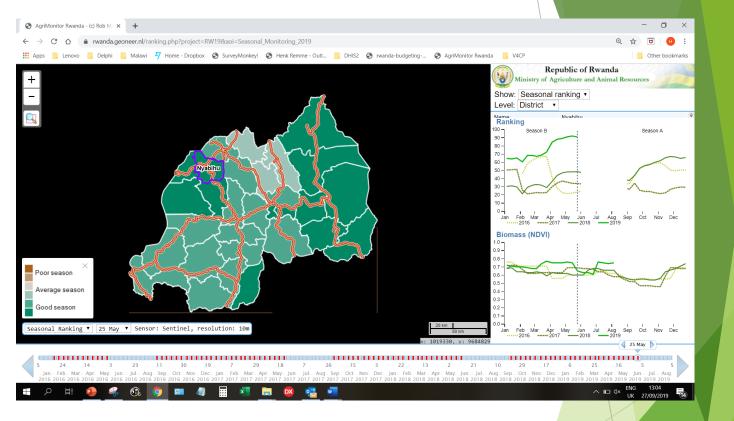# Rwanda Smart Satellite Crop Monitoring Application

Presentation AfricaGIS conference, 20 November 2019
Henk Remme

Background and purpose of the system

▶ Fully automated Satellite Crop Monitoring Application developed for Rwanda Ministry of Agricultural and Animal Resources (MINAGRI) with support from Agri-TAF (DFID-funded TA project):

▶ Web portal with a map window and graphs showing time series of NDVI values and crop growth status of selected areas on the map – enables detailed views (10x10m) and aggregated views

▶ **Purpose**: Support the management of the agricultural sector through nearly real-time monitoring of crop production in the country and facilitate analysis of trends in time and space➔

  ▶ Status of agricultural production every 10 days

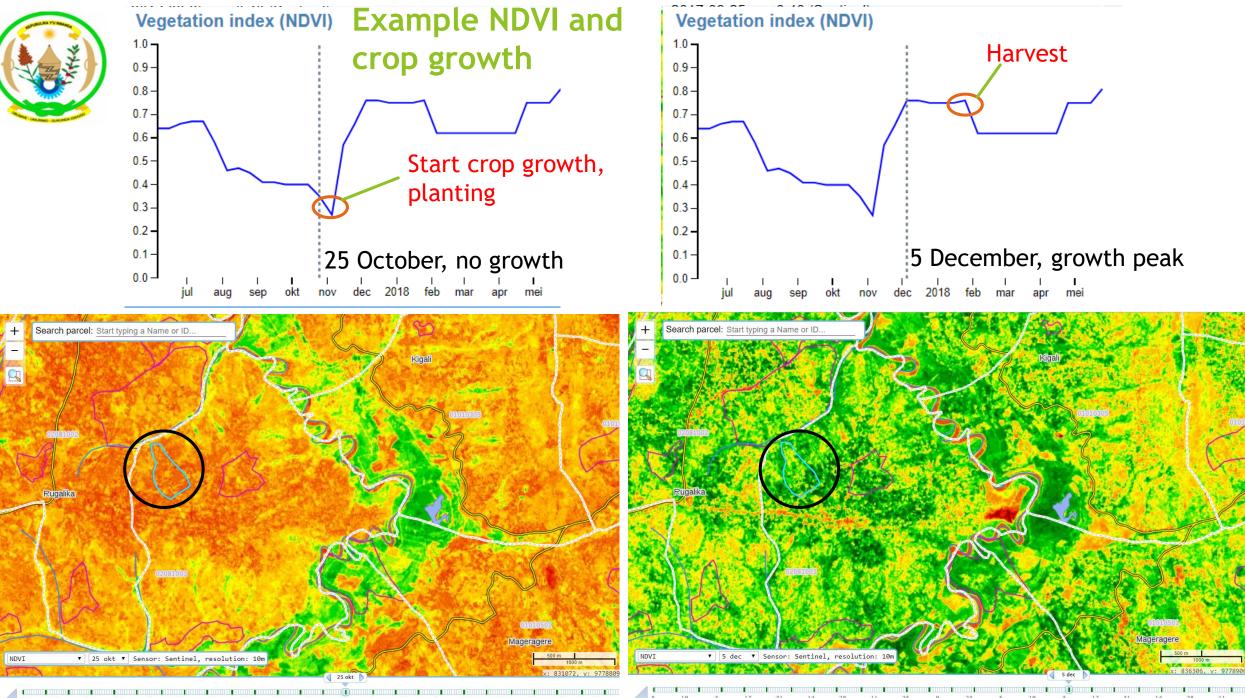 ▶ Early warning, providing alerts

  ▶ Prediction of production levels

Development team

- Development (1 year) through team of international and national consultants:
- Agri-TAF:
  - Henk Remme – overall management
  - Jules Kazungu – national coordination and support
- Developers (international):
  - Peter Hoefsloot – Remote Sensing (NDVI preparation, crop ranking)
  - Rob Marjot – Geo-data Infrastructure (server) and portal development (& land use cover)
- RCID National consultants (surveys):
  - Philippe Rumenera – Director RCID
  - Adrie Mukashema – GIS Specialist
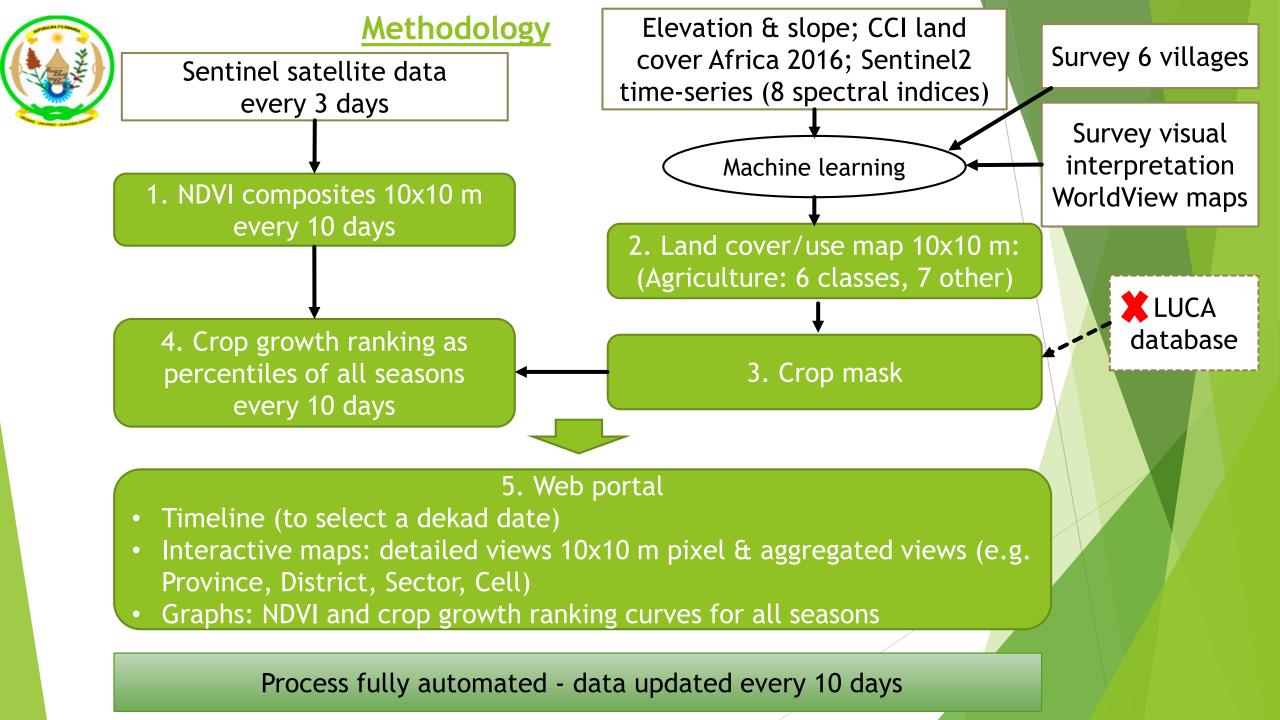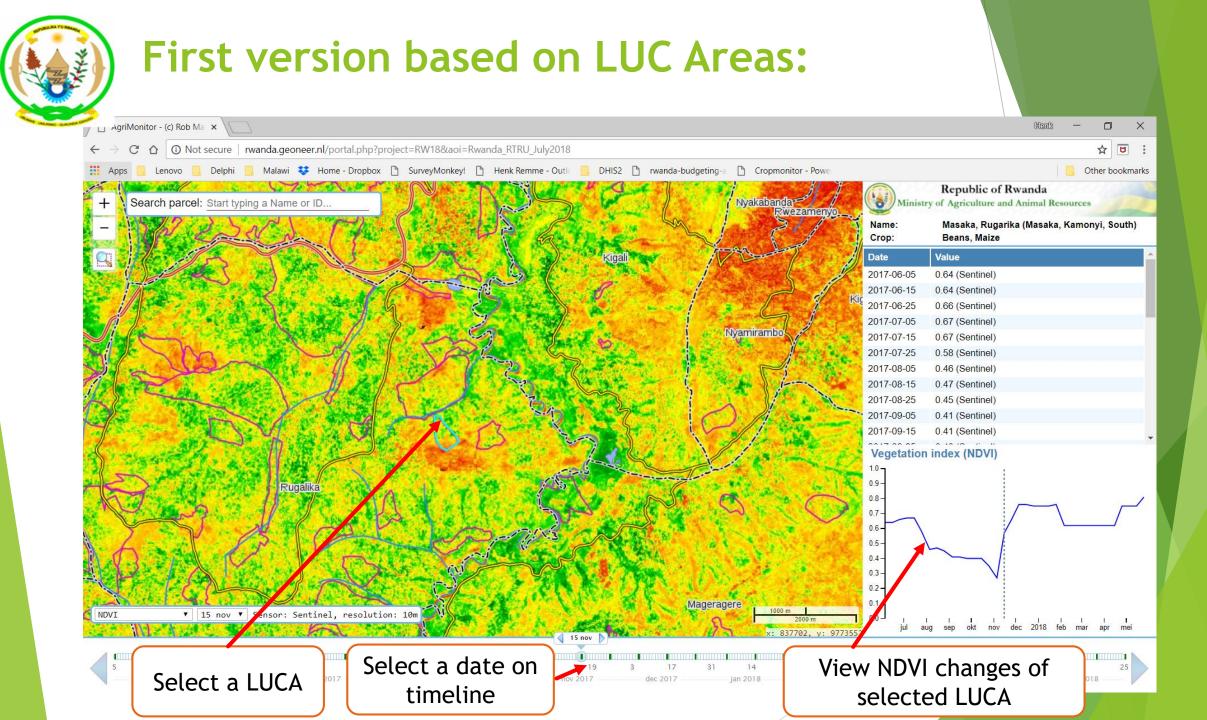 - Alexis Mutebutsi – Agricultural Researcher/Survey Specialist

Methodology

- Based on the Normalised Difference Vegetation Index (**NDVI**) as an indicator for crop growth ('vegetation greenness' ranging from -1 ('water') to +1 ('dense green leaves'). Reasons:

  1. NDVI reflects plant growth/"biomass" (=output) regardless the factors that influence growth (e.g. rainfall, pests & diseases, use of inputs, crop management practices, etc.). Other indicators, such as WRSI look at inputs (water availability) and are more difficult to use.

  2. Sentinel NDVI data (ESA) are freely available every 3 days at high resolution (10x10 m) – 9 tiles for Rwanda

- Needed: identification of agricultural land (and crops) to distinguish crop growth from other vegetation growth (grass, forest, shrubs).

Example NDVI and crop growth

Vegetation index (NDVI) — 25 October, no growth

Start crop growth, planting

Vegetation index (NDVI) — 5 December, growth peak

Harvest

Methodology

Sentinel satellite data every 3 days

Elevation & slope; CCI land cover Africa 2016; Sentinel2 time-series (8 spectral indices)

Survey 6 villages

Survey visual interpretation WorldView maps

Machine learning

1. NDVI composites 10x10 m every 10 days

2. Land cover/use map 10x10 m: (Agriculture: 6 classes, 7 other)

❌ LUCA database

4. Crop growth ranking as percentiles of all seasons every 10 days

3. Crop mask

5. Web portal
- Timeline (to select a dekad date)
- Interactive maps: detailed views 10x10 m pixel & aggregated views (e.g. Province, District, Sector, Cell)
- Graphs: NDVI and crop growth ranking curves for all seasons

Process fully automated - data updated every 10 days

First version based on LUC Areas:

Methodology <u>season</u> ranking

▶ For each pixel when new info is available (new dekad):

1. Calculate average of all NDVIs (dekads) in the season

2. Determine rank for the new dekad for each season:

Example for 4 seasons:

Season A	NDVI Av.	Rank
2016	0.35	0
2017	0.38	33
2018	0.45	66
2019	0.55	100

Rank		Range	Label
1		0 – <18	Very poor
2		18 – <34	Poor
3		34 – <50	Below average
4		50 – <66	Above average
5		66 – <82	Good
6		82 – 100	Very good

▶ For aggregated level ('Cell'): average of all pixels in the area

Process of development (1 year – 3 phases)

▶ **July/August 2018**: first version, based on LUCAs (previous slide) - Issues:

1. LUCA database is not accurate
2. LUCAs only represent part of all crop production areas

➔ Need for accurate, detailed land cover/use map to identify cropland

▶ October 2018 – February 2019 Survey (by RCID) of 6 villages in different agro-ecological zones:

▶ Identifying and georeferencing main landuse (sub-) categories

▶ Interviews with farmers and KIs on crop production past 5 years

▶ Sample of 20 plots in each village – yield measurements (crop cut)

▶ **April 2019**: second version - land cover maps for blocks of 10x10km around the 6 villages (random forest machine learning). Issue: survey data not sufficient for nation-wide land use cover

District/Village
Gakenke/Ngarama
Gatsibo/Cyampirita
Kamonyi/Kabarama
Karongi/Rwakigarati
Musanze/Kaberege
Nyaruguru/Kinyaga

Process of development (cont'd)

- ➔April-June 2019 additional survey (RCID) interpreting high resolution WorldView maps (available at NISR)

- **August-November 2019** third version:

  - Improved land use (13 classes of which 6 agricultural sub-classes)

  - Season crop growth ranking function

  - Improved portal: interactive maps and graphs of crop growth ranking for selected areas (province, district, sector, cell)

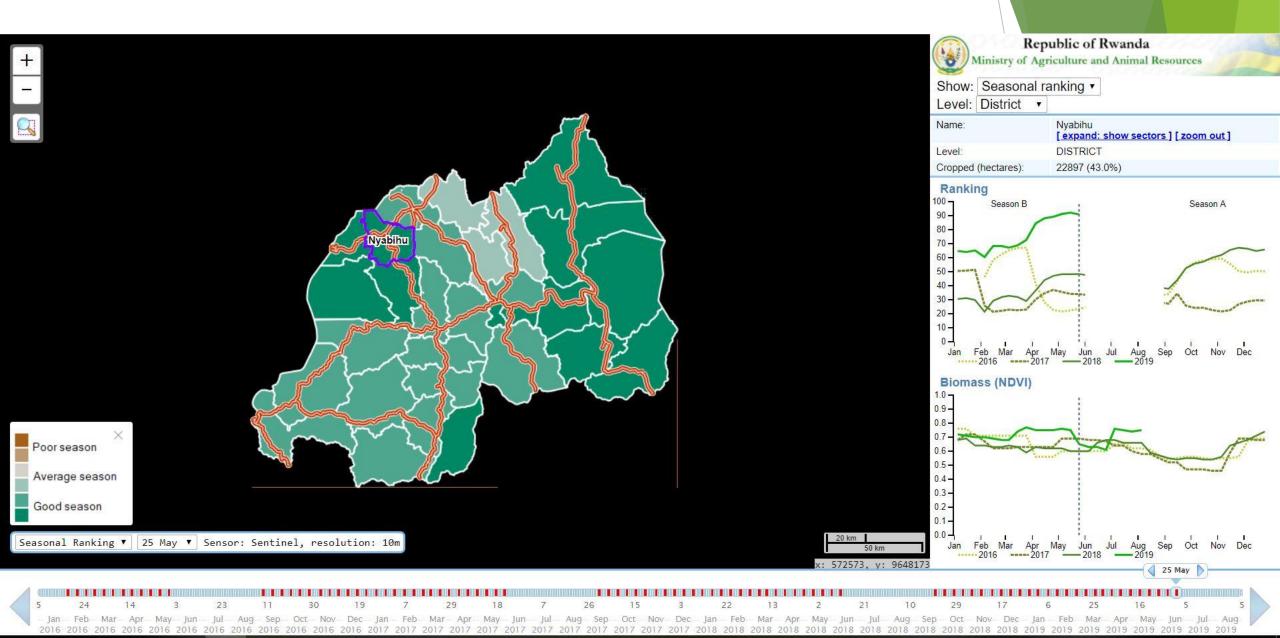 - Automated NDVI and crop growth ranking (based on crop mask from land use cover) every 10 days

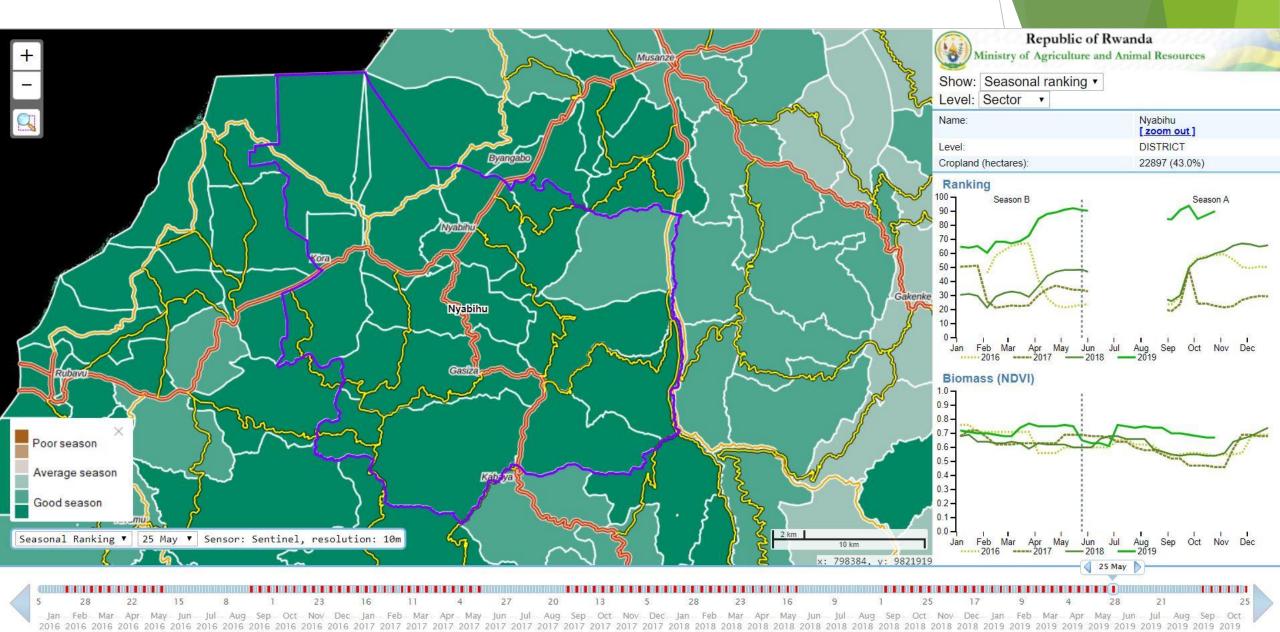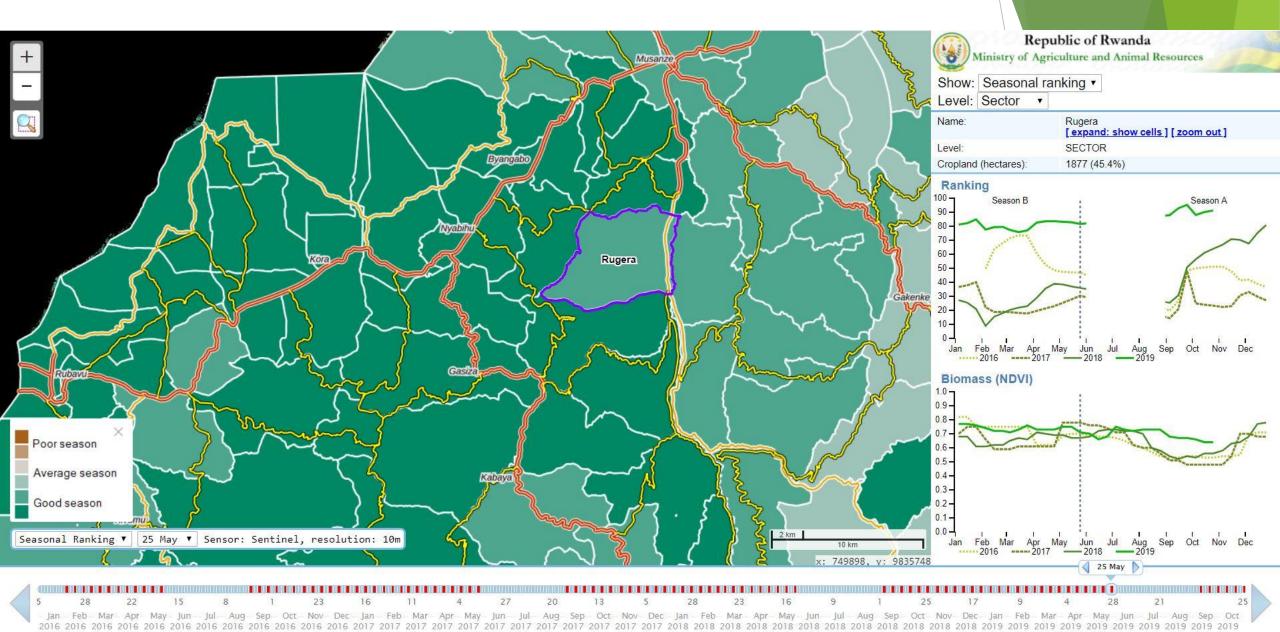|	
⬛	Aquatic vegetation
⬛	Banana
⬛	Bare area
⬛	Beans
⬛	Coffee
⬛	Forest
⬛	Grassland
⬛	Permanent Water
⬛	Residential area
⬛	Rice
⬛	Shrubs Cover Area
⬛	Tea
⬛	Seasonal Crop

Presentation of the system

Log-in with user credentials

Main window – District seasonal ranking
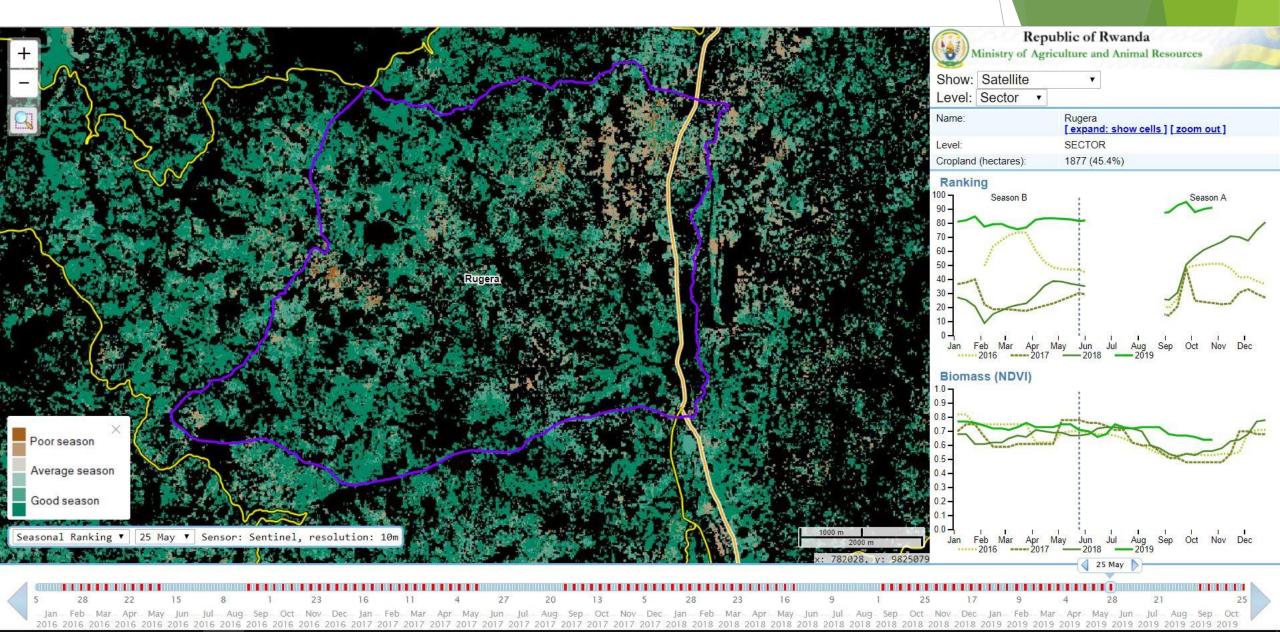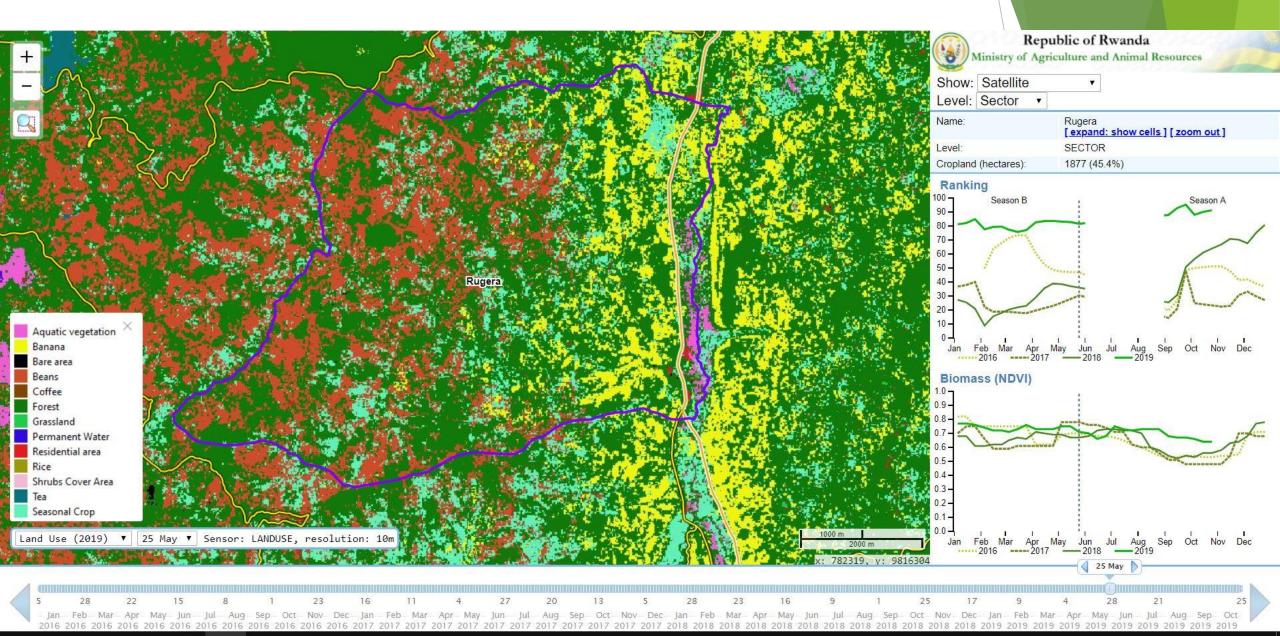
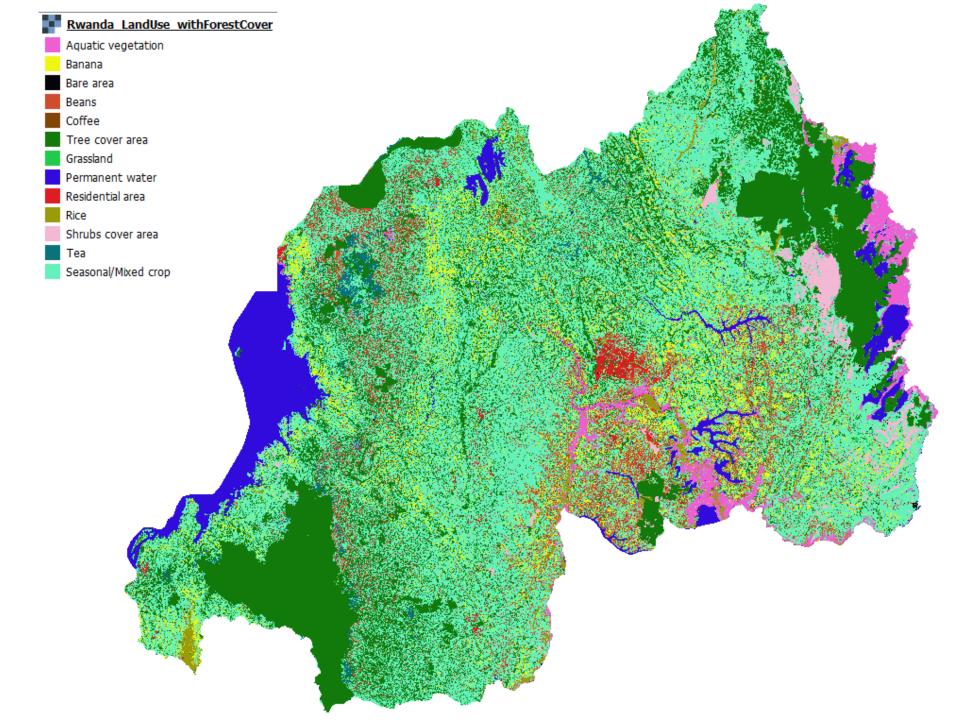# Nyabihu district – zoom in sectors

Rugera sector ranking
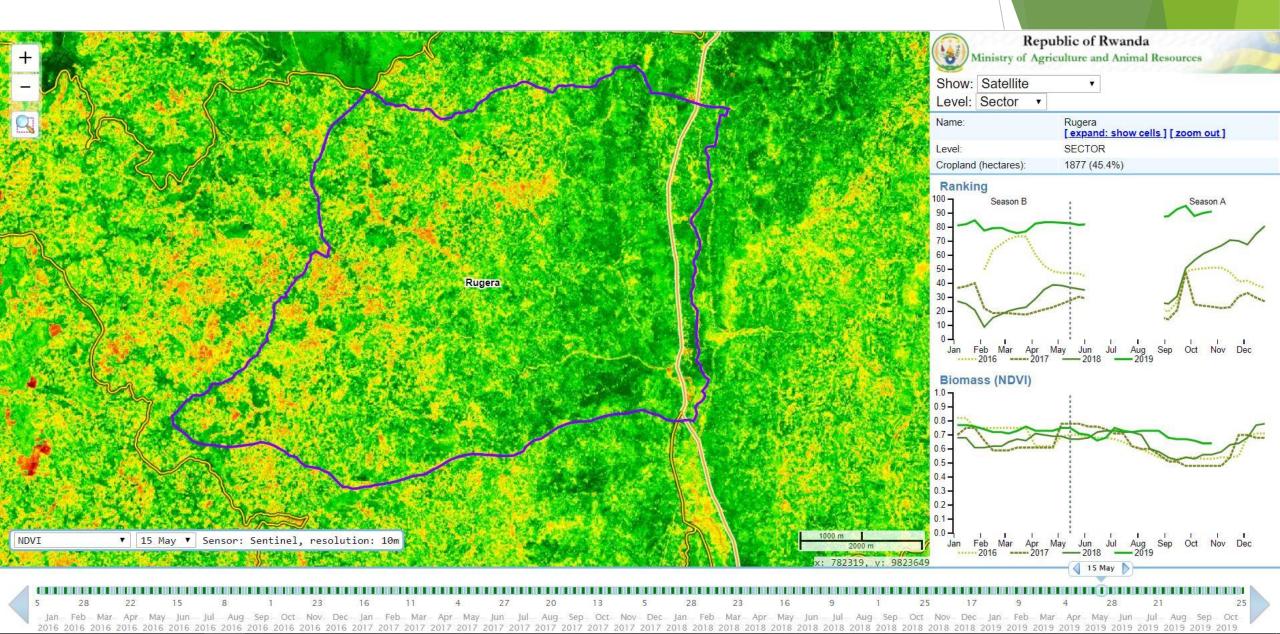
Rugera sector detailed ranking views by pixel

Land cover/use

New Land cover/use

Rwanda_LandUse_withForestCover

- Aquatic vegetation
- Banana
- Bare area
- Beans
- Coffee
- Tree cover area
- Grassland
- Permanent water
- Residential area
- Rice
- Shrubs cover area
- Tea
- Seasonal/Mixed crop

NDVI

Conclusions

▶ The system can already be used for monitoring of the overall agricultural production – indicate when planting was done, area planted and estimate yield changes.

▶ Advantage: updated NDVI and season ranking every 10 days

▶ It has great potential but can be further improved.

Ideas for further development

▶ **Improve analysis functions** – downloadable graphs, tables, automatic alerts (emails), etc. and improved visualisations

▶ **Make the system more crop specific ➜ update land use** for next seasons (using WorldView data and ground truthing surveys)

▶ **Improve the LUCA database** – georeferencing of LUCAs and getting key data (zoom in for specific functions)

▶ **Farmer feedback**: (i) use of NISR sampled farmer data; (ii) Farmer/frontline extension feedback through mobile phone

▶ **Integrate additional data and systems**: agricultural land parcels, meteorological data, soil maps, MIS, SNS, RAB projects

▶ **Training**