## Application Form

## GEO-Amazon Earth Observation Cloud Credits Programme

Application for $60,000 of Amazon Web Services cloud credits over a 3-year period

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### Collaborators

Please indicate all collaborating agencies and institutions, and the relevant focal points from each (with contact information):

| **Collaborating Agency** |
|---|
| **Kenya Agricultural and Livestock Research Organization (KALRO)**<br><br>Director General, KALRO Headquarter<br>P.O. Box 57811-00200<br>Nairobi, Kenya<br>Kaptagat Road, Loresho<br><br>www.kalro.org |
| **KALRO www.kalro.org**<br>The Kenya Agricultural and Livestock Research Organization is composed of semi-autonomous institutes established under the Kenya Agricultural and Livestock Research Act of 2013.<br><br>**Functions**<br>1. Advise on, and develop appropriate systems to promote balanced, diversified and sustained agricultural development and to optimize agricultural production through adaptive and investigative research; and<br>2. Facilitate the use of improved production technology, and to establish adequate feedback systems from agricultural producers in order to achieve and maintain national self-sufficiency and export capacities in agricultural products<br>3. It is expected that the Institutes shall conduct research in their respective value chains and disseminate appropriate information and technologies to intended users. Although the key mandate of each institute will be restricted, the various research centres under the administration of each Institute may manage research projects covering multiple value chains and commodities. |
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**agriBORA**
Geodata for actionable farm intelligence

**Functions**

1. To provide near real-time geodata to support lending and insurance decisions in the agricultural sector thereby de-risking agricultural investments and creating opportunities for inclusive finance for millions of smallholder farmers.

2. To generate automated, tailored and hands-on agronomic content has been optimized for on-farm decision making, placing timely field-level agronomic insights in the hands of farmers. This enables them to improve their productivity and farm income.

3. To provide weather station network to fill the critical data gap and enable farmers to make smart plans and management decisions as well as access weather-indexed insurance.

**Title:** Geographical Information System for Sustainable Agriculture in Kenya and Beyond

## Executive summary

To date, Kenya's agricultural sector performance has been highly volatile with growth rates dipping into negative. In the just released Kenya Economic Survey 2018, the agriculture sector recorded a decline in agricultural production for the year 2017 of 1.6 per cent, occasioned by drought coupled with pests such as the fall army worm and diseases. For Kenya to address these challenges there is need to derive agricultural intelligence and insights from predictive data analytics to support decision making and agricultural performance optimization. Proper planning using up to date geo information could minimize negative impact of climate change on people's livelihoods and economy. Accurate and decision-relevant geo information is critical to plan & minimize negative impact of climate variability. Using modern ICT tools KALRO has developed various technologies in crop and livestock and documented the best practices for each. These coupled with real time geospatial data KALRO can help policy makers, counties and farmers optimize their decision making. The Geographic Information System (GIS) will support provision of data and information to relevant stakeholders and policy makers in real-time. Access to Sentinel-2 data, Landsat and MODIS satellite data offers value added services and sustainable impacts to improve agricultural performance.

## Introduction and context

The tremendous global rise in the number of providers of remotely sensed data coupled with the almost simultaneous open data approach being adopted by many of these providers and other global organizations is seeing a a huge deluge of satellite data available to the remote sensing community. Processing such huge amounts of data may not be effectively handled in the traditional way, and there is need to overcome the challenges of low computing capacity and slow internet especially among the developing nations. Sentinel Hub is a remedy to these problem by provision of satellite imagery through an easily accessible standard web service which can be easily integrated into any desktop, web or mobile mapping application.

The project will support provision of data and information that are needed for base, advance and insight for decision making. The project will design a GIS platform to capture, store, analyze and represent spatial data. It will be used to analyze and visualize data and trends over time in agriculture for sustainable development. With the help of developed APIs the designed GIS platform will use and adopt unique features of Sentinel Hub for example the; global coverage, efficient access to imagery at any scale; preconfigured earth observations (EO) products; multi-temporal processing and custom scripts to meet localized demands. Sentinel Hub removes the complexity of handling satellite data. It makes Sentinel, Landsat, and other Earth observation imagery easily accessible for browsing and analysis.

The team will also use intelligent analysis techniques to generate farm intelligence remotely. This will include: Algorithms to automatically derive vegetation indices from sentinel imagery once available. This will include indices derived from Sentinel 2 (Optic) as well as Sentinel 1 (Radar) imagery to enable constant vegetation index monitoring not affected by clouds or day/night. Combination of weather data with soil and agronomic data to run crop simulations. The developed system shall be used to compute and correlate simulated vegetation indices with observed indices from earth observation data for intelligent crop growth and yield estimations.

Using $60,000 of Amazon Web Services (AWS), credits KALRO and agriBora will build the GIS platform in support of non-commercial earth observations applications that promote environmental and development goals, including the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the United Nations Sustainable Development Goals.

**Goals**

Promote improved utilization of geospatial data: to aggregate field and farm level data into map able (GIS ready) information that provide insight in addressing a host of challenges, for example where did it rain? Where did crops fail?- and how many people were impacted?, how much fertilizer (tons) are needed in a particular area among others.

**Problem statement**

The main development challenge in Kenya is lack of accurate, timely and reliable weather data, its integration to agricultural research data and interpretation to support an effective decision making process. In addition the effect of weather and climate variability has increased risks to agricultural performance.

Adopting GIS techniques requires investments in computing and human capacities. While the techniques are not relatively new adoption into main stream science and research these are used there minimum and still evolving, many of the practices that make up GIS already exist worldwide and are in use by developed countries.

**Targets**

Extracting information from the GIS platform will facilitate a) improved access to accurate information on science and agriculture in Kenya; b) improved access to planning and implementation frameworks using agricultural research and science agenda; c) Improved access to policy making tools as captured by Policy Practice Index for policy makers and other agencies; d) Increased access to planning data from megatrends/foresight by stakeholders, and e) Increased and better targeted investments in Agricultural Research in Kenya.

***Agricultural research in Kenya***

Over the years agricultural research in Kenya has generated important datasets through various programs and research activities. These datasets include; information on rural farming such as crop varieties, acreage cultivated, faced challenges, number and types of livestock; farmer household data; productivity levels; agricultural technologies adopted and adapted; farming systems among others. Processing and managing these datasets using GIS techniques will help identify the different stakeholders' needs and expectations and as a result classify the different types of datasets and metrics that are critical in decision making and policy direction. For instance using GIS tools to integrate multiple datasets with ecological requirements of crops has generated crop suitability to help find what is relevant and important and to explore different scenarios in improving agricultural productivity in Kenya and beyond. On the other hand land imaging is on an upward trend in Kenya since the year 2013. Figure 1 below shows the growth of land imaging data in Kenya between the years 2000-2017.

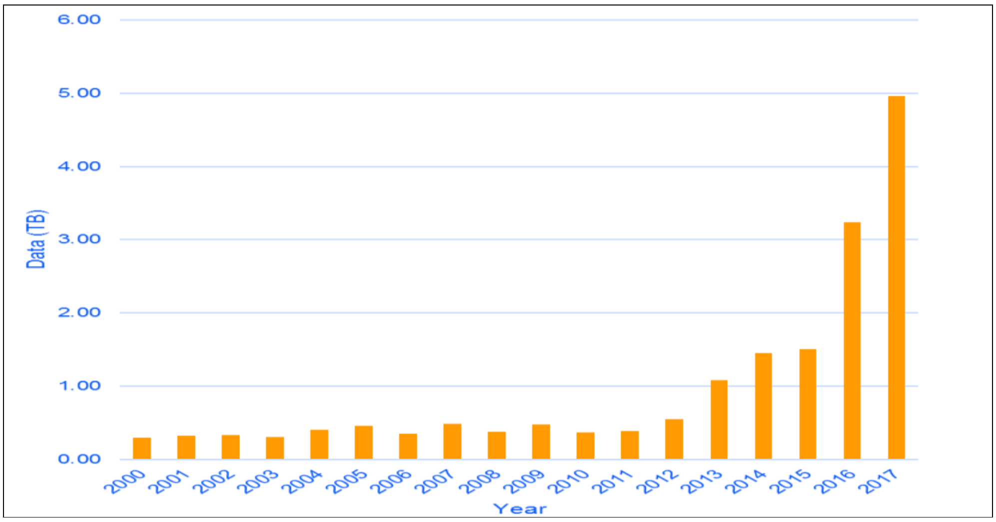


**Figure 1**: The growth of land imaging data in Kenya (*Adopted from Brian Killough, 2016*)

In general, the project is expected to provide comprehensive data and information, enable agricultural institutions, counties and humanitarian agencies access to high resolution geospatial and agro-meteorological data. As a result, access to information will encourage and empower youth involvement in agriculture and mitigate the effects of climate variability.

***Crop mapping techniques***

Kenya is subdivided into 47 Counties. Crop mapping techniques can be used to determine the total yield, calculate metrics like total yield per County, Sub County and even the Ward. Combined with population density, poverty rates to map out and analyze an area and determine trends. Crops can be mapped to determine the location of smallholder farmers and potential hazards i.e. drought and floods.

***Climate mapping techniques***

Climatic factors have a great effect on crop development. It is therefore essential to achieve a high spatial and temporal resolution of these factors, for example of temperature, radiation and precipitation (and strong precipitation with flooding effects). Besides historical and current weather information, reliable forecast data needed to minimize risks and make recommendations. To achieve this, different interpolation and downscaling techniques of global climate models and in-situ observations can be used. To get an overview of the crop status, climate data can be aggregated per County, Sub County and Ward. It can be calculated in more detail, so that farmers can receive actionable information for their farming decisions. Mapping of the precipitation rates, temperature across the country could also lead to greater awareness and minimize effects and causalities.

***Pastoralism and climate change***

Pastoralists occupy the driest areas in Kenya and face greater risks from droughts and deteriorating purchasing power during such incidences making them very vulnerable. During drought livestock populations are depleted due to high mortality, scarcity of animals drives the price up posing a great challenge to these communities. The recovery time is also limited by the reproductive rates of the animals.

***Early warning system***

There is need to develop an early detection system to inform on the onset of drought. The early warning system for the onset of drought will use the approach of identifying the different types of drought which are connected in time, assessing spatial and temporal trends in key weather variables. Through the system, less than normal rainfall or higher than normal temperatures shall be monitored using satellite and proprietary forecast data. This shall be used to define meteorological drought. With the persistence of this situation, soil moisture on the fields may fall below normal levels leading to an agricultural drought. This will be achieved through continuous monitoring of forage and capacity building related to; tracking systems, crisis identification and famine response.

Development of GIS platform to detect hotspots and mobile apps to ensure that this information reaches the stakeholders i.e. the pastoralists, County Governments, Insurance agencies, NGOs among others for early response would go a long way to mitigate risks and deaths of people and livestock.

***Relation to the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the United Nations Sustainable Development Goals***

The GIS platform for sustainable agriculture in Kenya and beyond is informed on ambitious aims to develop tools and analytical power into agricultural development activities. It therefore aims to achieve broader food systems development goals under changing climatic conditions and increasing food demand. The GIS initiative is to sustainably increase agricultural productivity, promote open data principles and decision making and policy direction.

The overall relationship of the project to the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the United Nations Sustainable Development Goals is to increase agricultural productivity through extraction of relevant information from the GIS platform and imagery data related to agriculture in Kenya.

**Indicators**

KALRO has a strong team of ICT and GIS/RS professionals. It has ready infrastructure to handle the GIS platform for its thematic applications. The GIS lab at KALRO Kabete has been undergoing capacity enhancement to handle large processing works. agriBORA has a host of technical expertise through delivery of geodata for actionable farm intelligence in Africa.

***The project will;***

1. Develop the GIS platform
2. Develop and test weather and yield models on the GIS platform
3. Access high resolution imagery from Sentinel Hub services
4. Create valuable insights for farmers through weather, agronomics and analytics
5. Real-time and historical records of all relevant weather variables including short-term weather forecasts
6. Agronomics content for framers, crop monitoring and yield prediction
7. Provide actionable information and predictions that help farmers and policy makers to make better decisions
8. Map outputs against the Sendai Framework, United Nations Sustainable Development Goals and GWP activities

**Regional GEOs activities**

Africa Regional Data Cube (ARDC) http://www.data4sdgs.org/index.php/initiatives/africa-regional-data-cube

Regional Centre for Mapping and Resource Development (RCMRD) http://geoportal.rcmrd.org/

**Methodology**

The GIS platform for agriculture sector will utilize data from various sources. These data will be compiled into layers which will be used to represent the data generation and interaction as shown below;

**(1) Data Generation and Interaction**

- **Develop web based and mobile applications that input location and site data**

  Mobile phones will be used to provide; agricultural survey data, farmer location, crop under production, size of enterprise, planting date, photos, and geo-reference data.

- **Develop the GIS for agriculture database**
- **Develop the geospatial database**

  Satellite data will provide, rainfall estimates, soil moisture, evapotranspiration and vegetation health indices.

- **Develop the simulation models database**
- **Provide localized weather services on demand**

  Ground weather stations will be used to provide ground based data for trothing, calibration and validation of indices. These data will include the total daily rainfall amounts, temperature data (mean daily, max daily and min daily), relative humidity data (mean daily, max daily and min daily) and global radiation data

- **Generate actionable agronomic advisories**

  Drone technology will be used to collect data for pre-season, on-season and post-season monitoring, soil health analysis, disease and pests, fire and flooding quantification and farmer conformant with good agricultural practices

**(2) Conduct agrometeorological observation**

- **Biological;** state of crop or pasture performance; state of pests and diseases; expected yield; vegetation
- **Physical;** air temperature; minimum & maximum temperature; wind; radiation; sunshine hours; relative humidity; evaporation; rainfall
- **Soils;** soil type; soil temperature at depths; field capacity; wilting point; bulk density and soil moisture determination

**(3) Organize hackathon using open satellite data (Sentinel, Landsat, MODIS and other earth observation data)**

**(4) Build human capacity in KALRO and agriBora**

To implement a GIS platform within KALRO and for execution of the organizations themes and optimise the use of remote sensing data and technology, crop productivity assessments, monitoring, soil and related biophysical resources management there is need to build human capacity at KALRO and agriBora.

There will be a need to assess the human and infrastructural requirements for implementation and operationalization of the GIS platform in KALRO.

Conduct capacity building at KALRO and agriBora for accessing, analysing and manipulating satellite imagery within the concept and framework of GIS platforms.

Collaborate with respected organizations (e.g. ARDC, ICRAF, RCMRD) in training staff on implementation and running of GIS specifically for analysis of remotely sensed imagery.

### Deliverables/applications and timeline

(1) Stakeholder mapping of data users, providers and enablers by end year 1

| Description | Responsible Organisation | 2019 | | 2020 | | | | 2021 | | | | 2022 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 |
| Stakeholder mapping of data users, providers and enablers to understand their their pains and gains using EO data. This data shall be collected all through year one to be used to co-design mobile and web application products in year 2. | KALRO | | | | | | | | | | | | |
| Field-level agronomic insights for decision making by policy makers, counties and farmers | agriBORA | | | | | | | | | | | | |
| Data from earth observation satellites: Sentinel, Landsat, MODIS, generated in agricultural operations into a decision support system | agriBORA | | | | | | | | | | | | |
| Prepare and submit annual progress report | KALRO/ agriBORA | | | | | | | | | | | | |
| Analyse satellite data and integrate in-situ data from ground waether stations to develop a machine learning algorithm for crop development monitoring | agriBORA | | | | | | | | | | | | |
| Develop and test a platform to provide insights to assist farmers, financial institutions, agro-input companies to make sound data-validated decisions | agriBORA | | | | | | | | | | | | |
| Policy paper on:water management: water extent and quality for drinking, animals and agriculture | KALRO | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prepare and submit annual progress report | KALRO/ agriBORA | | | | | | | | | | | | |
| Policy paper on the range land quality | KALRO | | | | | | | | | | | | |
| Policy brief on linkage to decision making and SDG's by year 3. | KALRO | | | | | | | | | | | | |
| Data, software and best practices used and developed will be made fully and freely open and accessible to the wider GEO community using a FAIR-compliant data license by year 3. | KALRO/ agriBORA | | | | | | | | | | | | |
| All software used to produce the results, including the base packages and user-developed algorithms, will be made available on approved Open Source Initiative by year 3. | KALRO/ agriBORA | | | | | | | | | | | | |
| Prepare and submit final report | KALRO/ agriBORA | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

(2) Field-level agronomic insights for decision making by policy makers, counties and farmers by year end 1 (this will continue over project period and beyond).
(3) Data from earth observation satellites: Sentinel, Landsat, MODIS, generated in agricultural operations into a decision support system by year 1 (this will continue over project period).
(4) Use of intelligent analysis techniques, to generate farm intelligence by year 2 (this will continue over project period and beyond).
(5) Insights to assist farmers, financial institutions, agro-input companies to make sound data-validated decisions by year 3.
(6) Policy paper on water management: water extent and quality for drinking, animals and agriculture by year 2.
(7) Policy paper on the range land quality by year 3.
(8) Policy brief on linkage to decision making and SDG's by year 3.
(9) Data, software and best practices used and developed will be made fully and freely open and accessible to the wider GEO community using a FAIR-compliant data license by year 3.
(10) All software used to produce the results, including the base packages and user-developed algorithms, will be made available on approved Open Source Initiative by year 3.
(11) Annual progress reports will be summited and final project report will be submitted by year 3.

**Use Sentinel Hub services**

The project will design a GIS platform to capture, store, analyze and represent spatial data. It will be used to analyze and visualize data and trends over time in agriculture for sustainable development in Kenya and beyond. The designed GIS platform will use and adopt unique features of Sentinel Hub for example the; global coverage, efficient access to imagery at any scale; preconfigured earth observations (EO) products; multi-temporal processing and custom scripts to meet localized demands.

**Cloud computing credits and earth observation requirements**

At the beginning the project will require a low cost regime but once launched the team will require the APP Developers and enterprise regime costing 500 Euros per month annually to delivery.

**Number of credits**

The team proposes to use 1.000 req/min (200.000 per month).

**The geographic region to be analyzed**

The East African region is classically presented as a major dry climate anomaly region in the otherwise wet equatorial belt, is a transition zone between the monsoon domains of West Africa and the Indian Ocean. Its complex terrain, unequaled in the rest of Africa, results in a huge diversity of climatic conditions that steer a wide range of vegetation landscapes, biodiversity and human occupations. With this in mind the geographic location will include East Africa, North and West Africa and the Indian Ocean.