st July 2023, working towards achieving the following outcomes, which the Roadmap must support:

- embedding DE Africa products and services across the continent to enhance national, and to scale regional activities
- empowering African-led climate action, by developing in-country knowledge and skills and through provision of relevant products and services
- driving wider uptake and impact, with DE Africa information consistently used by key stakeholders governments, academia, communities, private sector and individuals, to drive environmental, social and economic impacts.

Empowering African-led climate action is the thematic nexus of these priority areas. Phase III of DE Africa aims to produce climate-relevant services and to empower climate action by developing in-country knowledge and skills in the analysis and application of these for climate security.

⁶ Committee on Earth Observation Satellites Analysis Ready Data

We will ensure decision-ready services are well placed to enable policymakers, scientists, the private sector, and civil society to better address issues of climate adaptation, mitigation and reporting, at different spatial scales, across Africa. Key application areas and use-cases will include, but are not limited to, nature based solutions, land degradation, coastline monitoring, and food security

Enhancing national decision making through the use of DE Africa services and tools is key to driving **wider impact and uptake**. Guided by the DE Africa Phase-III country engagement approach, we will look for opportunities to produce, and provide, information that is more relevant and accessible to national decision makers. This includes information that is more timely, stronger partnerships to leverage expertise and data in specific thematic areas including food and water security, nature based solutions, and coastal management, and close engagement with interested governments.

- **Timely information for greater uptake and relevance**; the value of early, or 'timely', information is well recognised. Information is far more valuable *before* decisions are made, even information with higher levels of uncertainty, is likely to lead to a 'better' decision⁷. Timely information has the potential to engage a wider user-base including decision-makers. In Phase III DE Africa will therefore consider opportunities to produce timely information services, such as raising 'Alerts'.
- **Information services that support country engagement;** in order to engage with national decision makers and governments examples are required of services that are:
 - directly relevant to key questions climate action (including national adaptation planning and nationally determined contributions), food and water security, forest monitoring, land degradation neutrality, ecosystem restoration, urban resilience, nature based solutions, hazards and exposure to hazards etc,.
 - produced at country level, in a format that summarises the information (for example through national dashboards and analytics),
 - are part of a co-design process and can be tuned to national needs,
 - can be operated by the country, without needing to be too specialised (e.g., not requiring an expert sandbox user),
 - \circ $\,$ can be included within national coordination mechanisms as proposed under GEO $\,$
- National summaries; as DE Africa Services are produced at the continental scale, further analysis is needed to summarize these at the national scale. During Phase III we will consider ways to interpret, summarize, and present DE Africa Services targeted at specific scales and to customize services for country specific priorities and information needs.

⁷ Decision makers must often act with very little information, and generally make decisions based on a range of inputs, so even incomplete or uncertain information can be of great value. In contrast, information that is produced after the event is used to understand processes and to establish baselines of fact, and must generally be more complete and accurate.

- **Richer and more relevant thematic information**; DE Africa, as an African-based platform, can leverage the work of the international community and act as a conduit for diverse sources of information, as well as providing DE Africa produced services. Backed by recognised experts or institutions and in partnership with other groups will enable us to address priority areas such as food production (soils data and the iSDA⁸), water and agricultural water use (Precipitation, Evaporation, Evapotranspiration, Biomass Production and Water Use Productivity via WaPOR⁹), early warning and emergency response (the Copernicus EMS¹⁰) and Land Cover.
- New analysis-ready datasets; in order to support key issues and wider thematic areas we will work where feasible to include additional data pipelines such as Sentinel-3 surface reflectance¹¹, and data on air quality potentially available from Sentinel 5P.
- Harmonised analysis-ready data sources; 'harmonised' is the term used by CEOS for EO datasets from different sensors which have been processed to be compatible with each other. A step beyond ARD, products such as NASA's Harmonised Landsat-Sentinel (HLS)¹² enable DE Africa to focus more effort on applications and impact.

2.4 Partnerships

A greater emphasis on partnerships and relationships, in particular partnerships with groups in areas of thematic expertise that operate to support particular themes of decision making such as water use, food production or early warning and disaster management, is a critical opportunity for DE Africa in Phase III.

As an African platform DE Africa can leverage the work of the global international community, and act as a conduit for diverse sources of information, while also producing unique services for users across the continent. Co-design, user engagement, acceptance and partnerships are vital to cost-effective and high-impact implementation of this Roadmap.

⁸ iSDA develops intelligence-based agricultural information services targeting producers. They host open datasets of soil properties which are recognised by the international community - for example as source data for measurement of land degradation neutrality <u>https://www.isda-africa.com/</u>

⁹ WaPOR is the FAO portal to monitor Water Productivity through Open access of Remotely sensed data (<u>https://wapor.apps.fao.org/</u>)

¹⁰ Copernicus Emergency Management Service is an operational service, providing data from satellites to support emergency response: <u>https://rapidmapping.emergency.copernicus.eu/EMSR695/download</u>

¹¹ Sentinel-3 is a potential replacement for MODIS data from the NASA Terra and Aqua satellites. Terra and Aqua are at end of life after 23 years of operation, with data quality being affected (https://www.earthdata.nasa.gov/news/eos-data-continuity-rfi)

¹² NASA have developed the Harmonised Landsat Sentinel products to incorporate key corrections to make the data analysis ready, and go beyond ESA and USGS in applying a BRDF correction (lack of BRDF correction in DE Africa has a significant effect on the information that is able to be extracted reliably). HLS currently standardises the public data to a 30 metre pixel, however further developments can be expected as the community using this dataset for global assessments (including the lead US researchers) asks for more.

In engaging with national governments DE Africa will look to a more active partnership with GEO and AfriGEO, leveraging the concept of a National Coordination Mechanism (NCM). The NCM concept is a government-led process supported by GEO and AfriGEO that aims to unite Earth observation practitioners from both the public and private sectors.

In developing new **Input Datasets** teams will look to:

- Partners or providers that produce datasets that are ready to use and are operationally maintained, rather than replicating activity. This may include space agencies or other groups that have pre-processed EO data or created supporting geospatial data (elevation models, population density grids, etc.) with a track record of reliable delivery of those data;
- Continued partnership with AWS to host publicly accessible EO data under the Public Dataset Program. All DE Africa data are now stored in Cape Town, sponsored through the Amazon Sustainability Data Initiative (ASDI). Data pipelines are continuously monitored to ensure the archive is complete and accessible;
- Partnerships with technical providers who can facilitate EO data pre-processing;
- Other potential or current partners, as appropriate

In developing new **Services** teams will look, for example, to:

- Implementing Partners, as vital to the design and testing of, and user-engagement with, DE Africa Services including communication and promotion efforts, in-situ data and validation of Services, and training / capacity development;
- International frameworks that support the Sustainable Development Goals (SDGs) and Climate Agendas, and which set guidelines and methodologies that DE Africa should align with, for example in Land Degradation Neutrality (LDN)¹³;
- Esri, to ensure that DE Africa Services are available and accessible to as wide a range of users as possible and through multiple interfaces, increasing the opportunities to have impact through engagement with end-users and beneficiaries;
- Other partners, including AWS, to ensure that DE Africa work is as sustainable, cost-effective, and high-impact as possible.

3 Input Datasets

Input Datasets are datasets that are made *available to, and within* DE Africa, but are *not produced or maintained by* DE Africa¹⁴. They include:

• foundational CEOS Analysis Ready Datasets that can be used to derive output services and accessed directly through the DE Africa Platform. These Datasets come directly from Earth observation satellites and are constantly updated as the satellites gather more observations, with DE Africa playing a significant role in the curation of the data

¹³ The Land Degradation Neutrality Good Practice Guide, endorsed by the UN Convention to Combat Desertification (UNCCD), provides details of how LDN indicators can be produced from EO data. Alternative approaches are unlikely to be as relevant or easily accepted.

¹⁴ This 'DE Africa point of view' is a convenient way to define Input Datasets. As with all definitions there are some grey-zones here, for example DE Africa has a key role in CEOS-ARD production, despite being a user of these datasets.

• other datasets from satellite and other sources, processed by other parties, bring key environmental, geographic, demographic, meteorological and climate or other variables into the platform, or which can be reliably accessed from the platform. Typically these are continent-wide geospatial datasets that are updated annually or less frequently, as new versions are released.

Input Datasets generally measure key properties of the Earth surface. They may be used directly, for example to visualise land changes, floods, fires or lava flows. They also are the inputs to analysis to produce new information and provide additional services, such as Water Observations from Space (WOfS).

Earth observation data from satellites are a major part of the DE Africa Input Datasets. EO data are challenging because satellites capture new information each day, producing very large datasets that require robust, automated processes and large data stores. DE Africa EO datasets are, wherever possible, compliant to CEOS-ARD standards¹⁵.

Other Input Datasets are hosted on the DE Africa platform or are readily accessible to DE Africa users. For some datasets, access is facilitated directly from the provider, through use of the DE Africa Sandbox. These datasets will not appear in the data explorer or the DE Africa Map¹⁶.

In addition, there are different methods or ways in which Input Datasets are made available in DE Africa:

- 'Hosted' datasets are ingested, processed, maintained, and stored by DE Africa. Their status is monitored by the DE Africa team. They are fully available for use within DE Africa. That is, they can be accessed in the Sandbox environment for user access via Open Data Cube loading functions, in the DE Africa Map for visualisation, and queried via the DE Africa STAC API. They are also fully documented in the User Guide and metadata explorer.
- 'Indexed' datasets are indexed into the Open Data Cube database. As above, these datasets are fully available and fully documented in DE Africa. The difference is that the data is hosted in a publicly accessible location and not maintained by DE Africa.
- 'Loadable' datasets (the minority) can be accessed from their source location using DE Africa notebooks, and are available for Sandbox users. The functions for loading these datasets are documented in DE Africa tools code repository, but are not listed in the metadata explorer or STAC API. Datasets that are 'Loadable' are generally not available in conditions or terms that warrant indexing. For example the data may require user registration or may not be available in a sufficiently interoperable format. Bespoke data required for select uses may also be initially made available as a 'Loadable dataset' while under consideration for indexing.

¹⁵ Committee on Earth Observation Satellites - Analysis Ready Data; DE Africa has played an important role in supporting the development of CEOS-ARD specifications and of supporting technologies such as STAC ¹⁶ maps.digitalearthafrica.org

In the table below we list Input Datasets (of both types) that are currently available to DE Africa users, are under development, or have been nominated as potential future Input Datasets. The **Status** column indicates the stage of development of the Input Dataset, defined as:

- 1. **Nomination** by a team member or stakeholder, adding the dataset to the list of possibilities
- 2. **Ideation** to clarify the nature of the dataset, the possible sources of data and the anticipated users, users and beneficiaries
- 3. **Costing** to estimate the resources required to bring the dataset into DE Africa in the required form,
- 4. **Development** to implement the Input Dataset
- 5. Maintenance of the Input Dataset

The process to move through these levels is outlined in Appendix I.



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Foundational Earth observation datasets hosted by DE Africa		
Dataset	Description	Status
(1) Land Surface Reflectance Landsat Collection 2	Multi-spectral land surface reflectance and land surface temperature observations at 30 metre spatial resolution from Landsat 5, 7, 8 and 9 beginning in the late 1980s. Coverage increases over time as technical capabilities (instruments, satellites and ground stations) have improved. Provides unique information for land and water management in Africa, enabling time-series analysis going back 30 years in some cases (historic coverage is best in northern and southern Africa). It has a wide range of applications in helping to understand and monitor environmental changes. Surface Reflectance is bundled with Surface Temperature Data, available in AWS: <u>https://registry.opendata.aws/deafrica-landsat/</u>	Maintenance
(2) Land Surface Temperature Landsat Collection 2	Land surface temperature observations at 30 metre spatial resolution from Landsat 7, 8 and 9 beginning in the late 1980s. Coverage increases over time as technical capabilities (instruments, satellites and ground stations) have improved. Measures temperature changes on the land surface, providing unique information for land and water management in Africa. Provides unique information for land and water management in Africa, enabling time-deep analysis going back 30 years in some cases (historic coverage is best in northern and southern Africa). It has a wide range of applications in helping to understand and monitor environmental changes. Surface Temperature is bundled with Landsat Surface Reflectance Data, available in AWS: https://registry.opendata.aws/deafrica-landsat/	Maintenance
(3) Land Surface Reflectance Sentinel-2	Surface reflectance measurements at up to 10m spatial resolution from the ESA Sentinel-2 satellite constellation, beginning in 2017. Images are acquired over most of the land surface every five days. Provides high spatial and temporal resolution continental scale coverage, enabling characterisation and monitoring of the land surface to support management of natural resources. Data are available in AWS and nominally available to users within 1 day of satellite acquisition: https://registry.opendata.aws/deafrica-sentinel-2/	Maintenance

(4) Normalised Radar Backscatter Sentinel-1	Normalised C-band Radar Backscatter from the ESA Sentinel-1 satellite constellation with a spatial resolution of 20m, beginning in 2018. Provides a high spatial (20m) and temporal (12 days) resolution required for time series analysis, allowing for improved land cover classification and characterisation of dynamic systems. Failures in the Sentinel-1 constellation have led to reduced observations over parts of Africa from late 2021. Data are available in AWS and nominally available to users within 1 day of satellite acquisition: https://registry.opendata.aws/deafrica-sentinel-1/	Maintenance
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Other datasets (indexed by, or loadable in, DE Africa)			
Dataset	Description	Status	
(5)Annual Radar Mosaic - ALOS PALSAR	 ALOS PALSAR¹⁷ Normalised Radar Backscatter Annual Mosaic Annual data for 2007 to 2010 and 2015 onwards Spatial resolution: 25m L-Band Synthetic Aperture Radar (SAR) data provides a measure of the land surface that is sensitive to surface roughness and the density of vegetation (esp. forests), as well as the presence of water under forests (e.g. forested wetlands). Radar observations are not affected by clouds, thus enabling monitoring and change detection in tropical regions where cloud-free optical coverage is sparse. They also provide complementary measurements to optical data and can be used to map land cover and changes, including forested and other wetlands, surface water, urban areas, and vegetation. Hosted by DE Africa 	Maintenance	

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¹⁷ Phased Array-type L-band Synthetic Aperture Radar (PALSAR) mosaic data is a free and open dataset generated from L-band Synthetic Aperture Radars (PALSAR and PALSAR-2) on the Advanced Land Observing Satellite (ALOS) and Advanced Land Observing Satellite-2 (ALOS-2) operated by the Japan Space Exploration Agency (JAXA)

Other datasets (indexed by, or loadable in, DE Africa)			
Dataset	Description	Status	
(6) Annual Radar Mosaic - JERS	JERS Radar Annual Mosaic Available for the year 1996 Spatial resolution: 25m The JERS-1 ¹⁸ mosaic is provided by JAXA Earth Observation Research Center and reformatted for use in DE Africa. It is compatible with the Annual ALOS PALSAR mosaics extending the temporal coverage of L-band SAR data for over 20 years, enabling change detection over multiple decades. Hosted by DE Africa	Maintenance	
(7) Digital Elevation Model - SRTM	Digital Elevation Model - SRTM ¹⁹ Static dataset of estimated elevation Spatial resolution: 30m Sourced from NASA's LPDAAC ²⁰ and reformatted for DE Africa. Elevation models are a foundation descriptor of the land surface and are necessary inputs to many other analyses using EO data. Hosted by DE Africa	Maintenance	
(8) Digital Elevation Model - Copernicus	Digital Elevation Model - Copernicus Static dataset of estimated elevation Spatial resolution: 30m, 90m Sourced from the European Space Agency (European Union Copernicus Programme). Hosted by DE Africa	Maintenance	
(9) Digital Elevation Model - NASADEM	Digital Elevation model - NASADEM Static dataset of estimated elevation Spatial Resolution: 30m Quality controlled DEM derived from a combination of SRTM processing improvements, elevation control, void-filling and merging with data unavailable at the time of the original SRTM production. Sourced from Microsoft Planetary Computer. Hosted by DE Africa	Maintenance	

¹⁸ Japanese Earth Resources Satellite

¹⁹ Shuttle Radar Topography Mission

²⁰ Land Processes Distributed Active Archive Center

Other datasets (indexed by, or loadable in, DE Africa)			
Dataset	Description	Status	
(10) Soil Properties Grids - iSDA	Soil data for Africa - iSDA ²¹ Static dataset of soil and related parameters Spatial Resolution: 30m iSDA produces and shares an open dataset of multiple layers of soil and land use / land cover properties for Africa. DE Africa has indexed several of these: Bulk Density, Depth to bedrock, Soil Total Carbon, Clay, Sand & Silt content, at depths of 0-20cm and 20-50cm. Soil properties are a controlling factor for a wide range of agricultural, environmental and social processes. The ability to include soil properties in models and analysis will increase the accuracy and relevance of DE Africa services, especially in regard to Agricultural applications. Hosted by DE Africa	Development Additional data layers to be added (SOC)	
(11) Rainfall Estimates (monthly) - CHIRPS	Mean monthly precipitation estimates - CHIRPS ²² Available from 1981 and updated monthly Spatial resolution: ~5,000m Data are converted to cloud-optimised GeoTIFFs; the full archive of CHIRPS daily and monthly rainfall can therefore be easily used for inspection or analysis across DE Africa platforms, including the user-interactive DE Africa Map. Hosted by DE Africa	Maintenance	
(12) Rainfall Estimates (daily) - CHIRPS	Daily precipitation estimates - CHIRPS ²³ Available from 1981 and updated daily Spatial resolution: ~5,000m Data are converted to cloud-optimised GeoTIFFs; the full archive of CHIRPS daily and monthly rainfall can therefore be easily used for inspection or analysis. Daily rainfall is not currently included in the user-interactive DE Africa Map. Hosted by DE Africa	Maintenance	

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 ²¹ <u>https://www.isda-africa.com/about/</u>
 ²² Climate Hazards Group InfraRed Precipitation with Station data
 ²³ Climate Hazards Group InfraRed Precipitation with Station data

Other datasets (indexed by, or loadable in, DE Africa)			
Dataset	Description	Status	
(13) Land Cover - Impact Observatory Land Use/Land Cover	Land Use Land Cover - Impact Observatory Annual dataset available from 2017-2021 Spatial resolution: 10m Land cover as mapped by the Impact Observatory ²⁴ , Microsoft and ESRI, this is a series of annual global maps beginning in 2017 derived from Sentinel-2 imagery at 10m resolution. Each map is a composite of LULC predictions for 9 classes throughout the year in order to generate a representative snapshot of each year. These include water, trees, flooded vegetation, crops, built area, bare ground, rangeland, snow/ice. Hosted by DE Africa	Development (update to version 2 in 2024)	
(14) Land Cover - ESA WorldCover	Land Cover - ESA WorldCover Static dataset available for 2020, 2021 Spatial Resolution: 10m Global Land Cover as mapped by the European Space Agency for 2020 and 2021 from Sentinel 1 and 2, and provided as 11 classes including: Moss and Lichen, mangroves, herbaceous wetland, permanent water bodies, bare/sparse vegetation, built-up, cropland, grassland, shrubland, tree Cover, snow/ice. Hosted by DE Africa	Maintenance	
(15) Land Cover - ESA CCI	Land Cover - ESA CCI Annual dataset available from 1992 to 2019 Spatial Resolution: 300m Land Cover as mapped by the European Space Agency's Climate Change Initiative. Multiple classes. Hosted by DE Africa	Development (update to include 2020)	
(16) Geography - Openstreetmap	OpenStreetMap Dynamic vector dataset OpenStreetMap is a geographic database, providing location information of roads, buildings, and landmarks. It is built, maintained and supported by a world-wide geospatial community. Accessible through the Sandbox	Maintenance	

²⁴ https://www.impactobservatory.com/

Other datasets (indexed by, or loadable in, DE Africa)			
Dataset	Description	Status	
(17) Population: Population Density - Ciesin and Meta	Population Density produced by Ciesin and Meta Dynamic dataset Spatial resolution: 30m Created by Meta and the Center for International Earth Science Information Network (CIESIN) at Columbia University, this dataset combines information from census with building identification from high resolution satellite imagery. Accessible through the Sandbox	Maintenance	
(18) Human Settlement: World Human Settlement Footprint	 Human Settlement - World Settlement Footprint (ESA/DLR) Static dataset available for 2015 and 2019 Spatial resolution: 10m The WSF layers indicate the estimated extent of human settlements; The World Settlement Footprint 2015 is derived by jointly exploiting multitemporal Sentinel-1 radar and Landsat-8 optical satellite imagery while the 2019 dataset features data from Copernicus Sentinel-1 and Sentinel-2. 10m resolution for 2015 and 2019. Hosted by DE Africa 	Maintenance	
(19) Human Settlement: World Human Settlement Footprint Evolution	Human Settlement - World Settlement Footprint Evolution (ESA/DLR) Dataset available annually from 1985 to 2015 The WSF evolution layers indicate the estimated extent of human settlements at 30m resolution from 1984 to 2015 (WSF 'evolution'). Hosted by DE Africa	Maintenance	

Dataset	Description	Status
(20) Climate Gridded Data (WorldClim-2)	Gridded data of estimated climate variables (rainfall, temperature, evaporation, etc, are available from various sources, from low resolution global datasets (e.g, the 30 kilometre ECMWF ²⁵ ERA5) to high resolution (1 km) surfaces intended to support land and environmental management (e.g., the 1km WorldClim-2 dataset ²⁶). Climate is a fundamental driver of environmental processes and change. Access to climate data will improve the quality and relevance of DE Africa services by including climate variables in the modelling process. For example allowing users to correlate land surface changes with broader scale variations in the climate, including future climate scenarios, and supporting calculation of new indices, e.g. drought indices. Multiple sources. Low resolution ERA5 data is available in cloud optimized format in AWS at https://registry.opendata.aws/ecmwf-era5/. Higher resolution datasets are required for land surface studies	Costing
(21) Land Surface Reflectance and Surface Temperature - Sentinel-3	Sentinel-3 data provide high temporal resolution monitoring over the land and ocean, helping to identify environmental changes and supporting management of natural resources. Sentinel-3A was launched in 2016 and Sentinal-3B in 2018. The satellites carry the Ocean and Land Colour Instrument (OLCI) and the Sea and Land Surface Temperature Radiometer (SLSTR), producing observations at a moderate (300 metres to 1 kilometre) spatial resolution every 1 – 2 days. The Sentinel-3 synthesis SYN-SDR product includes surface-reflectance and aerosol parameters over land ²⁷ , projected to a geographical reference frame with 300m grid spacings, providing a source of analysis-ready data ²⁸ . The datasets are intended for monitoring of land use, land use change and the impact of weather and climate on agricultural activities, including food security worldwide.	Costing

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 $^{^{25}}$ European Centre for Medium-Range Weather Forecasts Reanalysis 5th Generation

²⁶ WorldClim-2 data http://www.worldclim.com/version2

²⁷ <u>https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy/product-types/level-2-syn</u>, also

https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-synergy/processing-levels/level-2

²⁸ <u>https://ceos.org/ard/index.html#specs</u> lists this dataset as under development or assessment for CEOS-ARD compliance

Dataset	Description	Status
(22) Aquatic Reflectance (Landsat)	Aquatic Reflectance (AR) is an Analysis Ready Data product available as a provisional product from the USGS ²⁹ from Landsat (and also under development by others ³⁰) to meet CEOS-ARD specifications ³¹ . AR is a dimensionless value "AR=pi*Rrs, or the Remote Sensing Reflectance (sr-1)". Compared to other surface reflectance products, AR uses more rigorous corrections to reduce the signal-to-noise level, which is often higher over water bodies ³² , and provides additional metadata relevant to water science. AR data will support water quality services and may lead to improved water detection (WoFS) and coastal mapping (Coastlines).	Development working with USGS to test
(23) Radar Coherence	Coherence measurements from radar satellites capture information on the land surface as it changes through time, unaffected by clouds. Published work indicates that this information complements other data types and can provide superior differentiation of land cover types ³³ , with each land cover type having a 'signature' temporal coherence matrix. Recent work funded by NASA has produced global maps of radar coherence which are freely available ³⁴ . More information is needed on the plans to update these datasets. As a DE Africa Input Dataset radar coherence has the potential to support more accurate services, especially in cloud-affected areas where optical instruments are less effective.	Nomination
(24) Air quality	Air quality significantly affects human health and is often a concern for developing countries. Air quality can be measured from satellite data by specialist teams. One measure, fine particulates (PM2.5), is estimated from multiple satellites as a time series from 1998, with the data freely available from Washington University. DE Africa stakeholders have indicated an interest in these datasets.	Nomination
(25) Radar ALOS-2 PALSAR	Additional data produced by JAXA. Discussions are continuing on the methods for DE Africa to access these data	Nomination
(26) Mangroves Global Mangrove Watch	Mangrove extent - Global Mangrove Watch (GMW). GMW captures the global extent of Mangroves from 1996 (1996, 2007, 2008, 2009, 2010, 2015 and 2016). Version-4 released in 2022.	Development
(27) Evapotranspirati on and Interception - WaPOR	'Actual Evapotranspiration and Interception' produced by the Food and Agriculture Organisation (FAO). Annual, monthly and dekadal (10 day) periods. 100m postings (grid spacing). units: mm per unit time The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Development

²⁹ United States Geological Survey

³⁰ ESA are developing an AR product from Sentinel-2, and DLR from EnMAP (ceos.org/ard).

³¹ CEOS-ARD specifications for Aquatic Reflectance can be sourced from ceos.org/ard.

³² Areas of water are often dark (reflecting less radiation than many land surfaces) and are associated with complex atmospheric conditions, including moisture content and aerosols.

³³ <u>https://ieeexplore.ieee.org/document/8966616</u>

³⁴ https://storymaps.arcgis.com/stories/1d134497e47a47fda5ff2ddf05ec0015

Dataset	Description	Status
(28) Evaporation - WaPOR	Evaporation produced by WaPOR Annual and dekadal (10 day) periods 100m postings (grid spacing). units: mm per unit time The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Costing
(29) Transpiration - WaPOR	Transpiration produced by WaPOR Annual and dekadal (10 day) periods 100m postings (grid spacing). units: mm per unit time The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Costing
(30) Interception - WaPOR	Interception (of precipitation) produced by WaPOR Annual and dekadal (10 day) periods 100m postings (grid spacing). units: mm per unit time The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Costing
(31) NPP - WaPOR	Net Primary Production produced by WaPOR Annual and dekadal (10 day) periods 100m postings (grid spacing) units: grams of Carbon per m2 per unit of time The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Costing
(32) Root Zone Moisture (relative)	Relative Root Zone Moisture produced by WaPOR Annual and dekadal (10 day) periods 100m postings (grid spacing) units: percentage of a maximum The dataset will significantly increase DE Africa's capabilities in water. food security. and wetlands	Costing
(33) Climate Gridded Data - ERA-5	Accessible via Sandbox ERA5 data is available in cloud optimized format in AWS at https://registry.opendata.aws/ecmwf-era5/. 5km resolution	Maintenance
(34) Cropland - World Cereal	Cropland areas and associated data layers produced by the World Cereal Project. The datasets will significantly increase DE Africa's capability in food security.	Costing
(35) Land Surface Reflectance HLS - NASA	Harmonised Landsat Sentinel (HLS) land surface reflectance data produced by NASA This dataset integrates Sentinel-2 surface reflectance with Landsat surface reflectance to produce a single 'harmonised' data source with Landsat-like characteristics, but more frequently updated than Landsat. The data have improved radiometric corrections, including normalisation for BRDF effects. Harmonisation includes correction for spatial misregistration. The dataset will significantly increase DE Africa's capabilities in water, food security, and wetlands	Costing
(36) Habitat Connectivity - TNC	Habitat Connectivity Models for Africa produced by The Nature Conservancy. These models provide information on how land management and land use conversion may benefit or limit native animals' movement through the landscape.	Ideation

Dataset	Description	Status
(37) NICFI - Planet	Norway International Climate and Forests Initiative (NICFI) data are provided by Planet. Datasets that support visualisation are freely available for not for profit uses. WMS service can be accessed by DE Africa users	Maintenance

4 Services

Services are outputs produced within DE Africa, from various combinations of the Input Datasets along with models, ground-truth data & etc. In the following, current services are listed along with services that are under development or may be developed in the future.

The 'status' of each service indicates its progression from

- 1. being **nominated** for inclusion in the table,
- 2. ideation to develop the idea more clearly, clarify relevance and 'additionality'
- 3. costing to determine the expected resource level, complexity and benefit
- 4. **development** of the service to the agreed level of operational maturity
- 5. **maintenance** of the service at the agreed level

<u>Upgrades to a service</u> would progress through the same cycle, from nomination for the change through to maintenance of the improved service.

See Appendix-I for more detail.

Each service is developed to an agreed/approved level of operational maturity:

- A. **Prototype**: an internally shared product or workflow, likely on a local or regional (rather than whole-of-continent) scale.
- B. **Beta**: an early release service, possibly with only minimal validation in Africa, released to gather feedback from some or all stakeholders.
- C. **Provisional**: a pre-operational service , with some validation in Africa, released for operational assessment.
- D. **Operational**: a service, with production and update are normally automated, generally validated³⁵, with defined service levels including

See Appendix II for more depth on operational maturity levels.

Thematic Areas: In order to summarise the relevance of a Service we identify the Thematic Areas that it is expected to support. Thematic Areas were determined with reference to the UN Sustainable Development Goals (SDGs), the African Union's Agenda 2063, the priorities of the

³⁵ Some services, such as NDVI ratios, are typically not field-validated. Others such as fractional cover may be well established with limited validation in Africa.

Group on Earth Observations (GEO), and broader social, environmental, and economic trends in Africa. The identified Thematic Areas are:

- Enabling Services are foundational, providing value in their own right whilst also enabling or supporting other services.
- Natural Resources, relating to the African Union's Agenda 2063 Goal 7 (Environmentally sustainable and climate resilient economies and communities) and a range of SDGs, including 6: Clean water and sanitation and 15: Life on land.
- Food Security,
- Urban Sustainability
- Disaster Risk Reduction
- Coastal and Marine Environments



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Current and future services

Name	Description	Stage of Development	Th su	Thematic Areas supported				
			E	Ν	F	U	D	С
(1) GeoMedian / GeoMAD - Annual	Geomedian / GeoMAD. The Annual Geomedian integrates the satellite images for a (calendar) year to produce a cloud-free image that can be used for further analysis. The Mean Absolute Deviation statistics (MADs) included in the dataset are the mean value of two metrics of variation which can then help in classification and identification of change. Input Datasets are Surface Reflectance, either Sentinel-2, giving a 10m Geomedian, or Landsat, giving a 30m Geomedian. Operational level: Operational Update frequency: Annual Update latency: 3 months	Maintenance (~2022)	x	x	x	x	x	x
(2) GeoMedian / GeoMAD - Semi-Annual	Geomedian / GeoMAD. The semi-annual Geomedian integrates the satellite images for six consecutive months to produce a generally cloud-free image for each half of the calendar year that can be used for further analysis. The Mean Absolute Deviation statistics (MADs) included in the dataset are the mean value of two metrics of variation. These can help in classification and identification of change. Input Datasets are Surface Reflectance - Sentinel-2, giving a 10m resolution Geomedian. Operational level: Operational Update frequency: Semi-Annual Update latency: 6 weeks	Maintenance (LR 2023)	x	x	x	x	x	x
(3) GeoMedian / GeoMAD - Rolling Monthly	Geomedian / GeoMAD. The Rolling Monthly Geomedian is produced each month. It integrates the satellite images for three consecutive months to produce a generally cloud-free image that can be used for further analysis. The Mean Absolute Deviation statistics (MADs) included in the dataset are the mean value of two metrics of variation which can help in classification and identification of change. Input Datasets are Surface Reflectance - Sentinel-2, giving a 10m resolution Geomedian. Operational level: Operational Update frequency: Monthly Update latency: 6 weeks	Maintenance (LR 2023)	x	x	x	x	x	x

Name	Description	Stage of Development	Th su	ema ppo	tic /	Area	IS	
			Е	Ν	F	U	D	С
(4) Water - WOfS	Water Observations from Space (WOfS) captures the history of surface water across the continent based on satellite observations. Each pixel is tested for the presence or absence of water, and this is summarised to produce an annual surface water dataset indicating the frequency of water, from the 1980s onward. An 'all time' summary is also produced. The dataset maps water bodies and floodplains. Input Datasets are Surface Reflectance - Landsat, producing a 30m resolution product. Operational level: Operational Update frequency: Annual, calendar year. Update latency: 3 months	Development (2019)	x	x	x	x	x	
(5) Crop Land Map 2019	The Crop Land Map identifies areas that have been cropped in a given year. A consistent up-to-date crop land mask for the continent (at Landsat/Sentinel-2 spatial resolution) is noted as a gap in Agriculture monitoring tools operated by e.g. GEOGLAM crop monitor. Specifications of this product will be defined in consultation with collaborators. The crop land map was created for 2019. Impact: A crop land map/mask is critical for crop monitoring and crop modelling. A continental-wide consistent product will support regional and local crop monitoring services and is expected to be used by ministries and state departments of Agriculture in the countries, international organizations, academia and private sector. Operational level: Provisional Update frequency: not updated Update latency: n/a	Maintenance			×			

Name	Description	Stage of Development	Thematic Areas supported			Thematic Areas supported				
			Е	Ν	F	U	D	С		
(6) Fractional Cover - Annual	 Fractional Cover - Annual (FC) measures the percentage of green vegetation (PV), brown vegetation (NPv), or bare soil (BS) on the land surface, for each pixel in the satellite image. Unlike indices, FC is a measurement of a physical quantity with the potential for field validation. Impacts: FC is relevant to wind and water erosion, soil carbon dynamics, land management practices, land condition, vegetation status, fuel load, ecosystem modelling, rangeland condition & etc. FC calculated from MODIS data has been used to identify significant changes in grasslands in Africa³⁶and supports tools such as the Rangeland and Pasture Productivity tool (RAPP) developed by GEO (GEOGLAM). The DE Africa FC service is calculated from Landsat data, providing higher spatial resolution. Values are aggregated through time to produce an annual (Julian calendar year) statistical summary of FC, i.e., the 10th, 50th and 90th percentile values of Pv, NPv and BS. Resolution: 30m Operational level: Provisional (un-validated) Update frequency: Continuous (satellite tiles), and, Annual (calendar year). Update latency: Per image: Annual summary: 3 Months 	Maintenance	x	×	×	×				
(7) Coastlines	DE Africa Coastlines service; including vectorised coastline locations for each year around the continent, and visualisation tools. The Coastlines service provides unique information on the exposure of African populations to coastal change and empowers community / stakeholder groups. Improvements include solving difficulties around island States and the use of Sentinel-2 to overcome problems with noisy data. Operational level: Operational Update frequency: Annual Update latency: 3 Months	Maintenance								

³⁶ <u>https://www.mdpi.com/2072-4292/12/3/406</u>

Namo	Description	Stage of		ema	atic .	Area	IS	
Name	Description	Development	su	рро	rted			_
			E	Ν	F	U	D	С
(8) Barest Earth Geomedian	'Barest Earth' Geomedian is a Geomedian image that shows the land surface at those times when vegetation is most sparse, revealing the 'bare earth', revealing as much as possible about the soil and surface rocks of the land. The geomedian statistics are calculated by applying a weighting to those images that have least vegetation ³⁷ .	Nomination	x	x	x			
	soil mapping and land degradation monitoring.							
(9) Land Cover Classification System	The Land Cover Classification System is a continental land cover service using EO data to implement the UN Food and Agriculture Organization (FAO)'s Land Cover Classification System (LCCS). The approach is hierarchical, and based on physical properties of the land (e.g., water, bare areas, vegetated areas). Methods would leverage work underway in Wales and Australia. Unlike alternatives, the approach supports constant improvement and comparisons of land cover between one year and the next ³⁸ . Impact: Governments are empowered with meaningful land cover information that can be	Nomination	x	x	x	x	x	x
	constantly updated, allowing changes through							
(10) Water Quality	Water Quality indicators can be derived from satellite data based on optical properties of the water. Several indices are well established in the literature and in practice, and major changes in some water properties can often be detected. Higher quality satellite data are desirable as an input, specifically the 'Aquatic Reflectance' dataset now under development as an input dataset. In order to progress beyond a provisional service, a validation campaign would be necessary including field data collection. Impact: Water quality relates directly to water security and the SDGs. For example, monitoring water quality using Earth observation enables improved identification of harmful algal blooms and can highlight events and processes affecting water quality.	Costing		x	x	x		

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³⁷ https://www.nature.com/articles/s41467-019-13276-1

³⁸ Prevailing approaches to land cover mapping are relying on a single machine learning process to detect all land cover types, rather than using the best possible algorithm for each landcover type (e.g., WOfS for water). Consequently they rely heavily on reference data, generally produce a list of classes that *can be* differentiated, rather than the classes *that are needed*, and lack transparency.

Name	Description	Stage of Thematic Are Development supported				Thematic Areas supported			
			Е	Ν	F	U	D	С	
(11) Wetlands	 Wetlands is an end-to-end workflow that provides a flexible and adaptable framework to create a wetland inventory or improve on existing inventories for an area of interest (e.g., a country). The wetland workflow is currently being tested out in South Africa, Kenya, Rwanda, Uganda, and Senegal. Impact: Many regions or countries do not have a complete inventory of wetland locations, extent or types. Wetlands are not only areas of high biodiversity, they also ensure the availability of clean water and sanitation for humans that contribute directly to monitoring the SDGs. This workflow directly supports Indicator 6.6.1 that monitors change in the extent of water-related ecosystems over time. An accurate, unbiased, and spatially aligned wetland inventory is a necessary first step for monitoring and characterizing wetlands. 	Development		x	x				
(12) NDVI Anomalies - Monthly	 NDVI³⁹ 'anomaly' - monthly is the difference between the mean monthly NDVI for a given year and month, and the mean NDVI for the same month over a specified number of years. The anomaly is expressed as the number of standard deviations of the observed monthly value from the longer-term mean. The anomaly is an indicator of vegetation health and drought. NDVI anomalies measured at 10 to 30 metre spatial resolution will enable monitoring of crop conditions at paddock scale. As a monthly product will be updated when a complete month of new observations become available. Impact: NDVI anomalies will support regional and local crop monitoring services. 	Maintenance (2022)		x	x				
(13) Waterbodies	Waterbodies will map permanent waterbodies and produce a geohash (label) for each one. The characteristics of each waterbody, and changes in those, will be able to be monitored (e.g., the surface area of water). Additional characteristics such as water quality indicators may subsequently be used to describe the waterbody and monitor its health. Impact: More informed decisions relating to water, water management, and water use (irrigation, flooding, wetlands, human health, etc.)	Development	x	×	×	x	x		

³⁹ Normalised Difference Vegetation Index

Name	Description	Stage of Development	Thematic Areas			IS		
			E	N	F	U	D	С
(14) Land Degradation / LDN Toolkit	 Land Degradation is a global concern, reflected in the UN Sustainable Development Goal 15.3 Land Degradation Neutrality (LDN), a major issue for agriculture in Africa. The UN Convention to Combat Desertification (UNCCD) has developed an open framework for EO-based indicators of land degradation, based on land cover change, land productivity and soil carbon stocks. DE Africa is well positioned to support monitoring and reporting of land degradation in Africa following endorsed processes, targeting national and sub-national users. Methods are also implemented on other platforms. Impact: Countries are empowered to act on land degradation within international climate frameworks / AFOLU accounting. 	Nomination (AL)		x	x			
(15) Agriculture Monitoring Tools	Tools and methods built on waterbodies and agricultural data provide insight into the dynamics between water availability and productivity. Methods for this are not currently under development for Digital Earth Australia, though may be developed for DE Africa. In developing Agricultural Tools, DE Africa may collaborate with GEOGLAM to ensure the utility and uptake of these services to existing African agricultural and food security initiatives. Impact: Monitoring agriculture links social, environmental, and economic factors that underpin several SDGs. As a driver for quality of life from small communities through to entire countries' populations, monitoring water availability and productivity to measure agricultural production is an invaluable tool for policy makers and private industry in Africa.	Nominated			x			
(16) Irrigated Extent of Crops	Impact: Improved strategies to support effective management of water and land resources, including irrigator responses to changes in water availability	Nominated			x			
(17) Fire-Scar Mapping	 Fire-Scar Mapping, or mapping of areas of burned vegetation, using EO data. Impact: Informed decisions regarding land degradation, land use change, carbon sequestration, and ecosystem management. Fire regimes in savannah can be adjusted to increase carbon sequestration. 	Nomination					x	

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Name	Description	Stage ofThematic AreasDevelopmentsupported					IS	
			Е	Ν	F	U	D	С
(18) Intertidal Digital Elevation Model	The Intertidal Digital Elevation Model would map the three-dimensional structure of the intertidal zone. Developed from EO data by mapping the location of the waterline across a range of tide levels. Methods developed in DE Australia are applicable. Impact: The intertidal zone is notoriously difficult to map. Intertidal zones are faced with increasing threats from coastal erosion, land reclamation (for example, port construction), and sea level rise. Accurate elevation data describing the height and shape of the coastline	Nomination	x	x		x	x	x
	can help predict when and where these threats							
(19) Coastal Change Characterisation	A Coastal Change Characterisation service would use imagery to allow users to visualise and understand coastal change. The imagery (geomedians corresponding to tide levels) would be produced during the development of the intertidal elevation model.	Nomination		x	x	x	x	x
onaracterisation	Impact: Improved awareness of and policies regarding coastal areas, relating to human health, urbanisation, coastal development, fisheries management, coastal wetlands and coastal ecosystems.							
(20) Mangrove Mapping (extent, density, change)	Mangrove Mapping workflows, which could be implemented at national and regional scales by users and stakeholders. DE Africa draws on the Global Mangrove Watch for continental data on mangroves. The GMW datasets provide the starting point for national and regional approaches.	Nomination (by unknown)	x	x	x		x	x
	regarding mangroves and coastal areas, relating to human health, urbanisation, coastal development, fisheries management, coastal wetlands and coastal ecosystems.							
(21) Terrain and Hydrological Indices	Terrain and Hydrological Indices (curvature, flow paths, flow accumulation, hydrologically enforced DEM, catchment delineation, etc.) developed in partnership with the IWMI.	ideation	x	x	x		х	
(22) Forest Cover and Condition	Forest Cover. Forests benefit Africa through water, habitat, production of materials and more, and are a major factor in carbon sequestration/storage. The protection of forest in critical areas such as the Congo has focussed the efforts of funders and the international community. Whilst multiple players are active in forest monitoring at the global scale, none are specifically African based. Impact:	nomination		x				

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Name	Description	Stage of Development	Th su	ema ppo	tic /	Area	IS	
			Е	Ν	F	U	D	С
(23) Drought indicators/monit oring information	Drought Indicator interfaces and workflows would enable drought assessment at the province/county scale and provide information on the nature of droughts (e.g. hydrological, agricultural, meteorological, socioeconomic) and their extent in time and space. Impact: Better information on droughts would inform institutional responses, including increased preparedness	Ideation						
(24) Terrain Slope and Flatness from SRTM	Terrain Slope and Flatness Topographic information that influences natural processes and local hydrology, used in modelling and classification. Static dataset of two hydrological measures produced by catchment modeling of the DEM. Spatial resolution: 30m Impact: Improvements in the accuracy of classifications etc. when these variables are included.	Maintenance	x	×	×	×	×	

5 Appendices

Appendix 1. Platform Requirements

This Appendix identifies where the Science-Data-Services Roadmap relies on the DE Africa 'Platform'. This allows:

- the **DE Africa Leadership** and **Governance Framework** to consider these dependencies; and the
- the **Platform Team** to be aware of and plan to support delivery of this Roadmap.

The Platform Team leads and operates the Cloud-IT infrastructure that allows DE Africa to bring data to Africa, prepare, store and manage data, access third party datasets, analyse data, provide computing environments for large scale processing and for small scale analysis (Sandbox). The many responsibilities of the team include ensuring appropriate levels of security and reliability, managing relationships with AWS partners, etc. The technical Platform is therefore the foundation for all of DE Africa.

The Data and Science Roadmap is particularly dependent on the technical Platform to be able to maintain access data, provide services, run processes, and provide users (internal, external) with effective environments.

Phase-III, which is considered 'Make or Break' for DE Africa, is focussed on impact and uptake at country and National levels to support practical requirements of governments. Phase-III places much greater emphasis on practical or 'operational' uses of DE Africa.

The Science, Data and Services Roadmap identified four functional areas for the Platform Team and listed specific dependencies within each.. The most critical and challenging dependencies relate to user experiences and are listed first.

1.	Capabilities that affect users' experiences and the ability to provide relevant services
	This is the most critical and challenging area of dependency on the Platform. Aspects of the Platform that have limited uptake, growth, and the formation of important partnerships were apparent in Phase-II, but were not resolved.
	If DE Africa is to succeed, it is vital to overcome these challenges early in Phase-III.
1.1	Running analyses at larger - National - scale.
	As DE Africa moves beyond students, academics, researchers & etc. to engage with users in Government and industry, and running processes that are tailored to specific country needs, running processes at country scale is fundamental. This is currently a barrier for internal and external users.

	New services, such as Wetlands, will be implemented at a country level, so that information can be tuned to national needs. Platform systems must be able to support these developments.
	This is a challenge of both skills and technology with a range of solutions. Learnings from the waterbodies implementation indicate that methodologies can be developed to build skills and the disciplines of running large scale processes, whilst simple steps such as expanding Sandbox sizes to 30 Gb can help to keep users who turn away when limits are hit.
1.2	Enabling other, funded, projects to fully exploit our systems and to work with us on our scalable systems. IWMI is an important example, developing water management tools for Africa.
1.3	 Interfaces, including with with other systems, that allow information to be leveraged by a wide range of users, eg. Transferring outputs to the cloud rather than downloading to a desktop Connecting with GIS systems, ESRI, QGIS, (meaningfully; it is not sufficient to say that DE Africa datasets are released as open source) Interactive interfaces to run analyses without going through a sandbox "Beyond the Sandbox ". It is well understood that the Sandbox is suited to highly skilled users and not to decision makers and specialists who simply require information from DE Africa. A 'polygon drill' is an example.
2.	Business-As-Usual (BAU) functions
	BAU functions are carried out on a day to day basis. BAU activities enable all capabilities and build the reputation of DE Africa as a reliable and operational infrastructure. Conversely, failure in BAU leads to a loss of capability and reputational damage. Phase-II established many of the BAU Platform methods and processes, however breaks in these basic activities at the start of Phase-III are impacting DE Africa Services.
2.1	Maintaining data pipelines for core data streams
2.2	Continental processing to maintain derived information - services - to match specifications
2.3	Monitoring and reporting against product and service specifications
2.4	Working with others to establish the performance specifications for data and services (clarify, agree and document the specifications, .such as how often a dataset is updated)
3.	Monitoring and Optimisation
	The Platform team has access to information on the use of computing resources, the cost of use, and of actual users. This information is vital to responsible management of resources, efficiency, relationship management (e.g., with the AWS Public Data Store), cost management, understanding of patterns of use, and reporting. Since Phase-II there has been a loss of reporting information.
	Monitoring and optimisation relates to efficiency, management of costs and capabilities, and understanding of use and uptake.

3.1	Monitoring of use		
3.2	Sandbox costs		
3.3	Production costs for continental products		
3.4	Liaison with AWS technical leads and account managers (with COO/Chief Scientist)		
4.	Platform Sustainability (skills and staff)		
	The Science Data and Services Roadmap assumes that the personnel and skills which constitute the Platform Team will be sustained. The critical dependency on the Platform Team is a point of discussion during each annual meeting of the Science Team. Platform Sustainability relates to how DE Africa sustains its Platform Team going forward.		
4.1	Clarity of team responsibilities		
4.2	Understanding of roles in the Platform Team		
4.3	Clarification of necessary skills		
4.4	Relationships and networking - building mutual support across datacube platform teams (Africa, Australia, Antarctica, Pacific)		

Appendix 2. Hosting models used by DE Africa

Please note: this appendix is a work in progress. Expect changes and corrections as it matures.

DE Africa hosts data in several different ways to minimise costs and depending on the way in which the data are made available. Table A2 (below) defines the types of hosting and the associated steps to maintain and make the data available.

	Description	Support level	Accessible through
Hosted	Data is maintained in the DE Africa data store (i.e., on AWS).	DE Africa: 1) Maintains update processes to bring in new data from sources it becomes available (data pipelines). 2) Prepares the data for use in DE Africa (e.g. implementing analysis ready data)	Data Explorer DE Africa map Sandbox
Indexed	Data is 'indexed' into DE Africa, allowing users to operate on the data. Data is maintained and stored, and made accessible to DE Africa, by the producers.	DE Africa: 1) Maintains an indexing service 2) Monitors the availability of the data 3) Maintains contact with the data provider to be aware of issues, improvements, or changes to the service	Data Explorer DE Africa Map Sandbox
Sandbox	Data is available from a provider through notebooks that run in the sandbox environment.	DE Africa: 1) provides example notebooks of how to access and apply the data	Sandbox
Visualise	Data is made available by the provider for limited use, but can be visualised in DE Africa.	DE Africa: 1)provides 'how-to' information for users	Sandbox

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Appendix 2. Stages of Development

Stages of development for a new Input Dataset or Service, or improvements to existing.



- Nomination (nomination accepted for listing in the Roadmap, no commitment to action. Nominations accepted from any source. Person nominating to be indicated in the table).
 <u>Output</u>: Listing in the Roadmap Table
- Ideation/specification (Science Director approval, date of approval, and person leading the ideation, to be indicated in the table) gathering information on partnerships, data sources, algorithms, use-cases, benefits, operational level (beta, provisional, operational) operational parameters (update frequency latency, delivery). For an Input Dataset the specification details will be different.

<u>Output</u> : A short report, included as an appendix to the Roadmap, with the details of the proposal, covering key points.

- **Costing** (Science Director approval after advice from the AC, date to be indicated in the table); estimation of the effort required to deliver on the idea. Assign a 'Tier' reflecting the level of effort and uncertainty. <u>Output</u> : Advice to management on costs, risks, methods etc.
- **Development** (Management Team approval, based on advice from the Science Director and AC, date of approval to commence development included in the table). Development to the approved operational level (prototype, beta, provisional, operational).

<u>Output</u> : A DE Africa product or service to specification

• **Maintenance** (Science Director acceptance; date of acceptance to be included in the table) acceptance of the Service at the planned operational level, based on advice from the AC and other Stakeholders.

<u>Output</u> : Maintenance of the dataset or service to specified levels.

Appendix 3. Operational Levels

Operational levels describe the level of maturity of a Service and the progression from beta to provisional and operational.

- A. **Prototype**: an internally shared product or workflow, likely on a local or regional (rather than whole-of-continent) scale.
- B. **Beta**: an early release service, possibly with only minimal validation in Africa, released to gather feedback from some or all stakeholders.
- C. **Provisional**: a pre-operational service , with some validation in Africa, released for operational assessment.
- D. **Operational**: a service, with production and update are normally automated, generally validated⁴⁰, with defined service levels including
 - 1. update frequency,
 - 2. latency of update and
 - 3. distribution channels.

A service is developed *to an agreed level*, for example, the DE Africa CropLand service is Provisional.

⁴⁰ Some services, such as NDVI ratios, are typically not field-validated. Others such as fractional cover may be well established with limited validation in Africa.

Appendix 4. Traffic Light Summary

Traffic Light Summary - Input Datasets (N=37)

Based on Input Datasets under active consideration 2024-03-07



Traffic Light Summary - Services (N=24)

Based on services under active consideration. 2024-03-07



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