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UMLINDI The Watchman

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NATURAL RESOURCES AND ENGINEERING
Soil, Climate and Water

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agriculture, land reform & rural development
Department: Agriculture, Land Reform and Rural Development
REPUBLIC OF SOUTH AFRICA

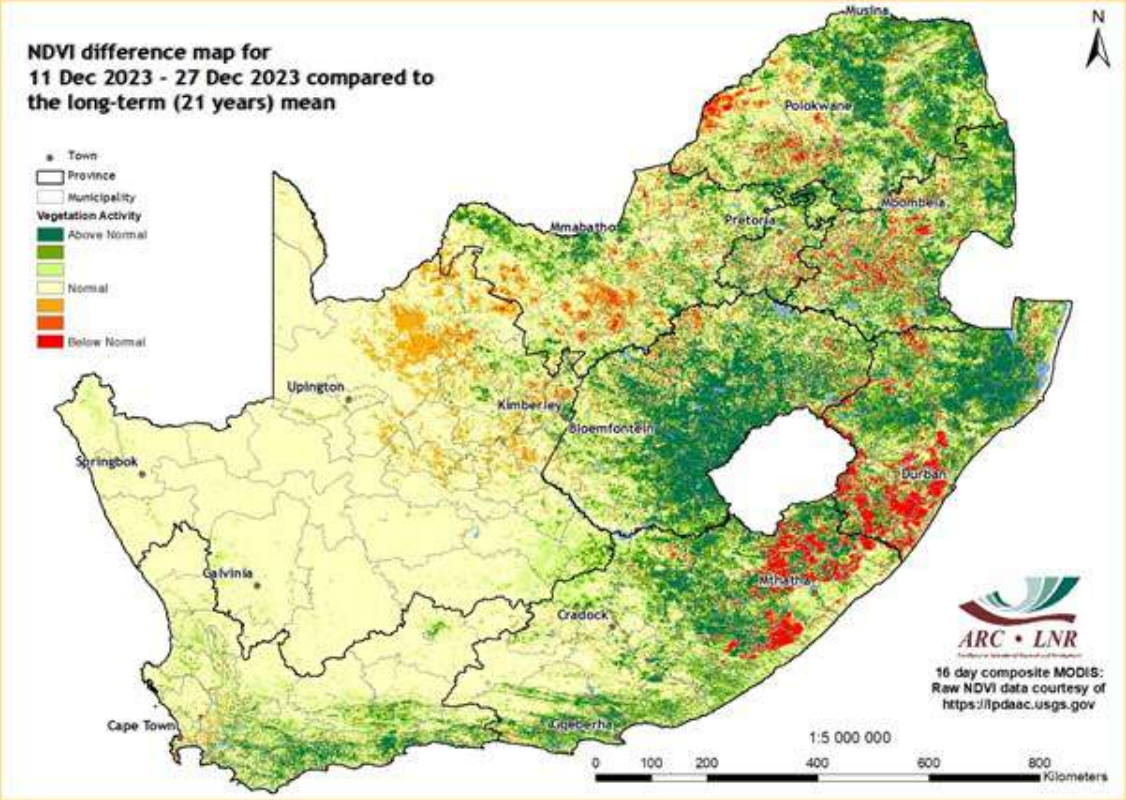
South African Weather Service

235th Edition

Image of the Month

Contrasting vegetative activity during early summer

A weak onset of the 2023/24 summer rains was observed since October 2023. November, in particular, proved to be a dry month across various regions. However, there was a notable improvement in rainfall during December, with rainfall totals increasing compared to the previous month. This shift in rainfall patterns contributed to the overall variation in vegetation conditions across the summer rainfall region. As depicted on the Normalized Difference Vegetation Index (NDVI) map for 11-27 December, the eastern half of the country was largely characterized by above-normal conditions, with notable patches of below-normal activity. While this serves as a valuable indicator of overall vegetation health, it points towards specific localized areas where the vegetation conditions were less favourable. This highlights the need for targeted assessments and interventions to address potential challenges and improve productivity. Therefore, in the affected areas, it is advisable to periodically assess the grazing and feed available for livestock, and never exceed the carrying capacity. Rotational grazing practices can further contribute to sustainable land use by improving soil health and maintaining long-term agricultural productivity.



The Agricultural Research Council - Natural Resources and Engineering (ARC-NRE) Soil, Climate and Water campus collected the data, generated the products and compiled the information contained in this newsletter, as part of the Coarse Resolution Imagery Database (CRID) project that was funded by the Department of Agriculture and Department of Science and Technology at its inception and is currently funded by the Department of Agriculture, Land Reform and Rural Development (DALRRD).

1. Rainfall

Overview:

In December 2023, a significant improvement in rainfall was observed across the summer rainfall region. The area experienced noteworthy rainfall totals, leading to widespread above-normal conditions. High rainfall totals exceeding 200 mm were recorded in parts of Limpopo, Mpumalanga, KwaZulu-Natal, the adjacent Eastern Cape and parts of the Free State. Stations that recorded monthly totals of 300 mm or more include Graskop in Mpumalanga (330 mm) and Van Reenen in the KZN Midlands (365 mm). Moreover, Ladysmith, also situated in the KZN Midlands, experienced heavy downpours that resulted in flooding of roads and low-lying areas, causing destruction during the latter part of the month. Regions that typically receive most of their rainfall in late summer, including the western parts of North West, Free State, and the Northern Cape interior, experienced above-normal rainfall, exceeding 200% of the long-term mean for December in certain areas. Positive deviations in rainfall were also noted over the major maize production areas, primarily located in the Free State and North West. Similar conditions were noted over the all-year rainfall region, with the western parts of the winter rainfall region recording dry conditions.

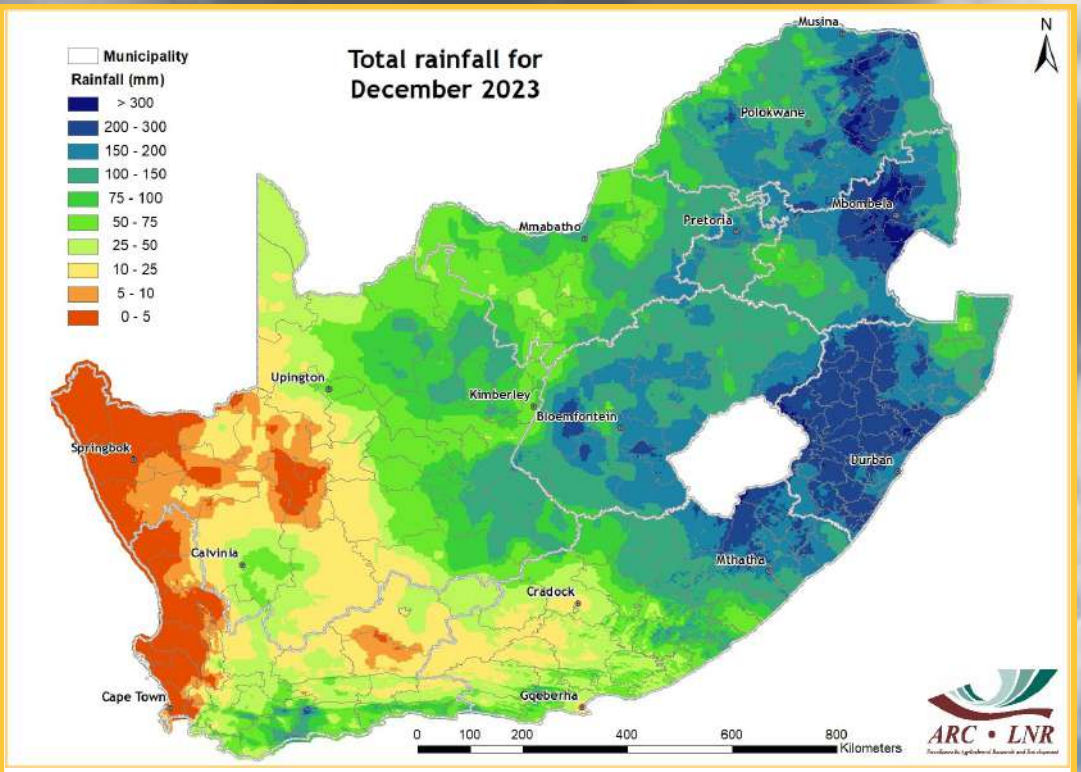


Figure 1

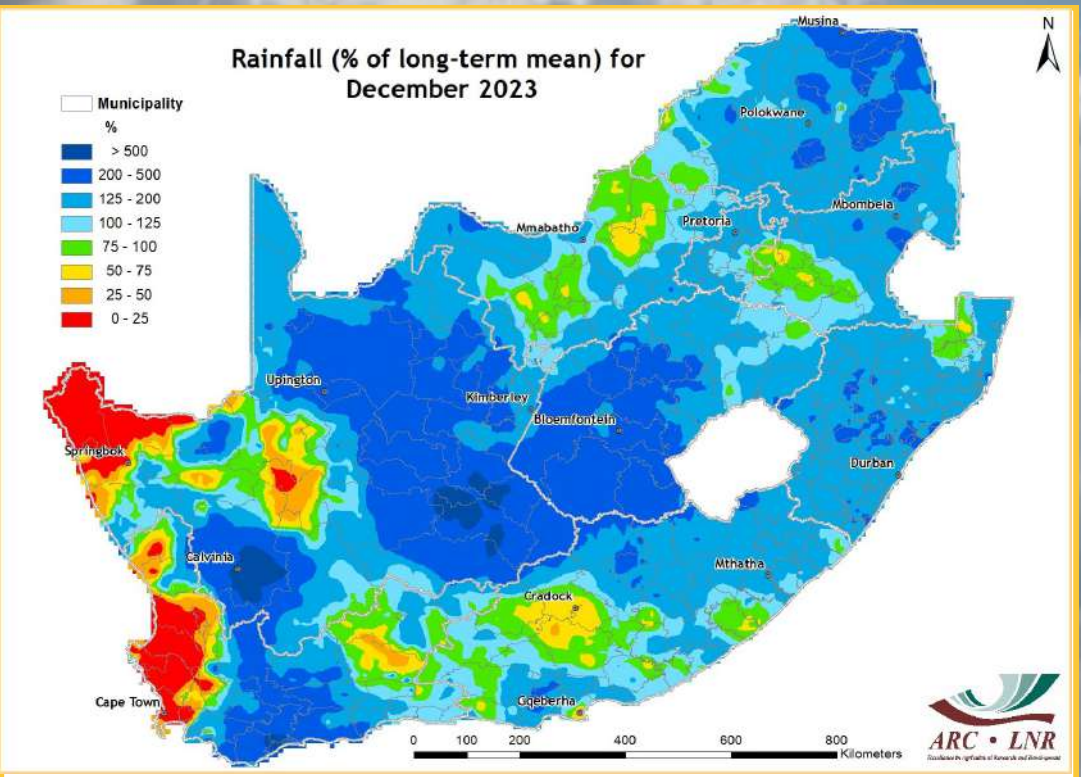
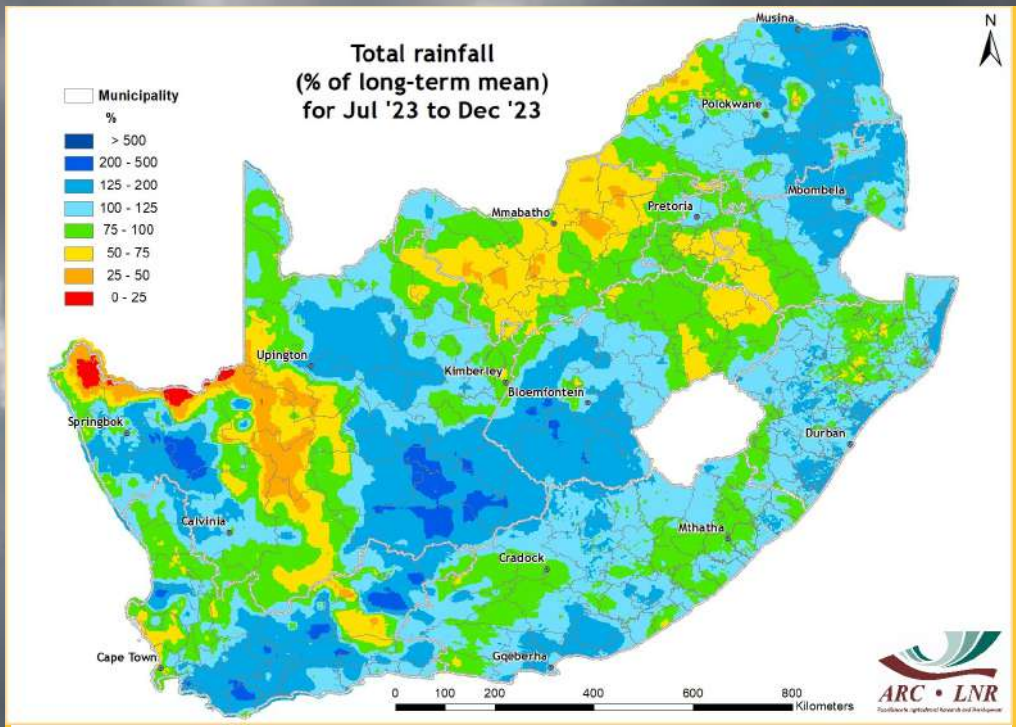


Figure 2



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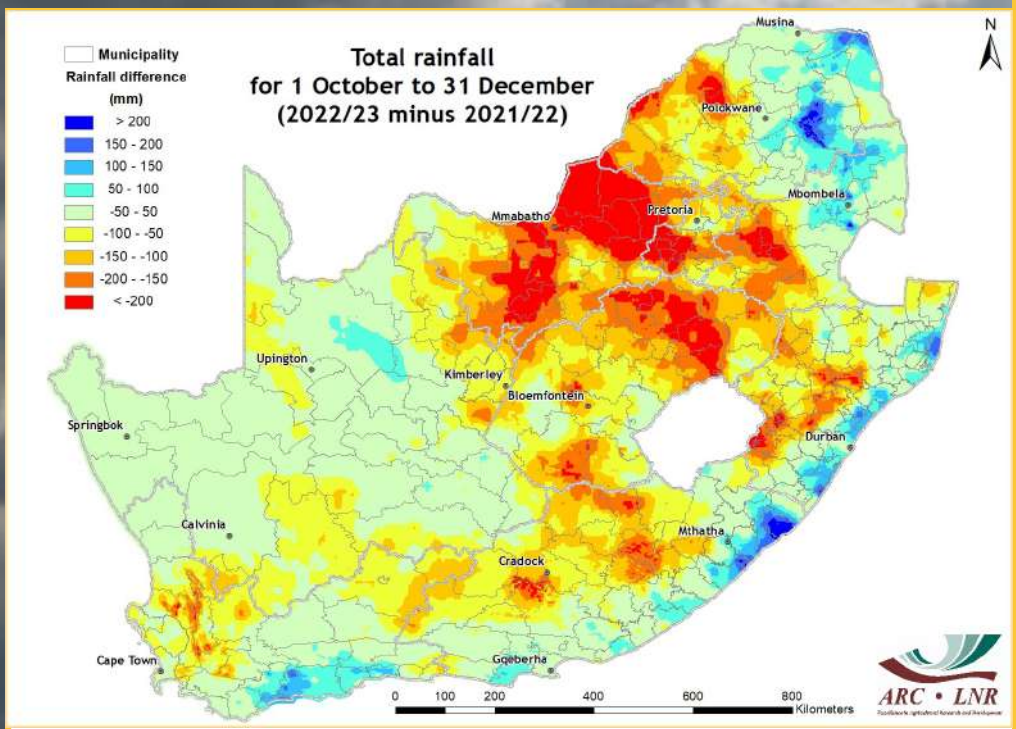

Figure 4

Figure 1:
A notable increase in rainfall totals was observed in December 2023, with some places in the eastern provinces recording more than 200 mm.

Figure 2:
Widespread above-normal rainfall was observed over the country during December, with near-normal conditions observed over isolated areas of North West, Mpumalanga, Eastern Cape and Western Cape. The only areas that received below-normal rainfall include the western parts of the winter rainfall region and the adjacent areas of the Northern Cape in the Namakwa District.

Figure 3:
The period between July and December 2023 was characterized by near- to above-normal rainfall over the country.

Figure 4:
Most parts of the eastern interior, moving towards KwaZulu-Natal, parts of the Karoo and the Western Cape, received less rain during October to December 2023 compared to the same period last year. Areas that recorded more rain include isolated parts of the coastal areas, Mpumalanga and Limpopo.

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2. Standardized Precipitation Index

Standardized Precipitation Index

The Standardized Precipitation Index (SPI - McKee *et al.*, 1993) was developed to monitor the occurrence of droughts from rainfall data. The index quantifies precipitation deficits on different time scales and therefore also drought severity. It provides an indication of rainfall conditions per quaternary catchment (in this case) based on the historical distribution of rainfall.

REFERENCE:
McKee TB, Doesken NJ and Kliest J (1993) The relationship of drought frequency and duration to time scales. In: Proceedings of the 8th Conference on Applied Climatology, 17-22 January, Anaheim, CA. American Meteorological Society: Boston, MA; 179-184.

The SPI maps revealing short-term (6-month), medium-term (12-month) and long-term (24- and 36-month) drought conditions ending in December 2023 are shown in Figures 5-8. The short-term SPI map indicates near-normal conditions over the country, with moderate to severe drought notable in the North West, Gauteng, the eastern Free State and neighbouring areas of Mpumalanga. These conditions, extending towards the Northern Cape, are further depicted on the medium-term SPI map, while moderate to extremely wet conditions can be noted over the Western Cape, adjacent Eastern Cape and the Lowveld of Mpumalanga. The long-term SPI maps indicate predominantly wet conditions over greater parts of the country.

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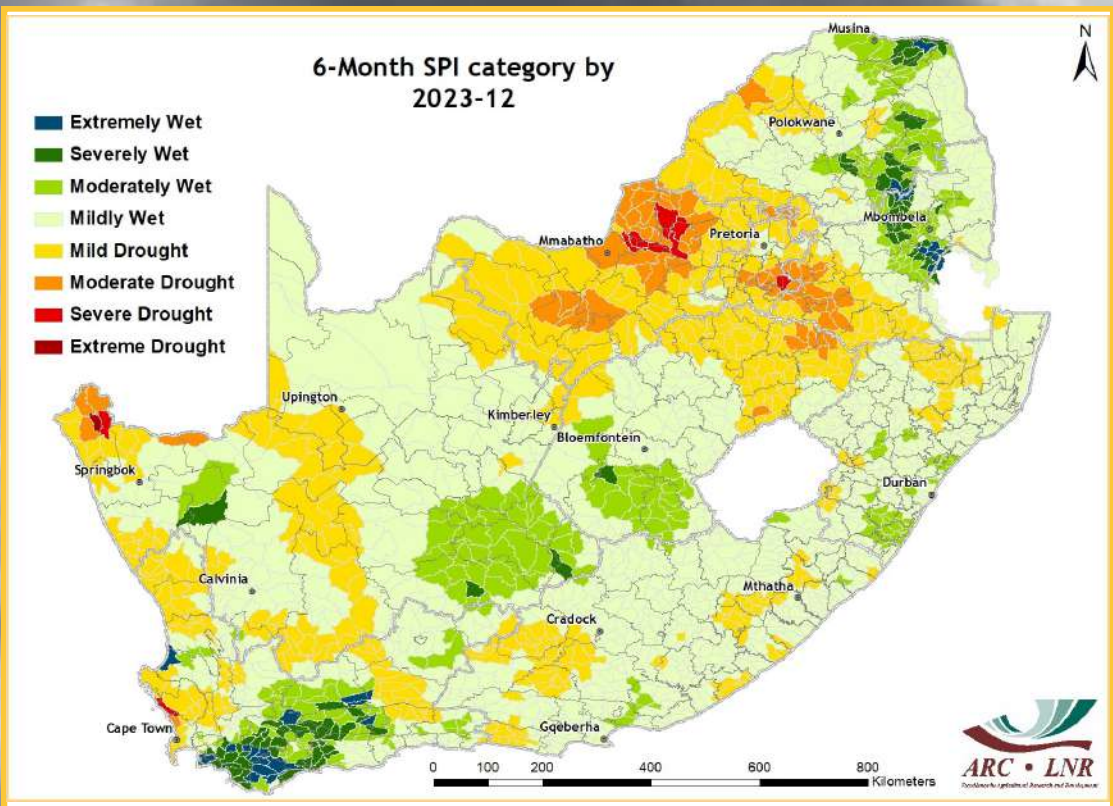

Figure 5

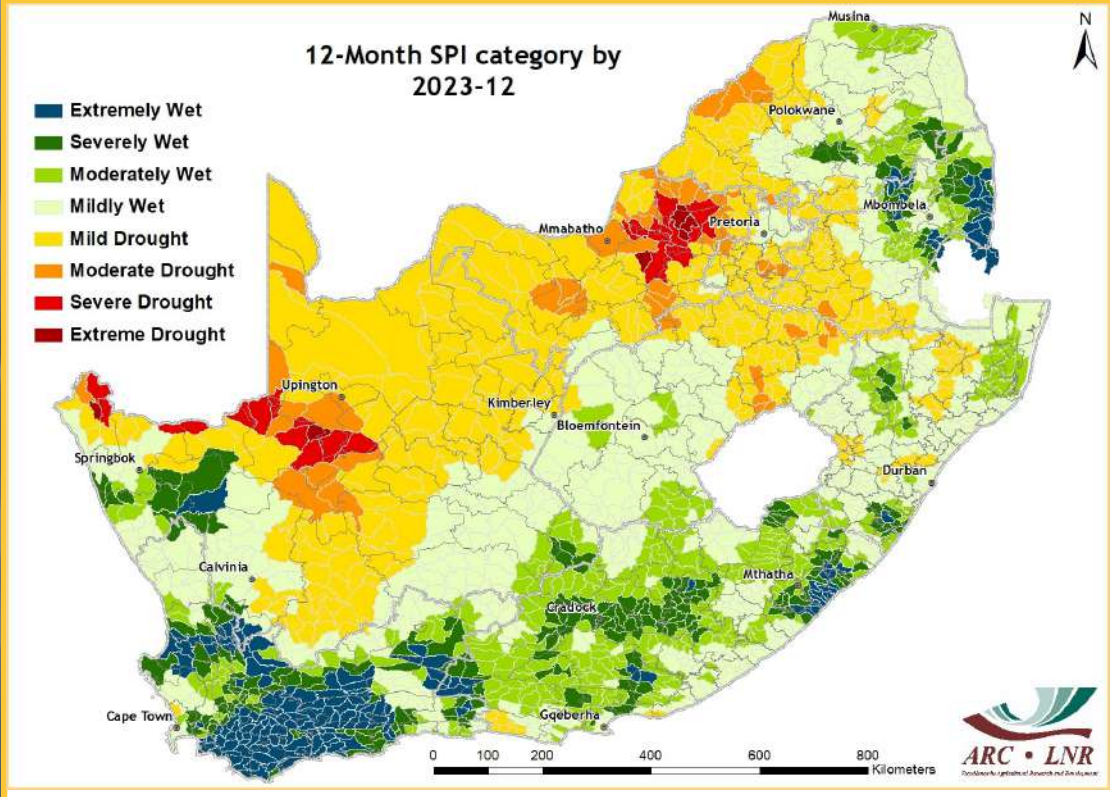

Figure 6

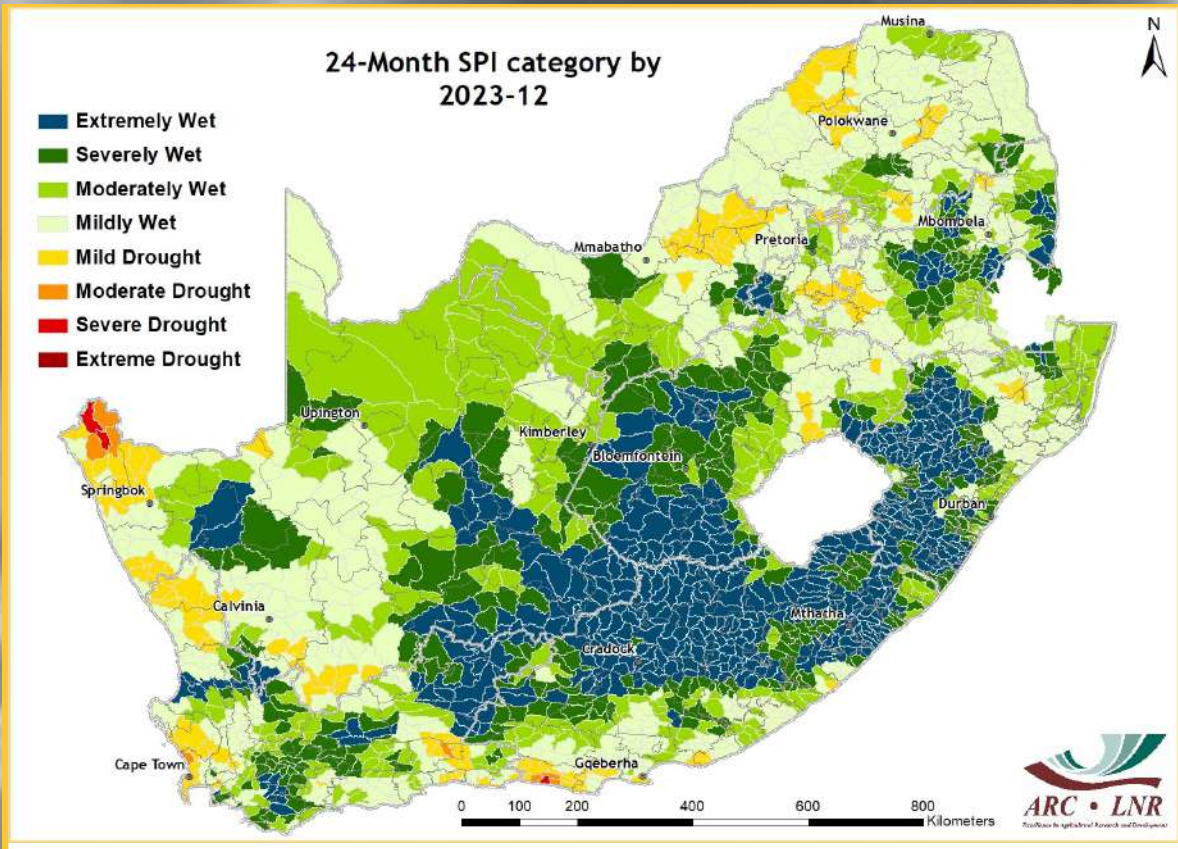

Figure 7

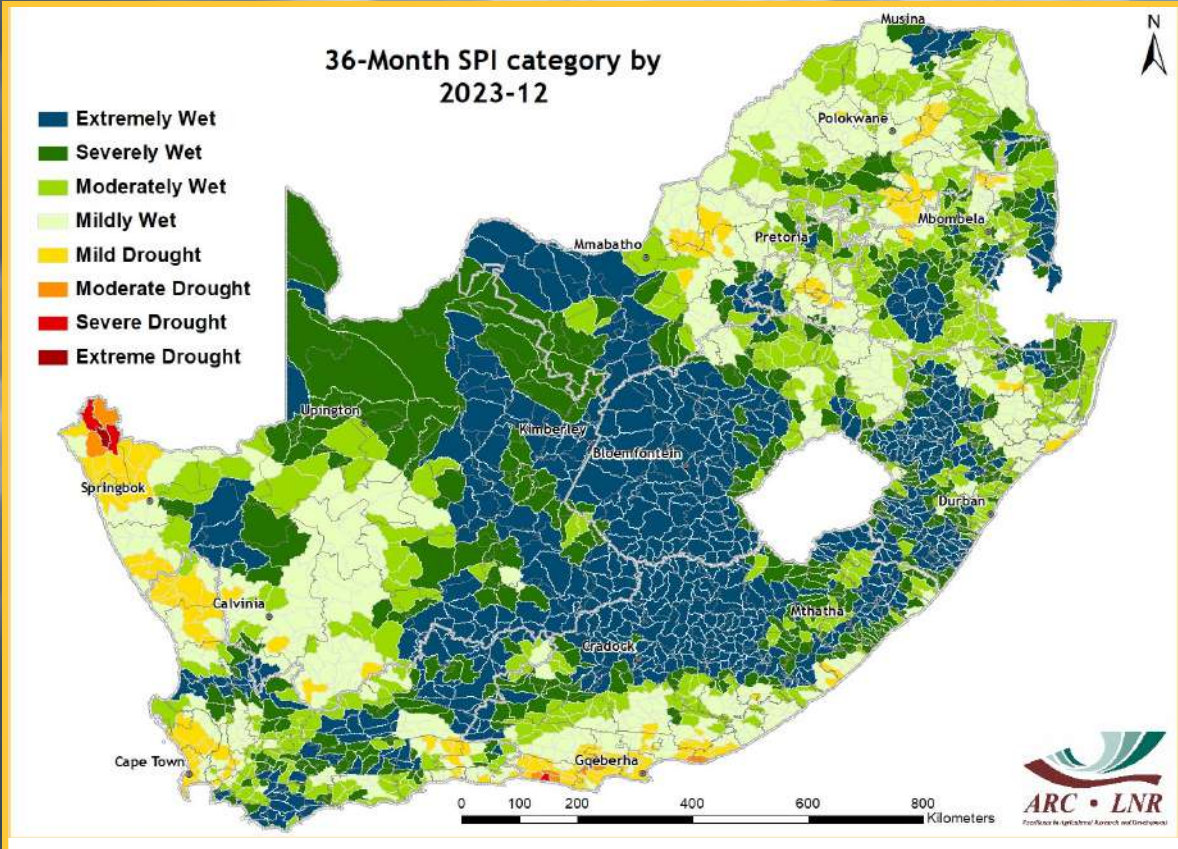

Figure 8

3. Rainfall Deciles

Deciles are used to express the ranking of rainfall for a specific period in terms of the historical time series. In the map, a value of 5 represents the median value for the time series. A value of 1 refers to the rainfall being as low or lower than experienced in the driest 10% of a particular month historically (even possibly the lowest on record for some areas), while a value of 10 represents rainfall as high as the value recorded only in the wettest 10% of the same period in the past (or even the highest on record). It therefore adds a measure of significance to the rainfall deviation.

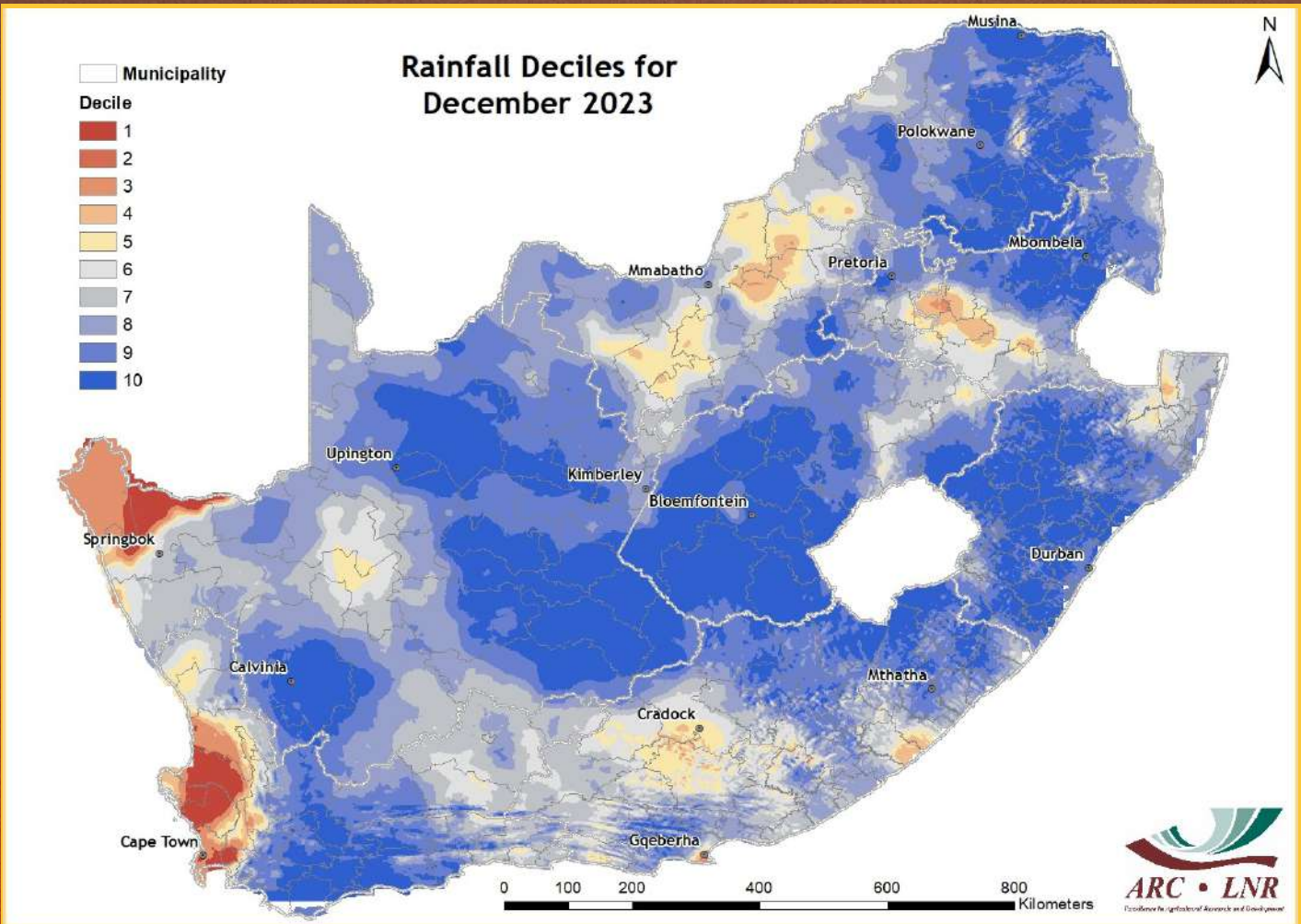

Figure 9

Figure 9:
In December 2023, greater parts of the country experienced rainfall totals that compare well with historically wetter December months.

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4. Vegetation Conditions

Vegetation Mapping

The Normalized Difference Vegetation Index (NDVI) is computed from the equation:

NDVI=(IR-R)/(IR+R)

where:
IR = Infrared reflectance &
R = Red band

NDVI images describe the vegetation activity. A decadal NDVI image shows the highest possible "greenness" values that have been measured during a 10-day period.

Vegetated areas will generally yield high values because of their relatively high near infrared reflectance and low visible reflectance. For better interpretation and understanding of the NDVI images, a temporal image difference approach for change detection is used.

The Standardized Difference Vegetation Index (SDVI) is the standardized anomaly (according to the specific time of the year) of the NDVI.

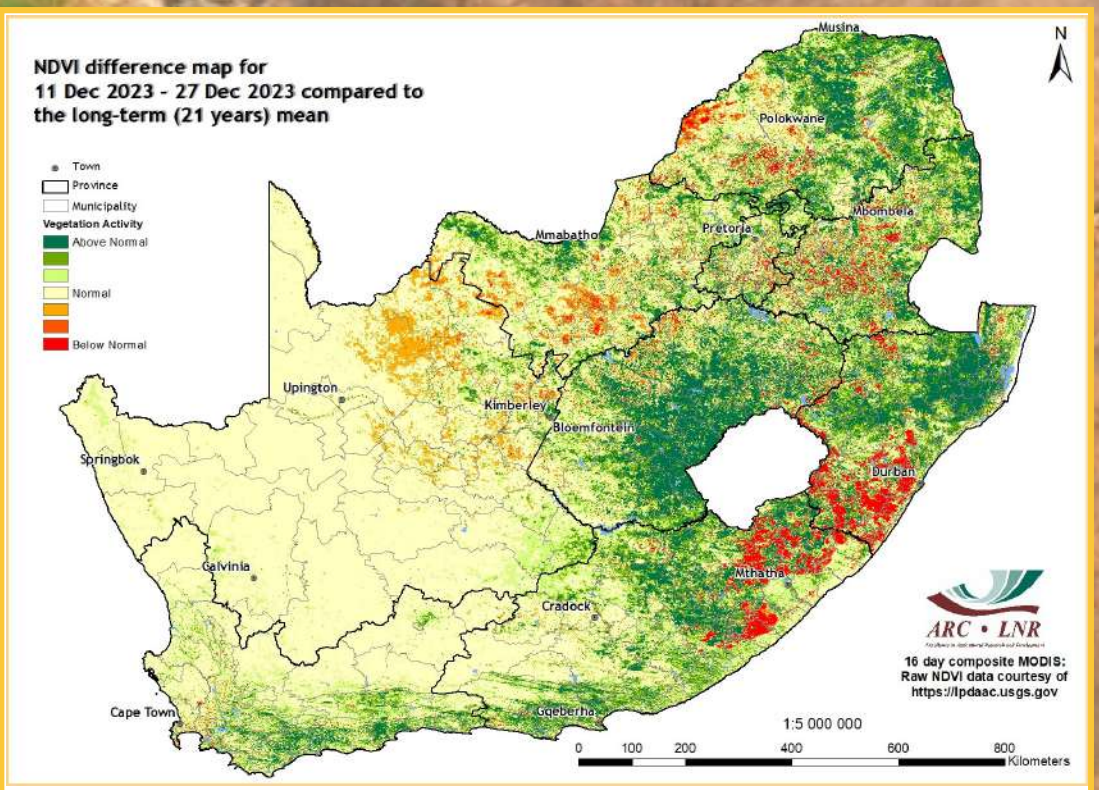

Figure 10

Figure 10:
Compared to the historical averaged vegetation conditions, the 16-day NDVI map for December 2023 shows that many parts of the country continue to experience normal to above-normal vegetation activity, with patches of below-normal activity in the central and northern parts.

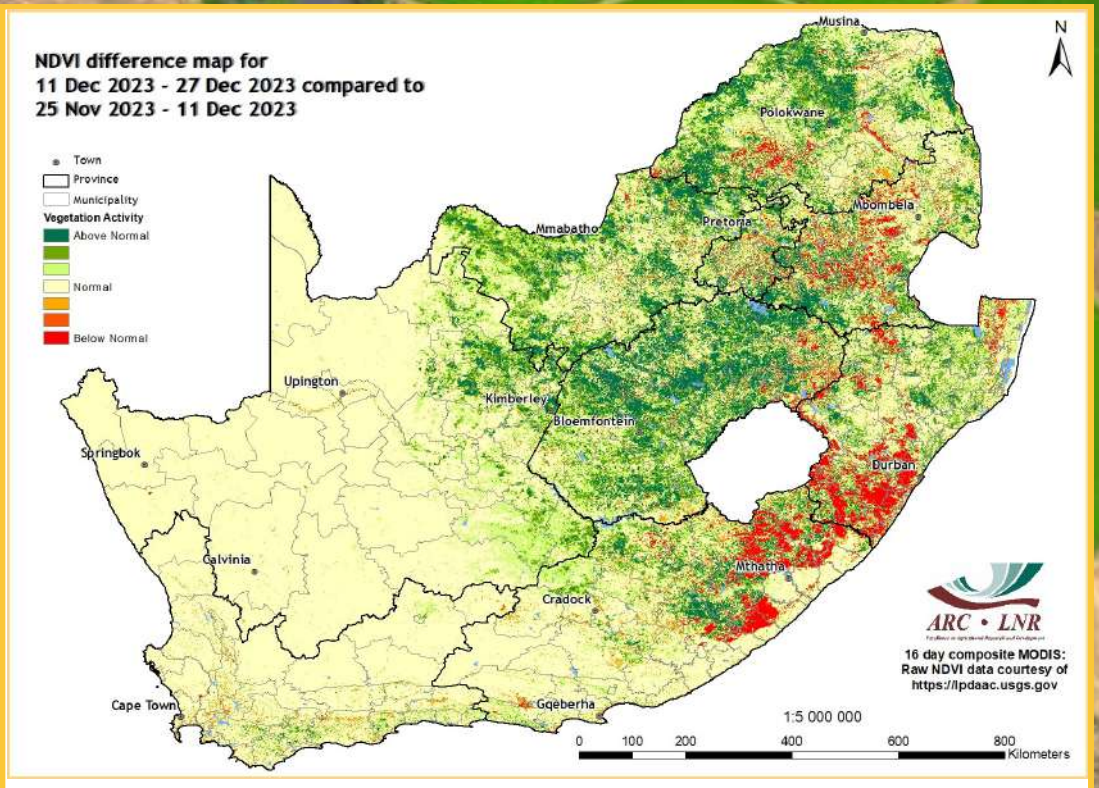

Figure 11

Figure 11:
The 16-day NDVI difference map for December 2023 compared to the preceding 16-day period shows that the western half of the country experienced normal vegetation activity, while the eastern half experienced above-normal conditions with patches of below-normal activity in isolated areas.

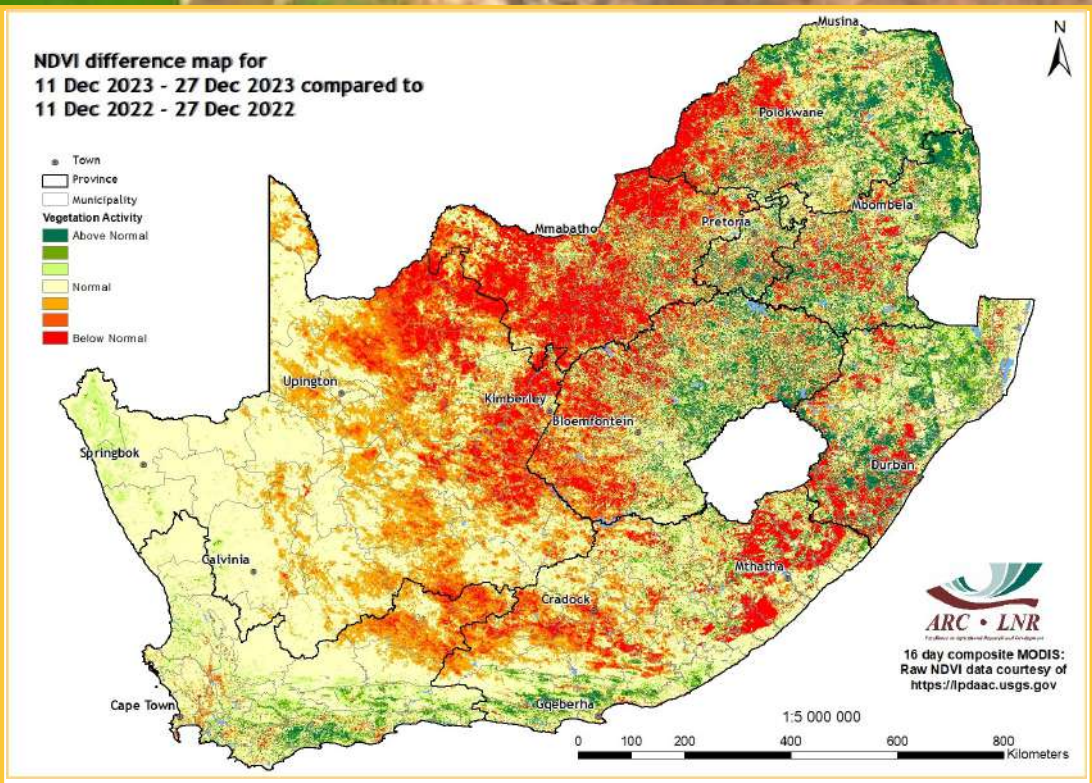

Figure 12

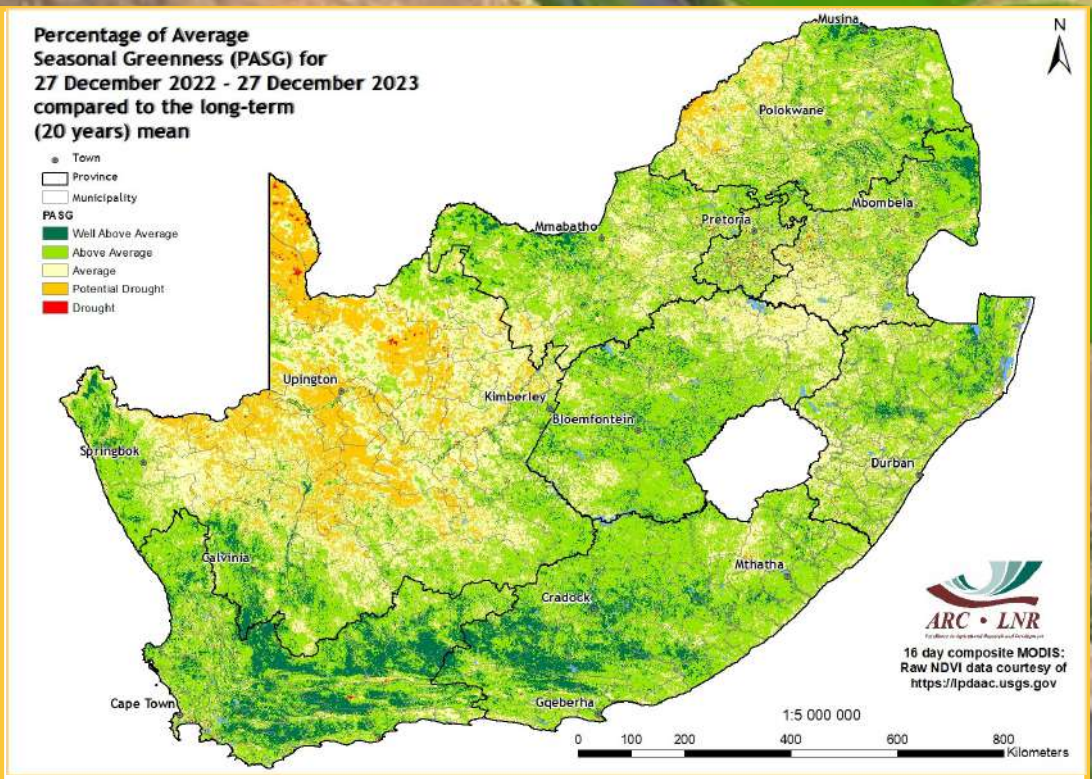

Figure 13

Vegetation Mapping
(continued from p. 7)

Interpretation of map legend

NDVI-based values range between 0 and 1. These values are incorporated in the legend of the difference maps, ranging from -1 (lower vegetation activity) to 1 (higher vegetation activity) with 0 indicating normal/the same vegetation activity or no significant difference between the images.

Cumulative NDVI maps:

Two cumulative NDVI datasets have been created for drought monitoring purposes:

Winter: January to December
Summary: July to June

Figure 12:
The 16-day NDVI difference map for December 2023 compared to the same period last year shows that the central interior experienced poor vegetation conditions, while patches of above-normal activity remain in the far northern and western parts of the country.

Figure 13:
The Percentage of Average Seasonal Greenness (PASG) map for the past 12 months, compared to the long-term mean, shows that above-normal seasonal vegetation greenness prevails in most parts of the country, with the exception of the western parts which experienced potential drought.

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5. Vegetation Condition Index

Vegetation Condition Index (VCI)

The VCI is an indicator of the vigour of the vegetation cover as a function of the NDVI minimum and maximum encountered for a specific pixel and for a specific period, calculated over many years.

The VCI normalizes the NDVI according to its changeability over many years and results in a consistent index for various land cover types. It is an effort to split the short-term weather-related signal from the long-term climatological signal as reflected by the vegetation. The VCI is a better indicator of water stress than the NDVI.

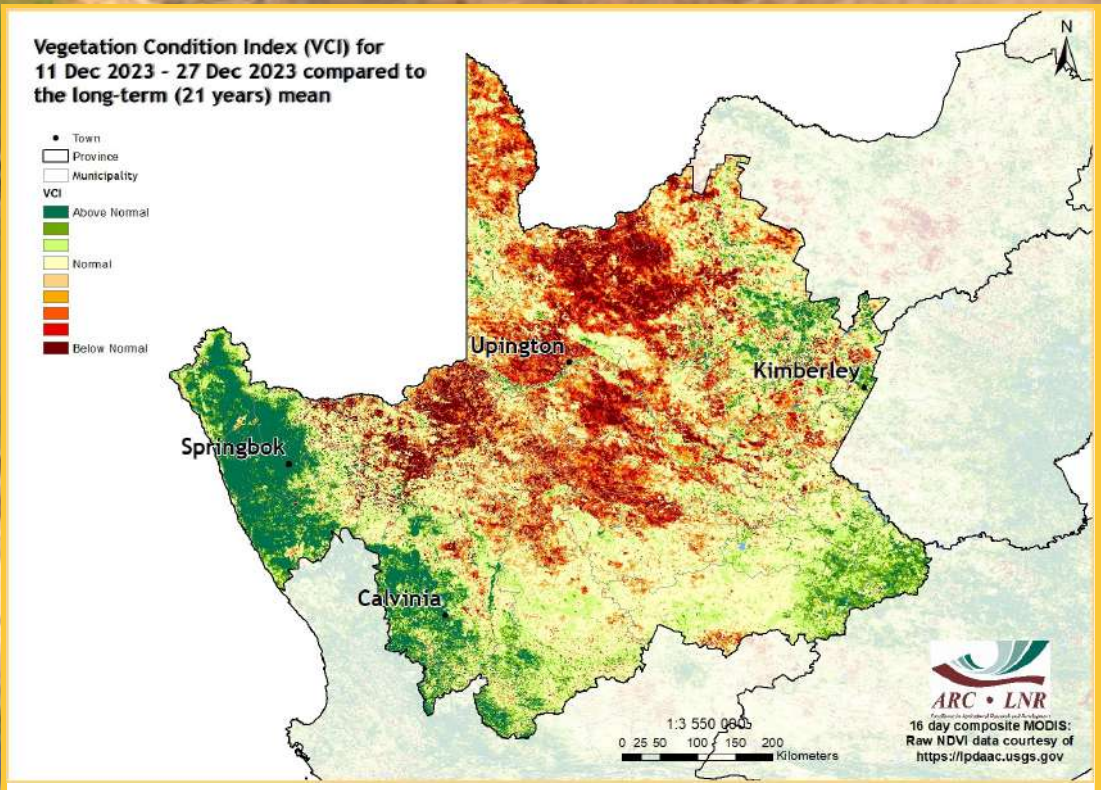

Figure 14

Figure 14:
The 16-day VCI map for December 2023 indicates that the northern and central parts of the Northern Cape continue to experience below-normal vegetation conditions, with areas of above-normal activity in the south and west of the province.

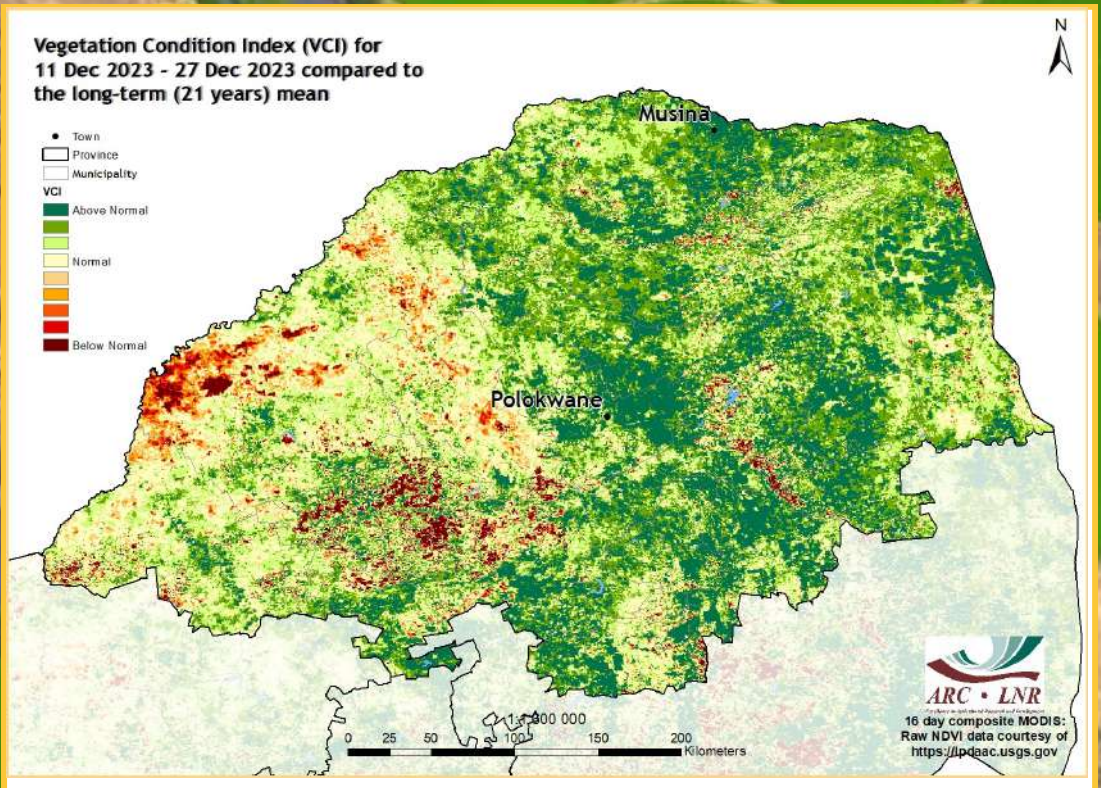

Figure 15

Figure 15:
The 16-day VCI map for December 2023 indicates that many parts of Limpopo experienced above-normal vegetation conditions, with below-normal activity in isolated areas.

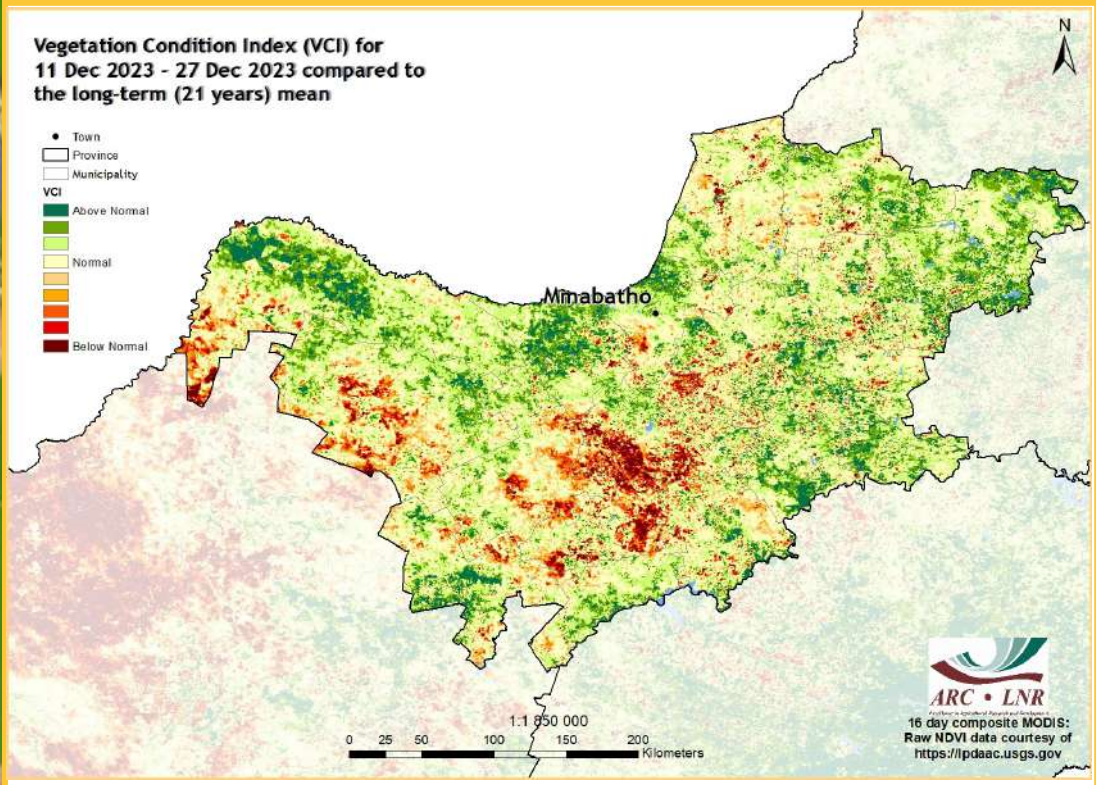

Figure 16

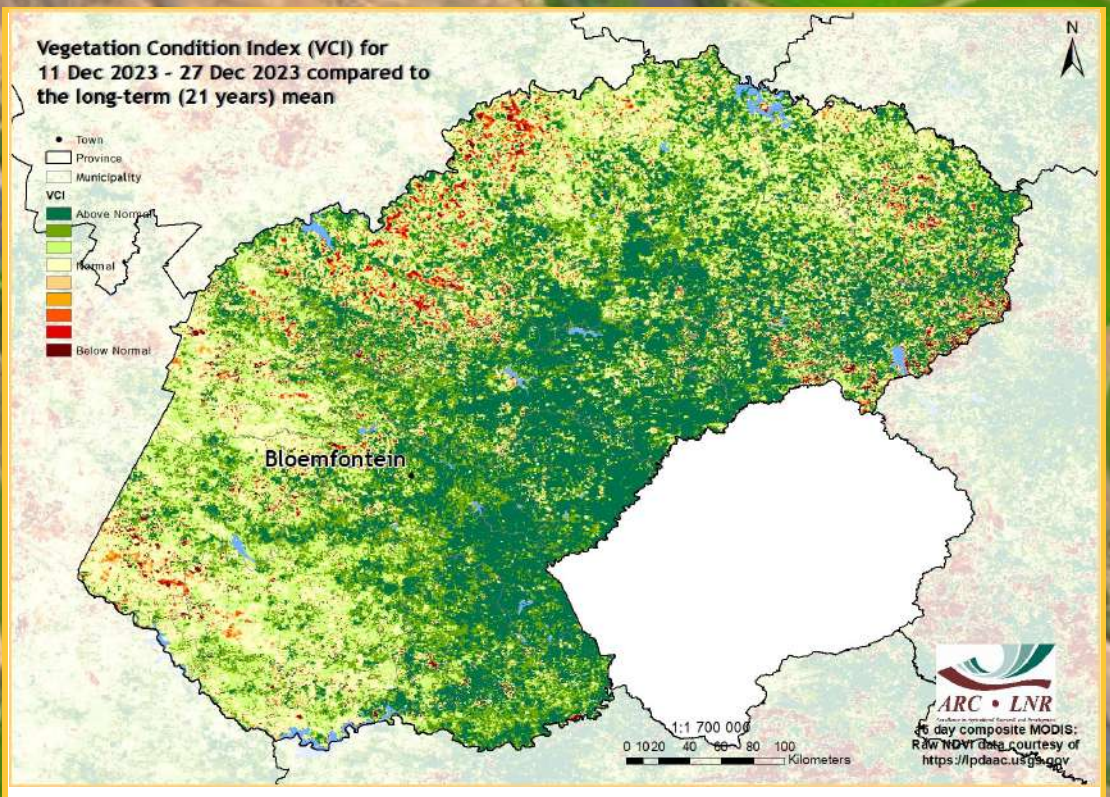

Figure 17

Figure 16:
The 16-day VCI map for December 2023 indicates that most parts of North West continue to experience below-normal vegetation conditions.

Figure 17:
The 16-day VCI map for December 2023 indicates that most parts of the Free State experienced above-normal vegetation conditions with patches of below-normal activity in isolated areas.

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6. Vegetation Conditions & Rainfall

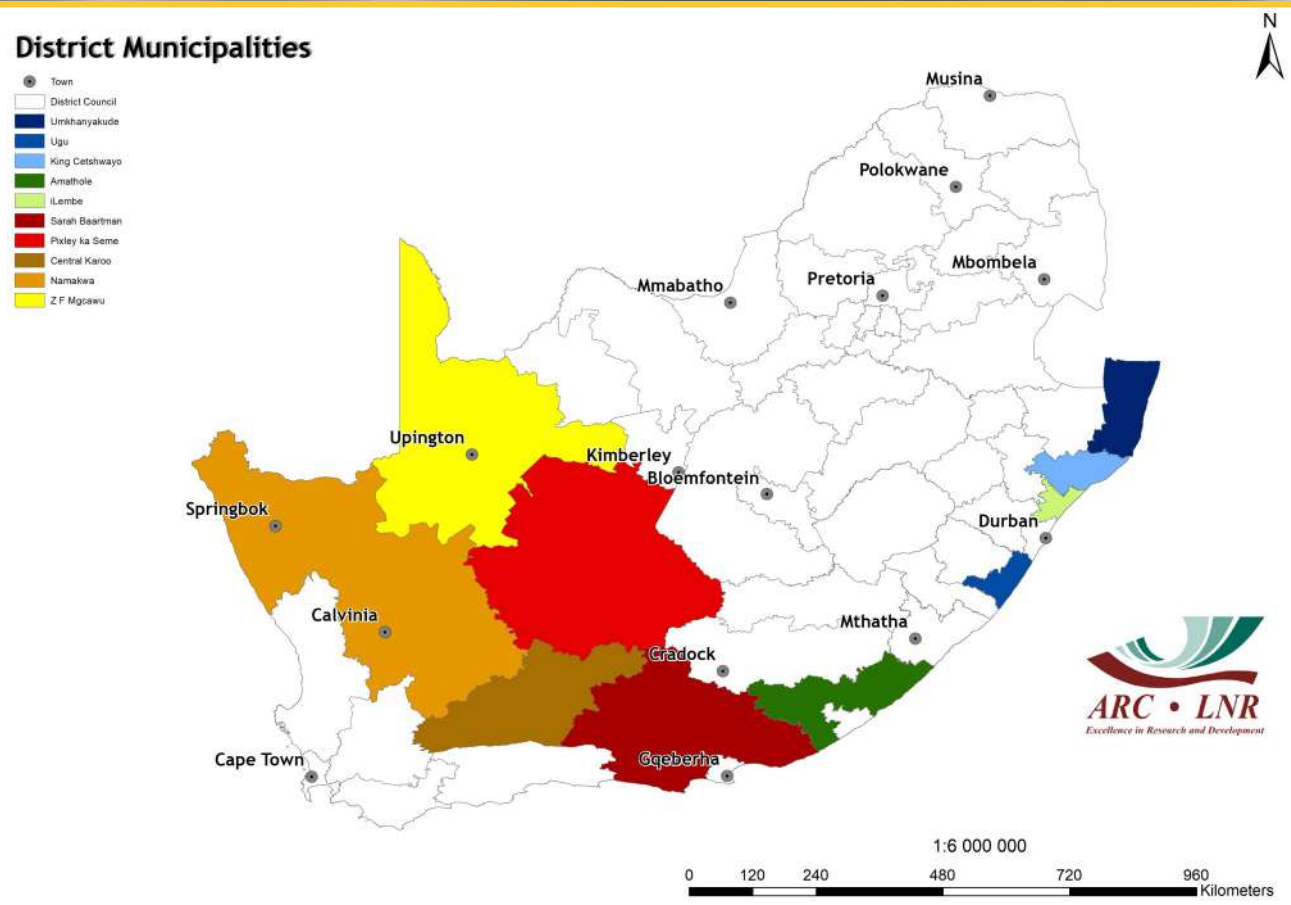

Figure 18

Rainfall and NDVI Graphs

Figure 18:
Orientation map showing the areas of interest for December 2023. The district colour matches the border of the corresponding graph.

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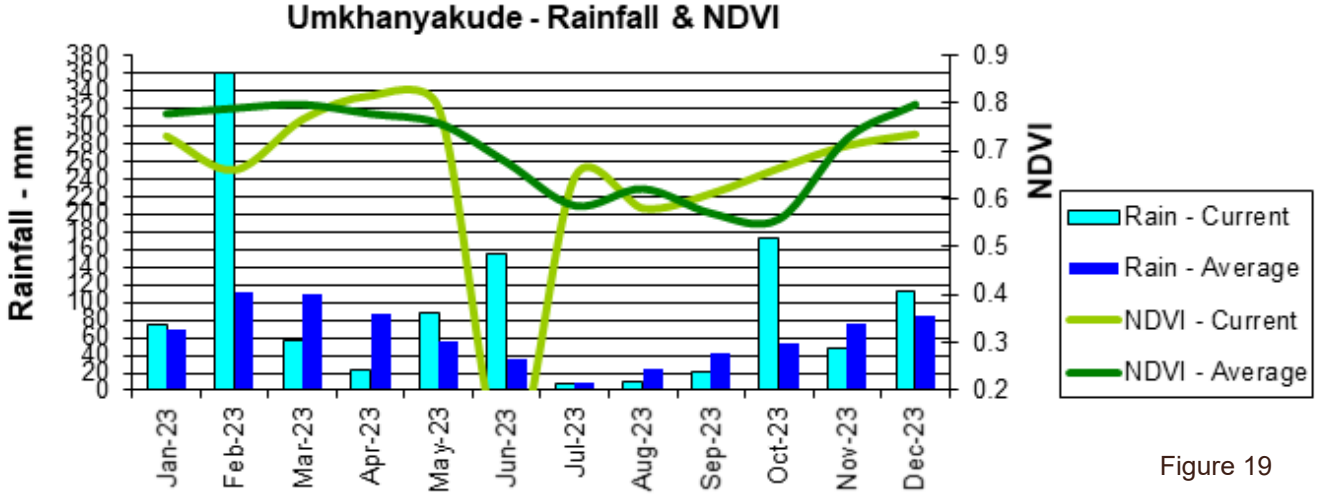
Figures 19-23:
Indicate areas with higher cumulative vegetation activity for the last year.

Figures 24-28:
Indicate areas with lower cumulative vegetation activity for the last year.



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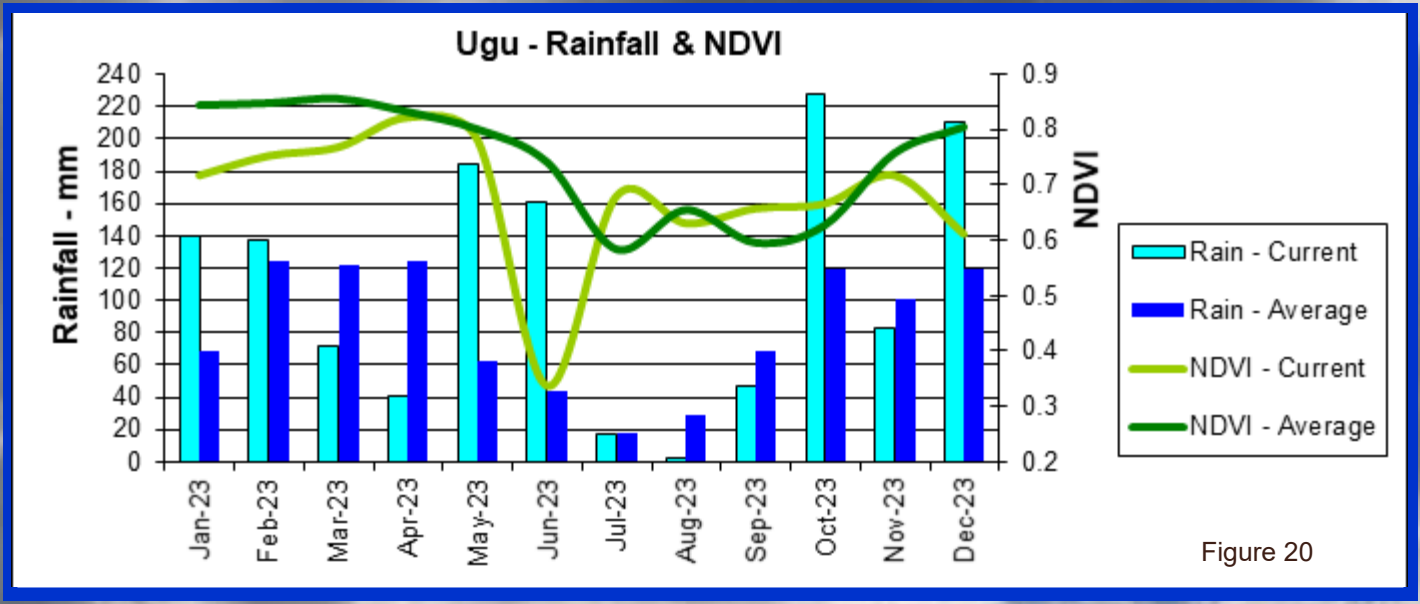

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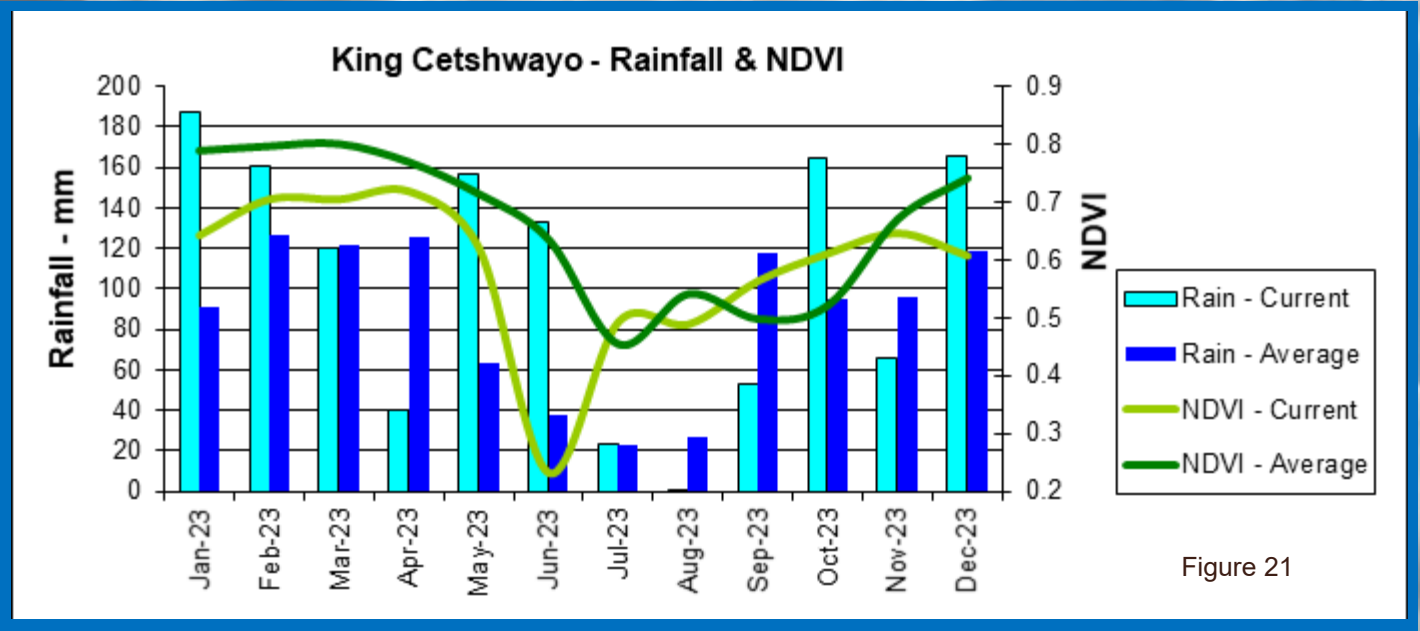

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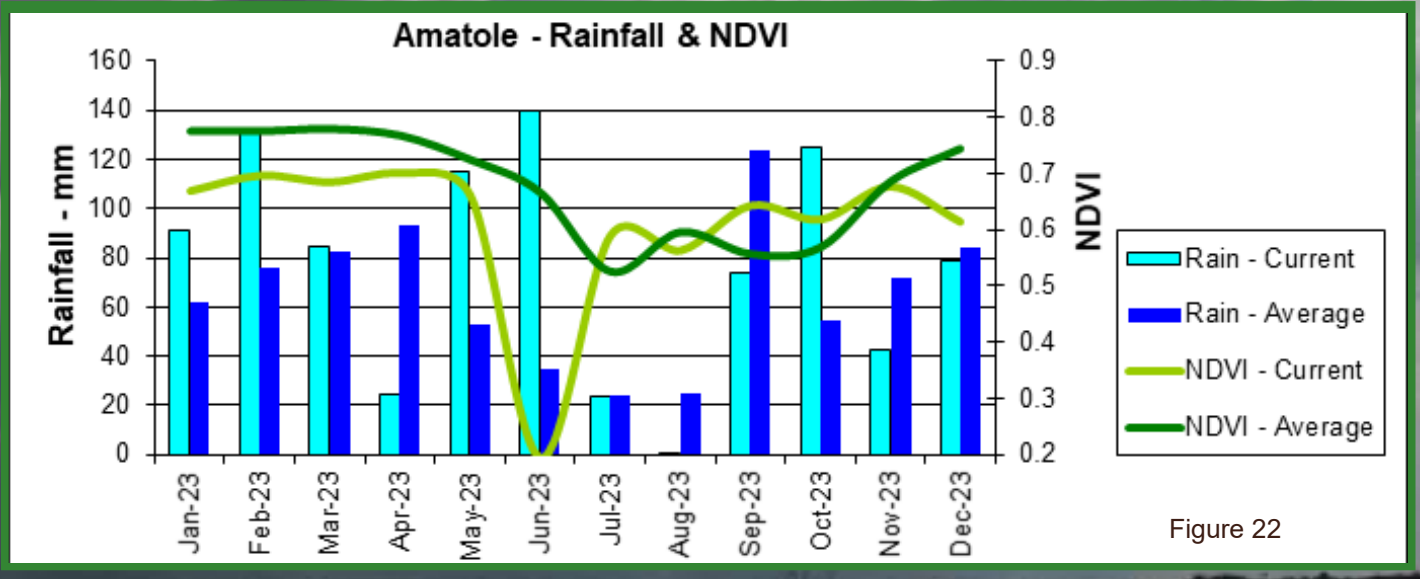

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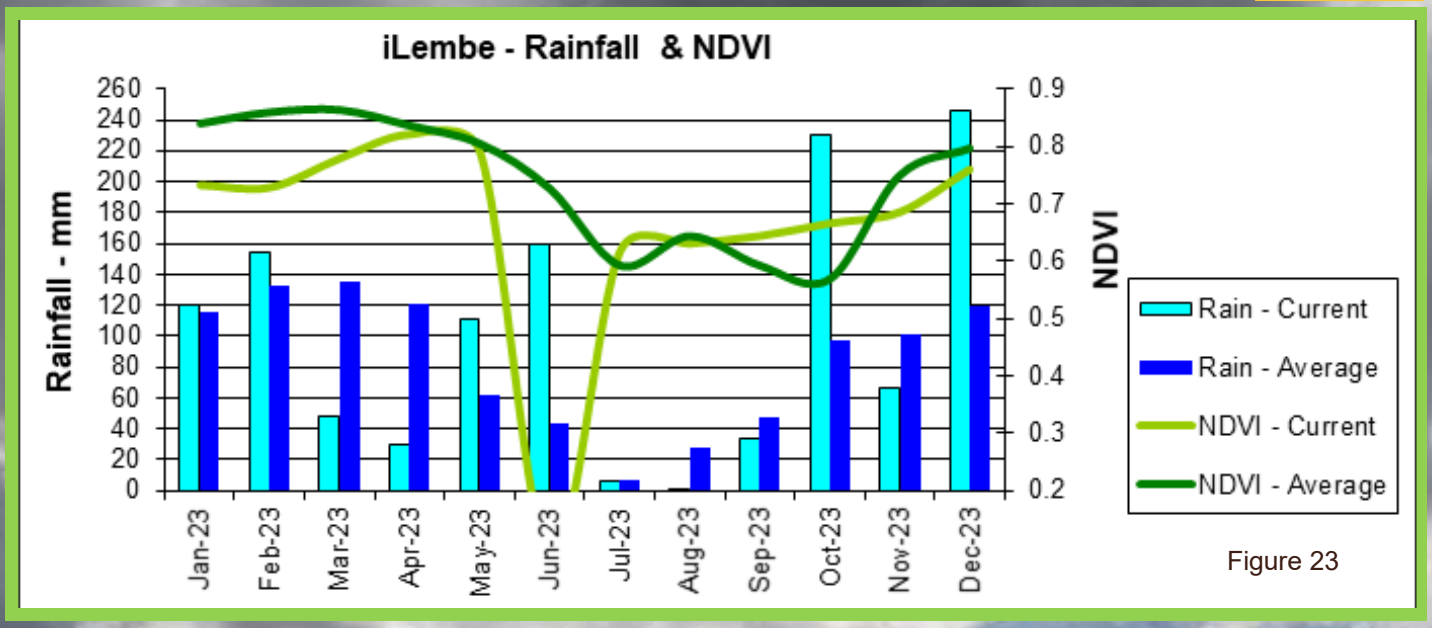

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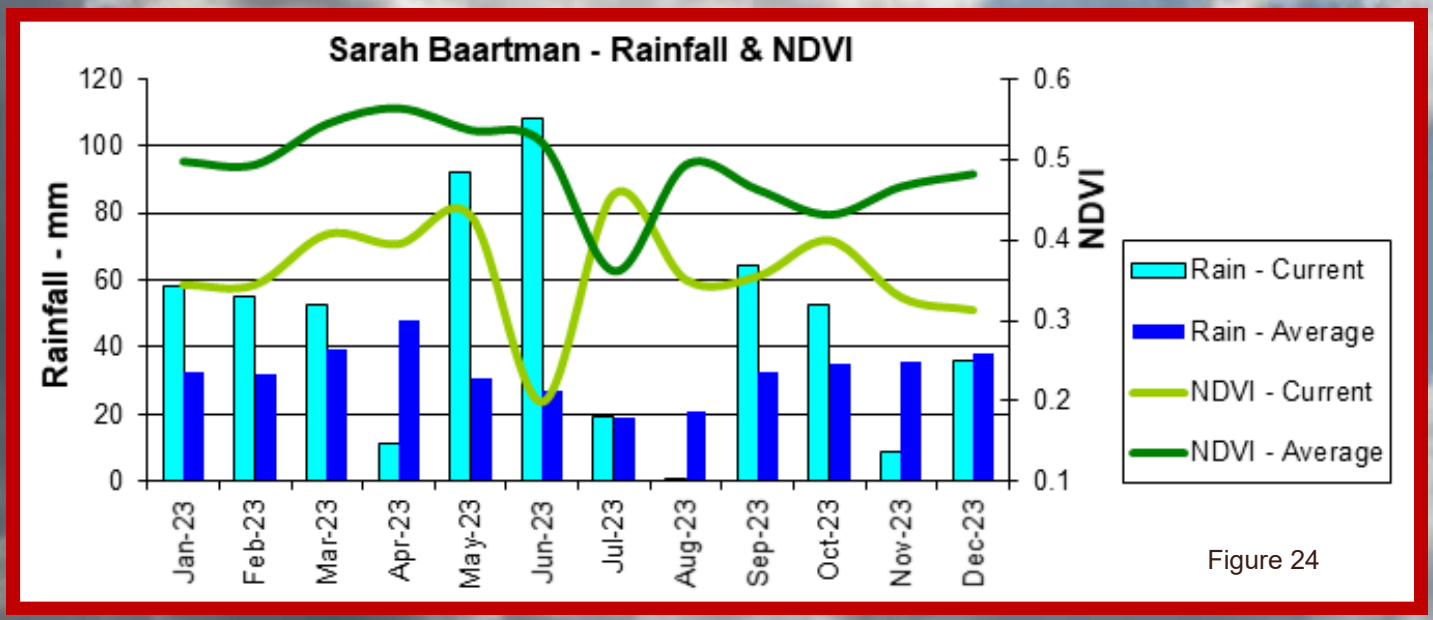

Figure 24

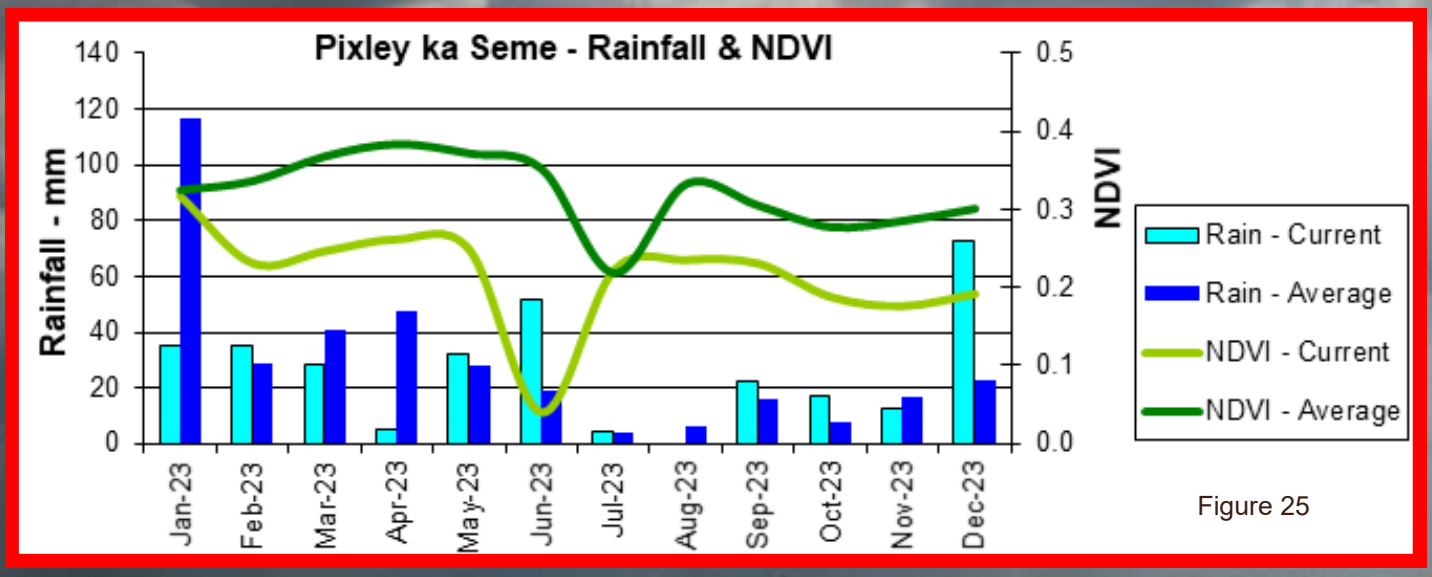

Figure 25

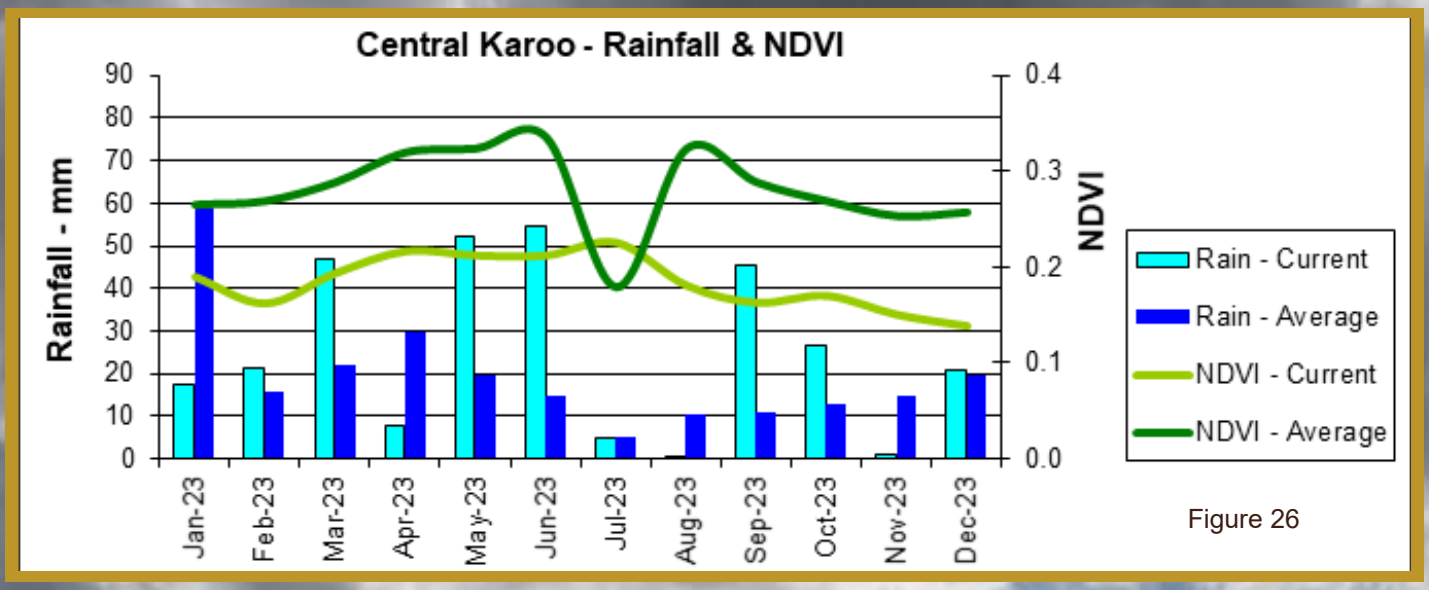

Figure 26

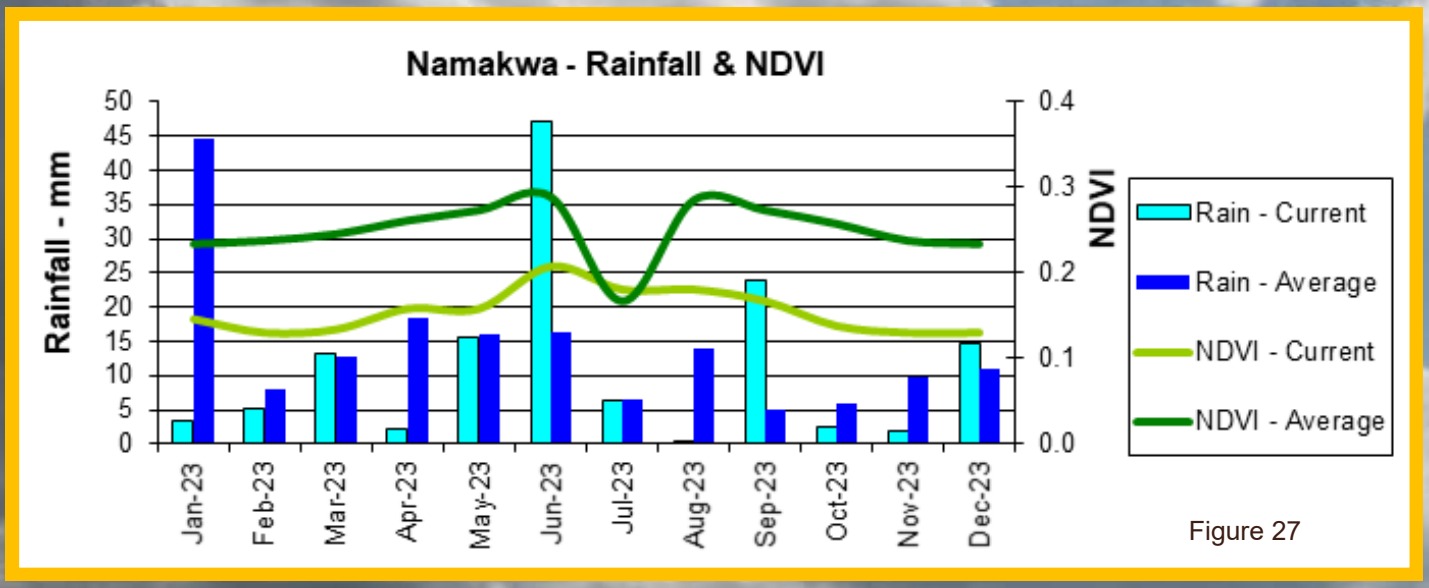

Figure 27

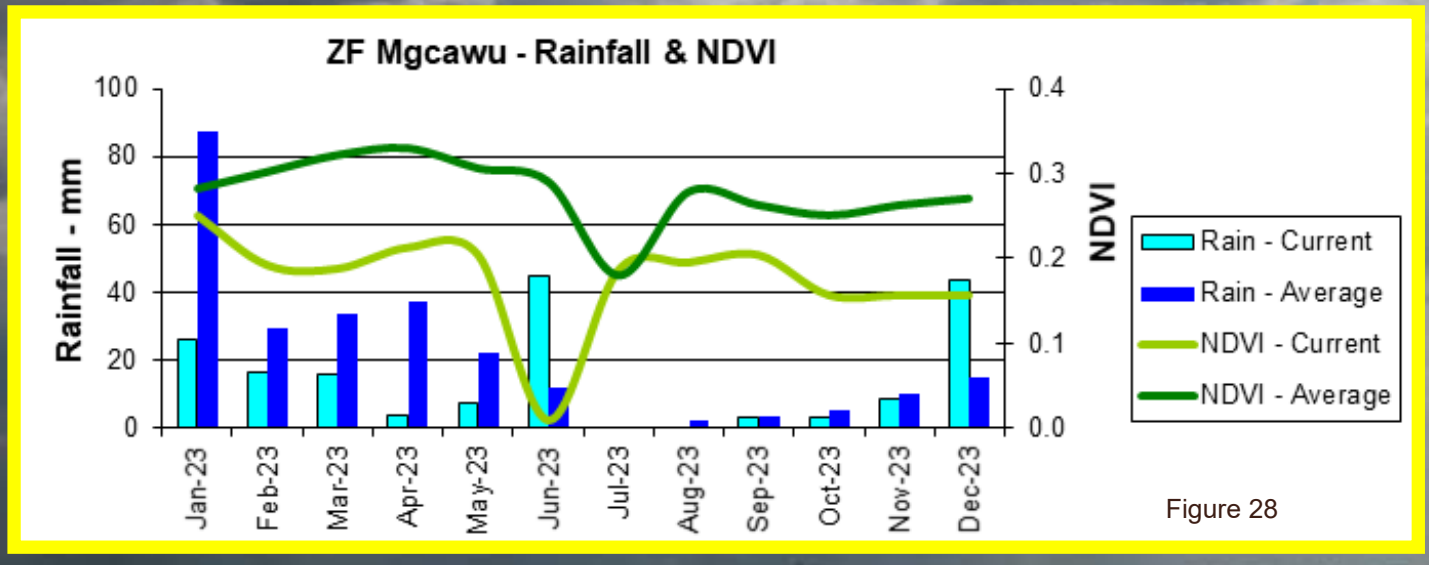

Figure 28

7. Fire Watch

Active Fires *(Provided when data is available)*

Forest and vegetation fires have temperatures in the range of 500 K (Kelvin) to 1000 K. According to Wien's Displacement Law, the peak emission of radiance for blackbody surfaces of such temperatures is at around 4 µm. For an ambient temperature of 290 K, the peak of radiance emission is located at approximately 11 µm. Active fire detection algorithms from remote sensing use this behaviour to detect "hot spot" fires.

Figure 29:
The graph shows the total number of active fires detected from 3 December 2023 to 1 January 2024 per province. Fire activity was higher in the Eastern Cape and Northern Cape compared to the long-term average.

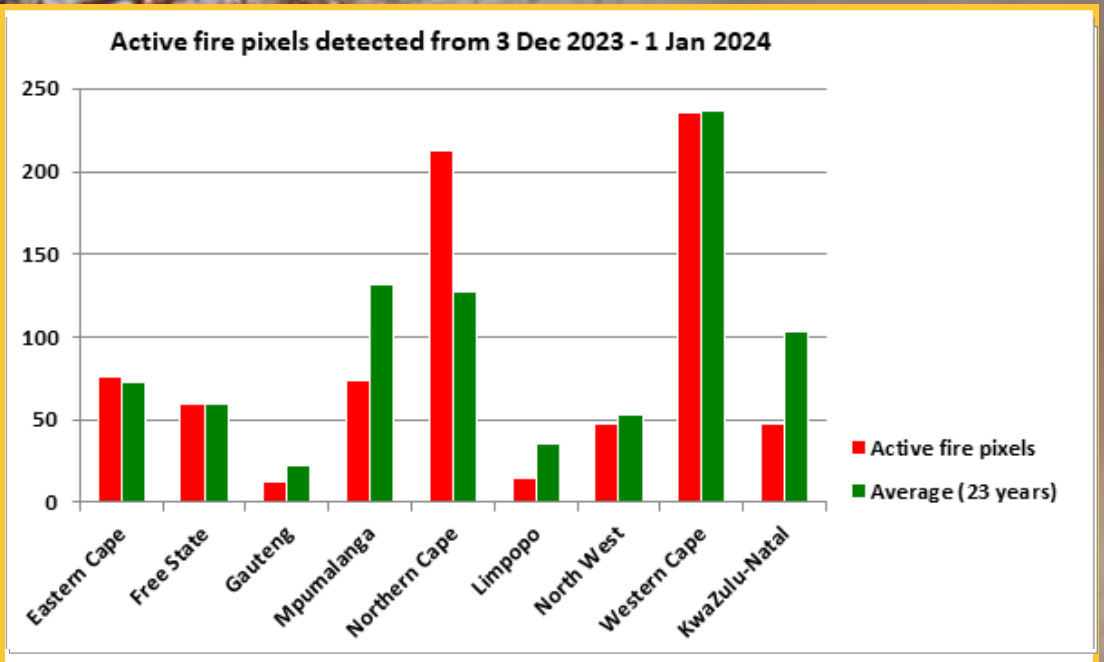

Figure 29

Figure 30:
The map shows the location of active fires detected between 3 December 2023 and 1 January 2024.

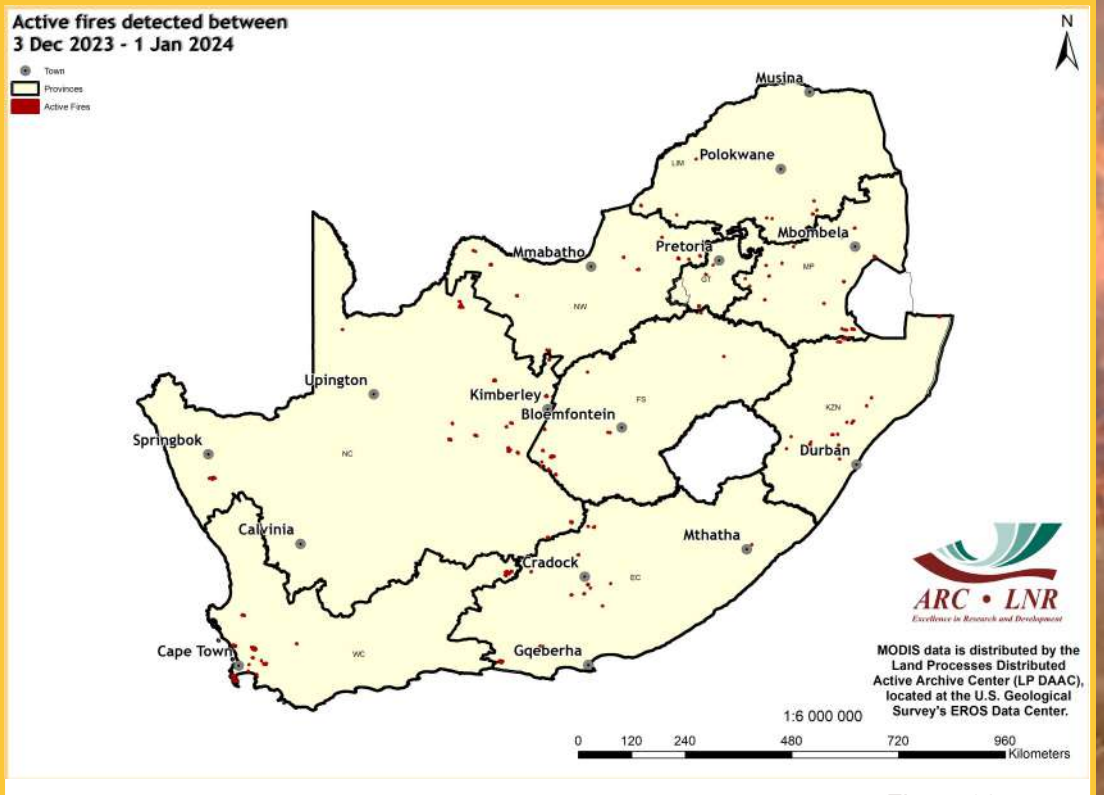

Figure 30

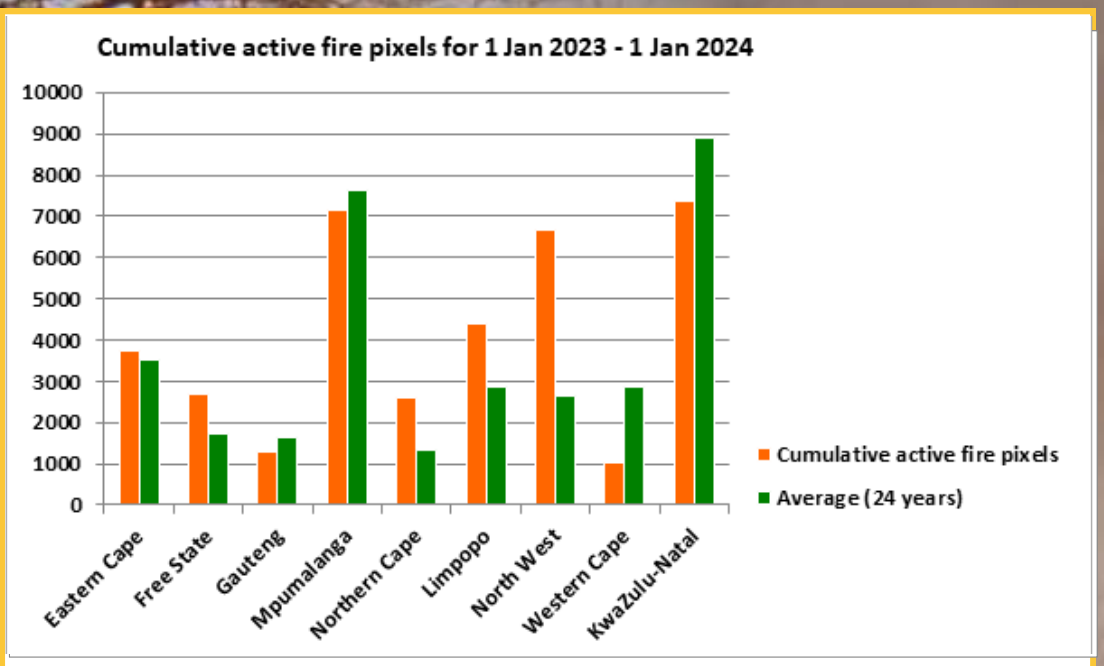

Figure 31:
The graph shows the total number of active fires detected from 1 January 2023 to 1 January 2024 per province. Fire activity was higher in all provinces except for Gauteng, Mpumalanga, Western Cape and KwaZulu-Natal, compared to the long-term average.

Figure 31

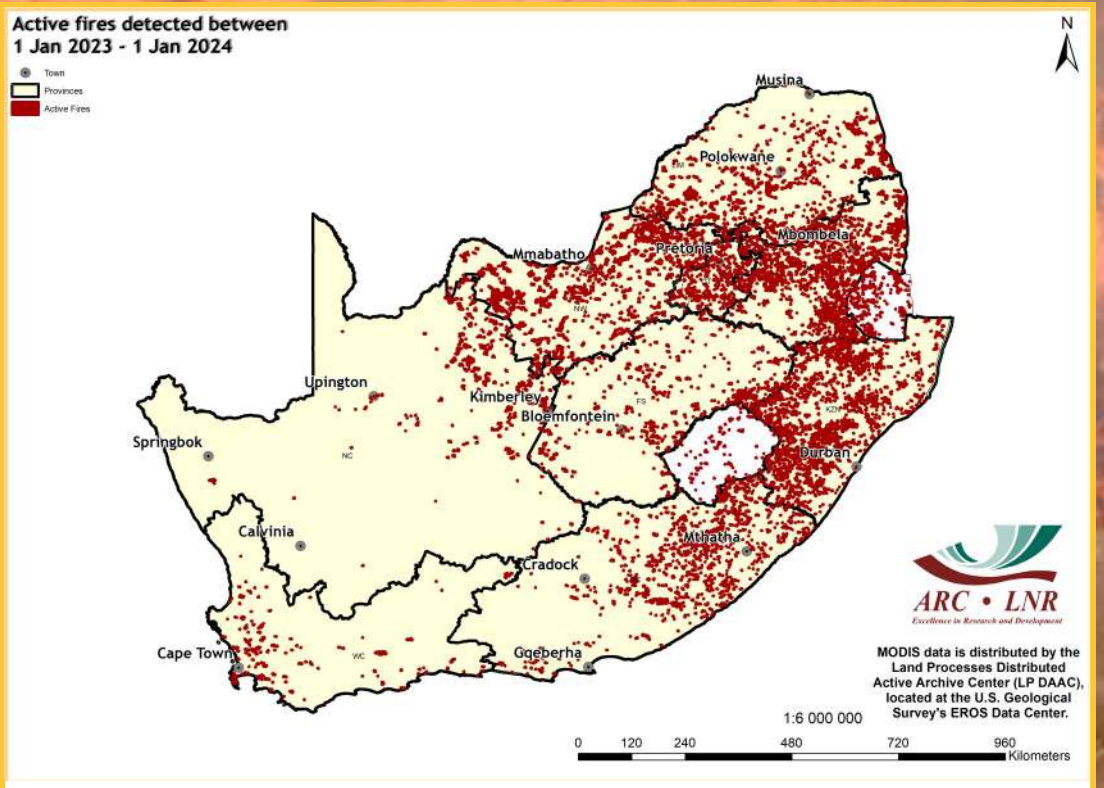

Figure 32:
The map shows the location of active fires detected between 1 January 2023 and 1 January 2024.

Figure 32

8. Surface Water Resources

Countrywide surface water areas (SWAs) are mapped on a monthly basis by GeoTerraImage using Sentinel-2 satellite imagery from the start of its availability at the end of 2015.

Figure 33 represents a comparison between the area of water available now and the maximum area of surface water recorded in the last 7 years. This 7-year historical window represents the operational period of the satellite from which the water information has been generated. In this map, any value less than 100 represents water catchments within which the current month's total surface water is less than the maximum extent recorded for the same area since the end of 2015.

Figure 34 represents a comparison between the area of surface water now and for the same month last year. In this map, any value less than 100 represents water catchments within which the current month's total surface water is less than that recorded in the same water catchment, in the same month, last year.

The long-term map for December 2023 shows a similar water distribution pattern to last month, and continues to illustrate the impact of the high rainfall experienced over most of the country during recent months. The majority of Tertiary catchments continue to show water levels equivalent to 60-100% of the 7-year, long-term maximum water levels. Most of the Western Cape and West Coast region of the Northern Cape continue to show maximum (80-100%) water levels.

The comparison between December 2023 and December 2022 shows significant areas of reduced water levels this year. This is a deviation from last month's pattern which indicated a greater area of either equal or higher water levels in November 2023 compared to the previous year. Northern Limpopo and the lower reaches of the Orange River in the Northern Cape are particularly low in December 2023 compared to the same month last year.

The SWA maps are derived from the monthly data generated and available through GeoTerraImage's 'Msanzi Amanzi' web information service: https://www.water-southafrica.co.za

Questions/Comments:
mark.thompson@geoterraimage.com

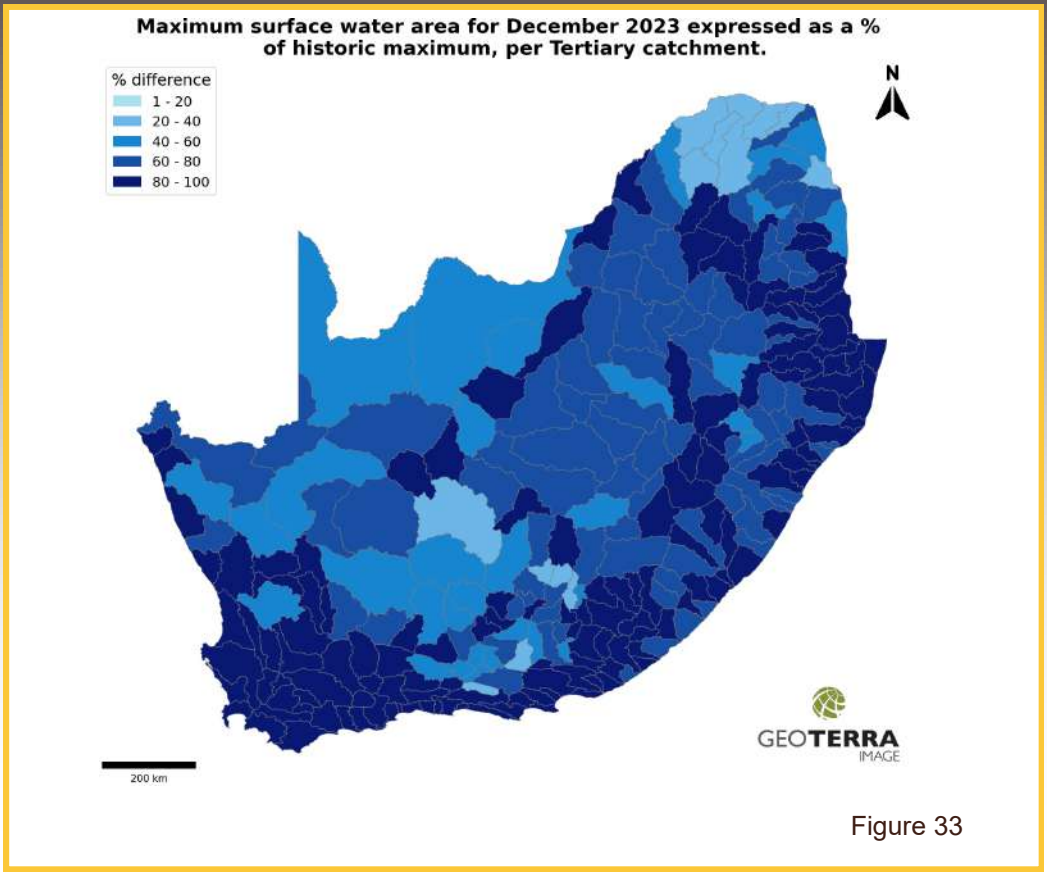

Figure 33

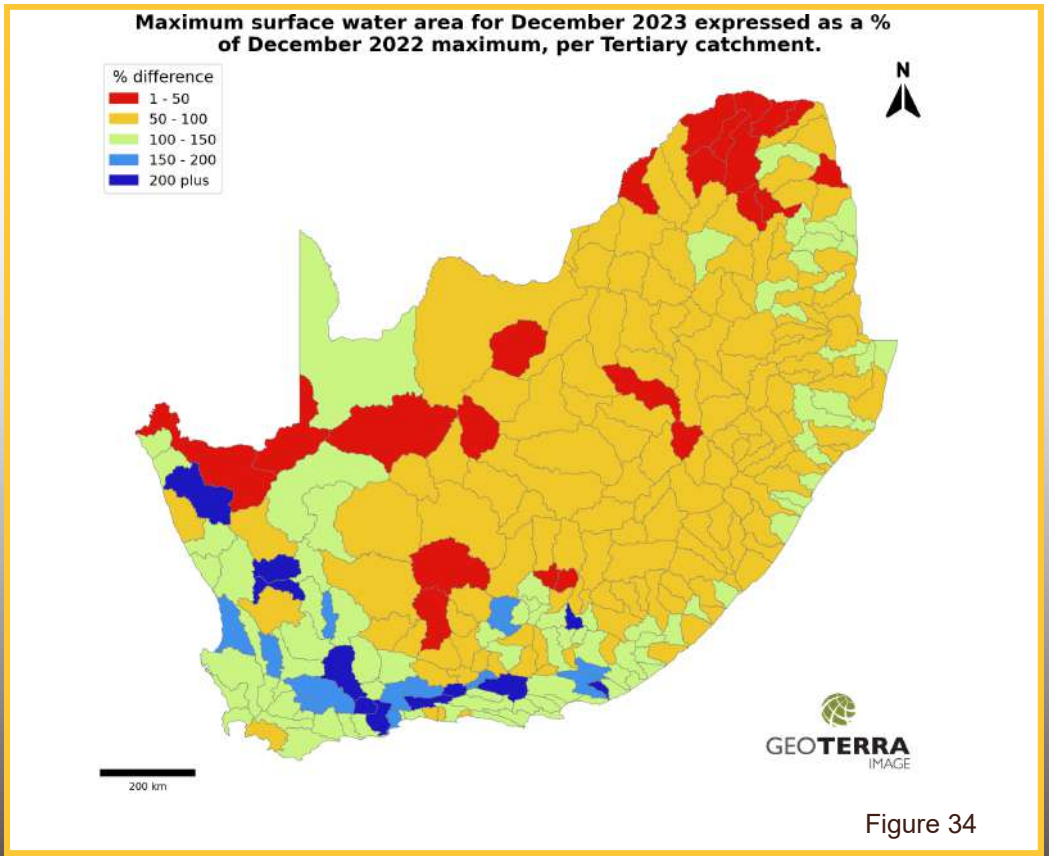

Figure 34

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ARC - NATURAL RESOURCES AND ENGINEERING

SOIL, CLIMATE AND WATER

Agrometeorology

The programme uses weather and climate information for agricultural planning and the enhancement of crop and livestock production systems. The impact of climate variability and change in the agricultural sector is investigated. Due to the increasing pressure to reduce greenhouse gas emissions globally, climate change mitigation is also an important facet of our activities. The Weather Station Network and Climate Database are maintained as a national asset for the benefit of the agriculture sector.

Activities

Agrometeorology and Crop Modelling

- Assessing climate risk for an area in relation to a particular crop
- Agroclimatological analysis of the suitability for crop production at a particular location
- Development of early warning systems for climate hazards (e.g. drought, floods)
- Agrometeorological forecasting and advisory services
- Crop modelling to assess the impact of weather conditions and climate on agriculture
- Conducting crop yield forecasting exercises, hydrological modelling, hydrometeorology and biometereology studies

Climate Change Adaptation and Mitigation

- Conducting research on possible impact of projected climate change on agricultural activities, potential, greenhouse gas emissions from various land use, climate change, mitigation and adaptation strategies for agriculture
- Developing greenhouse gas inventories at farm and national levels
- Conducting research on climate change mitigation and adaptation strategies for agriculture
- Promoting low-carbon technologies

Climate Monitoring, Products and Services

- Developing and maintaining a network of over 500 weather stations distributed all over the country
- Archiving historical and current weather data of good quality with some datasets dating back to 1900
- Developing weather/climate products and services together with stakeholders and clients to meet their specific requirements
- Disseminating weather/climate data, products and services via multiple platforms

Contact Person: Dr Mokhele Moeletsi
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For more information contact:
Adri Laas - Public Relations Officer
E-mail: adril@arc.agric.za

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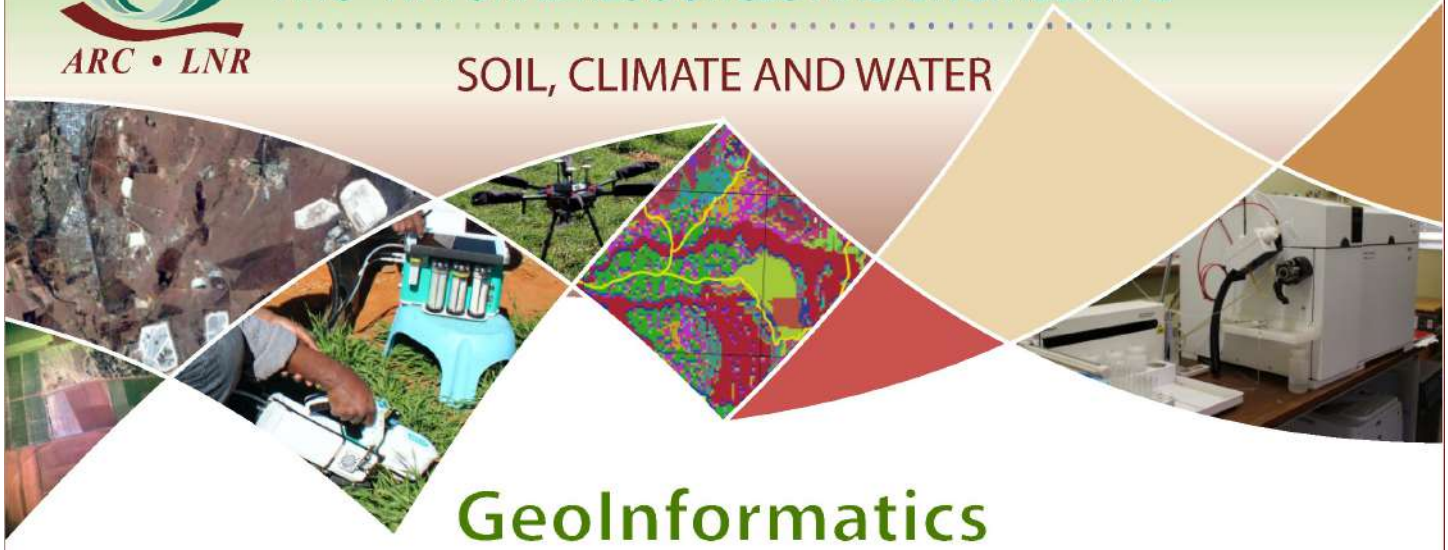
SOIL, CLIMATE AND WATER



GeoInformatics

The programme focuses on applied Geographical Information Systems (GIS) and provides leadership in GIS products, solutions and decision support systems for agriculture and natural resources management. The Coarse Resolution Satellite Image Archive and Information Database is maintained as a national asset.

Activities

Digital/Smart Agriculture/Drone Platform - Applications

- Yield & production estimation
- Insurance index
- Mapping crop types
- Monitoring growth stages
- Weed/invasive sp. mapping
- Water requirement
- Smart & digital agriculture
- Disease/pests

Applications in Natural Resources/National Assets

- Early warnings
- National & Provincial advisories
- Crop suitability changes
- Crop statistics
- Crop stress
- Spatially explicit information dissemination systems, e.g. Umlindi newsletter

Applications in Rangelands, Livestock and Wildlife

- Early warnings
- National & Provincial advisories
- Rangeland suitability
- Rangeland dynamics
- Rangeland stresses
- Spatially explicit information dissemination systems, e.g. Umlindi newsletter

Contact Person: *Dr George Chirima*
Tel: 012 310 2672 • E-mail: chirimaj@arc.agric.za

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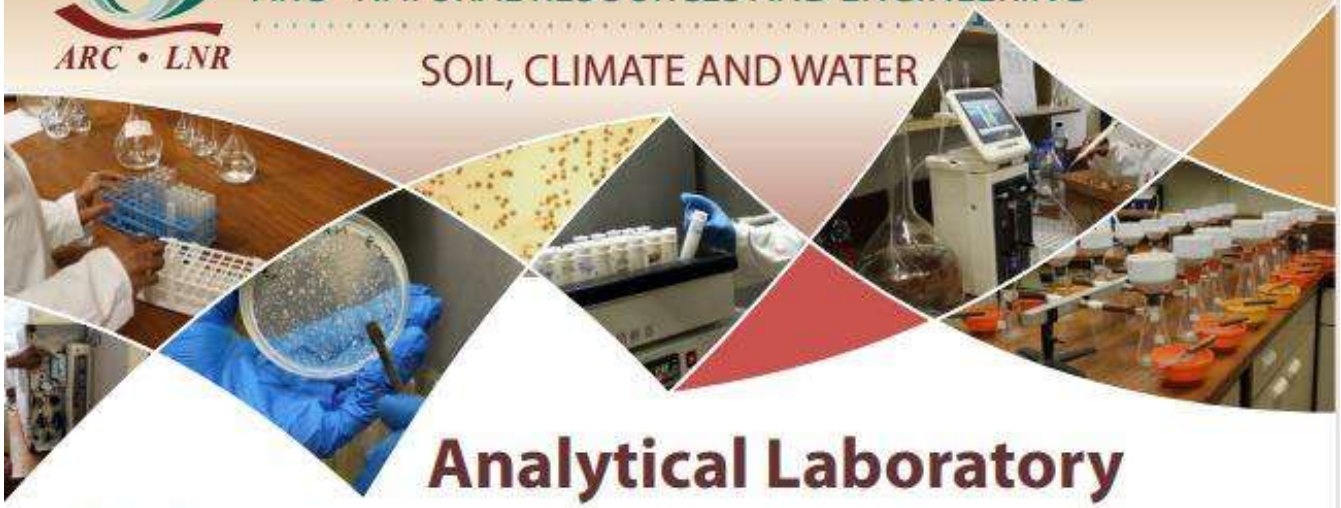

Analytical Laboratory

The unit focuses on the various procedures to analyze and determine the properties of soil, water and associated materials, mainly for agricultural purposes. The laboratory operates a range of equipment and participates in various quality control schemes, both local and international. The water analysis for anions is SANAS-accredited and other accreditations are underway.

Analyses and Services

Soil Physical Analysis

- Texture (sand, silt and clay content)
- Water-holding capacity
- Soil moisture content
- Bulk density
- Shrink-swell capacity

Soil Chemical Analysis

- pH
- Exchangeable and extractable cations
- Acidity
- Soil Organic Carbon
- Nitrogen content and C/N ratio
- Phosphorus
- Micronutrients

Soil Fertility

- Analysis package for farmers & gardeners
- Fertilizer recommendations for specific crops

Water Analysis

- pH, EC, anions, cations
- Water quality

ICP Scan

- Semi-quantitative scan for a range of elements (Li, Be, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Rb, Sr, Mo, Cd, Sn, Sb, Te, Cs, Ba, La, W, Pt, Hg, Tl, Pb, Bi, U), can be done on soil, water and plant

Plant Material Analysis

For example: leaves, roots, growth media, etc. – drying, milling, pH, EC, C, N, nutrients and toxic elements

Special Sample Analysis

- For example: sludges, compost, fertilizers – composition and other properties
- Elemental analysis of animal tissue (e.g. hair, bones, liver, muscle, milk)

For more information or to obtain prices or quotation, contact the Laboratory Manager: *Ms. Zanele Hlam*
Tel: 012 310 2531 • E-mail: HlamZ@arc.agric.za

In order to assist clients who wish to send samples to ARC, the courier costs can be borne by ARC for analysis packages of R10 000 or more.

Contact the Laboratory Manager for details.

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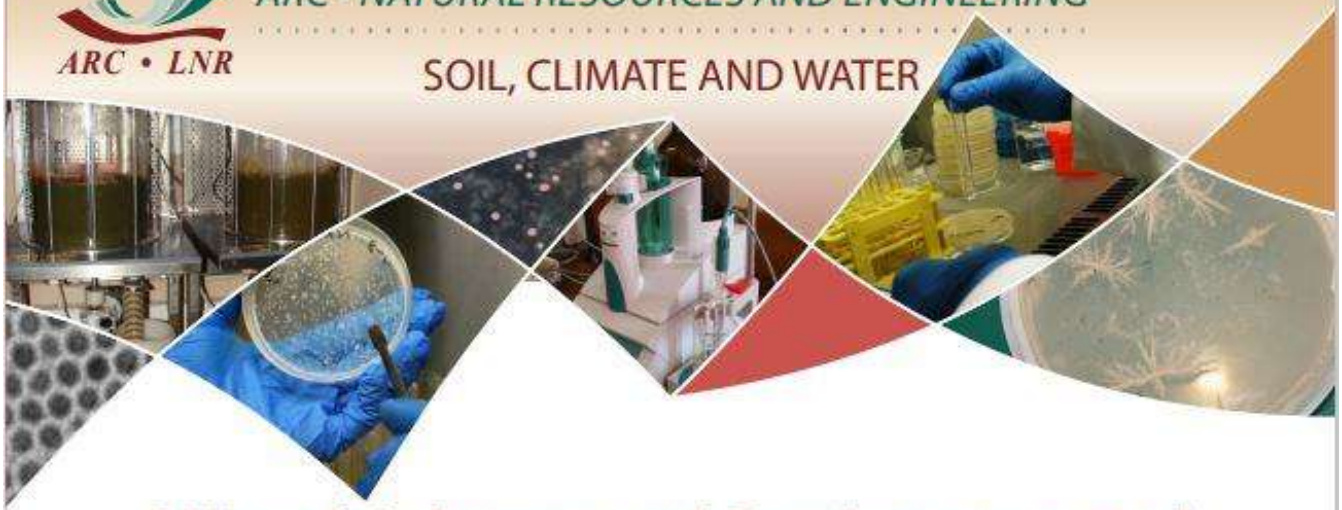

Microbiology and Environmental Biotechnology Laboratory

The Microbiology and Environmental Biotechnology Research Group forms part of the Soil Science Programme at ARC-SCW. The research group utilizes both fundamental as well as applied microbiology and biotechnology approaches to address soil, climate and water related problems in a sustainable and eco-friendly manner.

Analyses and Services

Renewable energy generation

- Gas Chromatography analysis of biogas - methane and carbon dioxide content measurements

Nanotechnology

- UV-Visible spectrophotometer analysis for colloidal nanoparticle synthesis

Phytochemical extraction

- Hotplate extraction of phytochemicals
- Soxhlet extraction of phytochemicals
- Microwave-assisted extraction of phytochemicals

Community-Level Physiological Profiling (CLPP)

- Microbial functional analysis using Biolog 31C plates

For information on microbiological analyses contact
Dr Ashira Roopnarain
Tel: 012 310 2650 • E-mail: RoopnarainA@arc.agric.za

In order to assist clients who wish to send samples to ARC, the courier costs can be borne by ARC for analysis packages of R10 000 or more.

Contact the Laboratory Manager for details.

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For more information contact:
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The Coarse Resolution Imagery Database (CRID)

NOAA AVHRR

ARC-NRE has an archive of daily NOAA AVHRR data dating from 1985 to 2004. This database includes all 5 bands as well as the Normalized Difference Vegetation Index (NDVI), Active Fire and Land Surface Temperature (LST) images. The NOAA data are used, for example, for crop production and grazing capacity estimation.

MODIS

MODIS data is distributed by the Land Processes Distributed Active Archive Center (LP DAAC), located at the U.S. Geological Survey's EROS Data Center. The MODIS sensor is more advanced than NOAA with regard to its high spatial (250 m^2 to 1 km^2) and spectral resolution. ARC-NRE has an archive of MODIS (version 4 and 5) data.

- MODIS v4 from 2000 to 2006
- MODIS v5 from 2000 to present

Datasets include:

- MOD09 (Surface Reflectance)
- MOD11 (Land Surface Temperature)
- MOD13 (Vegetation Products)
- MOD14 (Active Fire)
- MOD15 (Leaf Area Index & Fraction of Photosynthetically Active Radiation
- MOD17 (Gross Primary Productivity)
- MCD43 (Albedo & Nadir Reflectance)
- MCD45 (Burn Scar)

Coverage for version 5 includes South Africa, Namibia, Botswana, Zimbabwe and Mozambique.
More information:
http://modis.gsfc.nasa.gov

VGT4AFRICA and GEOSUCCESS

SPOT NDVI data is provided courtesy of the VEGETATION Programme and the VGT4AFRICA project. The European Commission jointly developed the VEGETATION Programme. The VGT4AFRICA project disseminates VEGETATION products in Africa through GEONETCast.

ARC-NRE has an archive of VEGETATION data dating from 1998 to the present. Other products distributed through VGT4AFRICA and GEOSUCCESS include Net Primary Productivity, Normalized Difference Wetness Index and Dry Matter Productivity data.

Meteosat Second Generation (MSG)

ARC-NRE has an operational MSG receiving station. Data from April 2005 to the present have been archived. MSG produces data with a 15-minute temporal resolution for the entire African continent. Over South Africa the spatial resolution of the data is in the order of 3 km. ARC-NRE investigated the potential for the development of products for application in agriculture. NDVI, LST and cloud cover products were some of the initial products derived from the MSG SEVIRI data. Other products derived from MSG used weather station data, including air temperature, humidity and solar radiation.

Rainfall maps

- Combined inputs from 450 automatic weather stations from the ARC-NRE Soil, Climate and Water weather station network, 270 automatic rainfall recording stations from the South African Weather Service (SAWS), satellite rainfall estimates from the Famine Early Warning System Network: **http://earlywarning.usgs.gov** and long-term average climate surfaces developed at the ARC-NRE.

Solar Radiation and Evapotranspiration maps

- Combined inputs from 450 automatic weather stations from the ARC-NRE Soil, Climate and Water weather station network.
- Data from the METEOSAT Second Generation (MSG) 3 satellite via GEONETCAST: **http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/GEONETCast/index.html**.

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The operational Coarse Resolution Imagery Database (CRID) project of ARC-NRE is funded by the Department of Agriculture, Land Reform and Rural Development (DALRRD). Development of the monitoring system was made possible at its inception through LEAD funding from the Department of Science and Technology.

For further information please contact:
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Adri Laas – 012 310 2518, AdriL@arc.agric.za

To subscribe to the newsletter, please submit a request to:
MaakeR@arc.agric.za

What does Umlindi mean?
UMLINDI is the Zulu word for "the watchman".

DISCLAIMER:
The ARC-NRE and its collaborators have obtained data from sources believed to be reliable and have made every reasonable effort to ensure accuracy of the data. The ARC-NRE and its collaborators cannot assume responsibility for errors and omissions in the data nor in the documentation accompanying them. The ARC-NRE and its collaborators will not be held responsible for any consequence from the use or misuse of the data by any organization or individual.