

**NATURAL RESOURCES AND ENGINEERING**  
Soil, Climate and Water

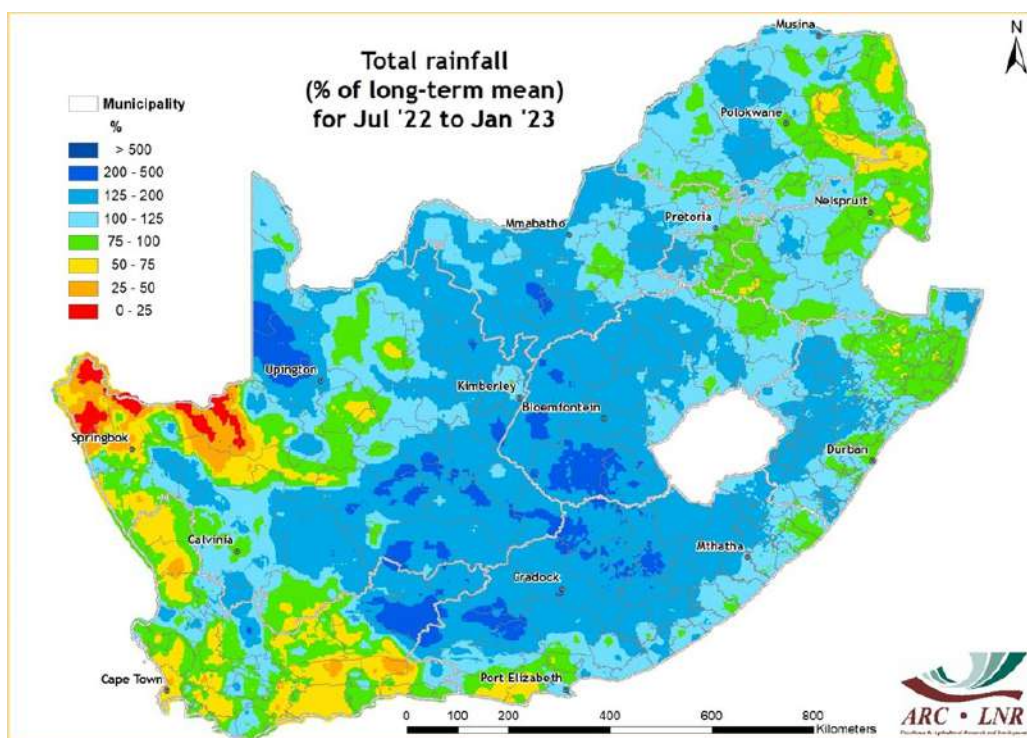
**CONTENTS:**

1. Rainfall	2
2. Standardized Precipitation Index	4
3. Rainfall Deciles	6
4. Vegetation Conditions	7
5. Vegetation Condition Index	9
6. Vegetation Conditions & Rainfall	11
7. Fire Watch	15
8. Surface Water Resources	16
9. Agrometeorology	17
10. Geoinformatics	18
11. Analytical Laboratory	19
12. Microbiology Laboratory	20
13. CRID	21
14. Contact Details	21

### Image of the Month

### Above-normal rainfall since the start of the 2022/23 agricultural season

The cumulative rainfall map from July 2022 to January 2023, given as a percentage of the long-term mean, shows that greater parts of the country, particularly the interior, have experienced above-normal rainfall. Areas which received near-normal conditions or up to 75% of their normal rainfall during this period include large parts of the Lowveld in Mpumalanga, towards the northeastern corner of Limpopo. These rains signify favourable conditions for crops and pasture yields as commonly expected during a La Niña summer. Moreover, the South African Weather Service forecasts the probability of above-normal rainfall during the remainder of the season. However, for the agricultural sector it is important to remain cognizant of potential drawbacks such as poor rainfall distribution, increased risk of erosion (water and wind) and outbreaks of insects, diseases and invasive weeds. Thus, preventative and mitigation measures to minimize the negative impacts are recommended per region.



## Overview:

A decrease in total rainfall was observed over the country during January 2023 as compared to the previous 2 months. The first dekad of January began with a series of showers over the summer rainfall region. By the 8<sup>th</sup>, a persistent mid-level high pressure system invaded most of the interior, reducing chances of convective rain. Thus, large parts of the summer rainfall region experienced heatwave conditions and a number of consecutive dry days. These conditions were observed largely over the Highveld (including the major maize production areas – mostly in the eastern Free State and North West) and the adjacent eastern summer rainfall region. From the 16<sup>th</sup>, the much-needed rains returned to the region. Areas that received above-normal rainfall for January include the central parts of Limpopo, parts of KwaZulu-Natal and the southern interior towards the Eastern Cape. Rainfall totals in excess of 200 mm for the month were recorded in parts of the Eastern Cape, KZN and isolated areas of Mpumalanga and Limpopo. In contrast, the winter rainfall region was dry when compared to the previous month, and experienced below-normal rainfall conditions.

# 1. Rainfall

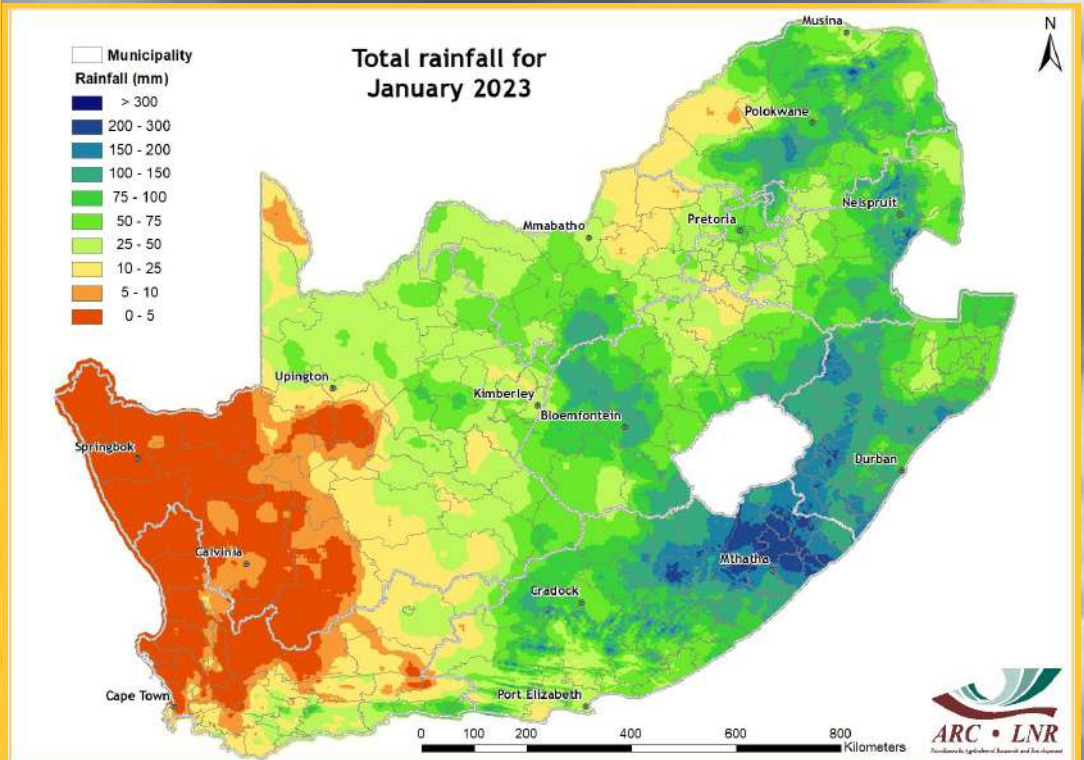


Figure 1

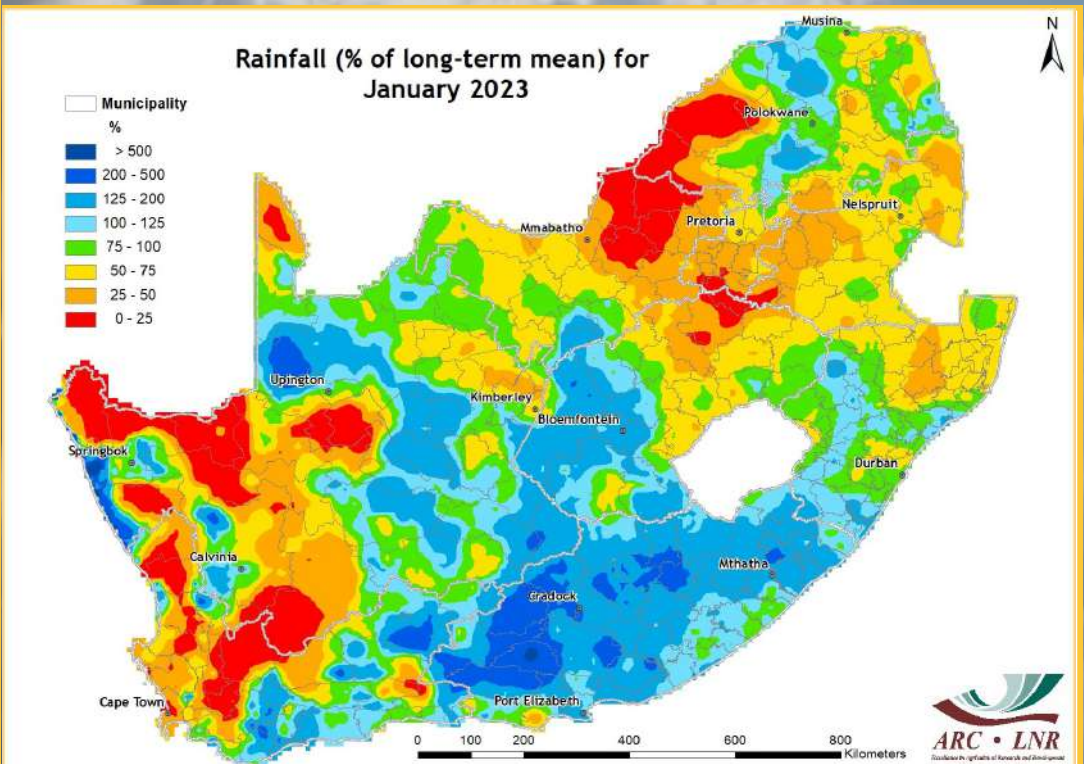


Figure 2

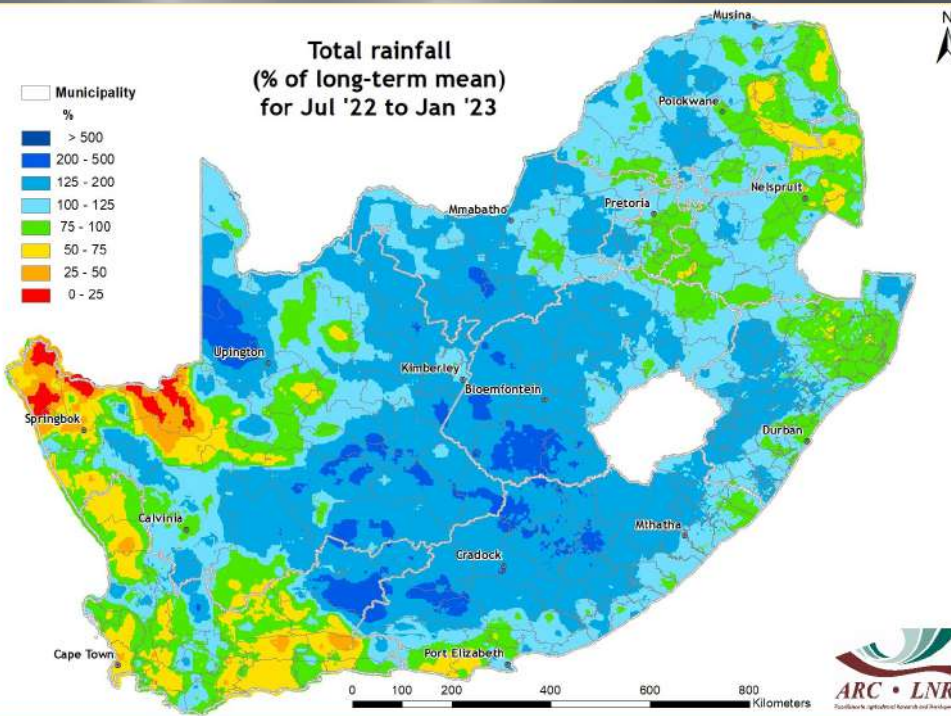


Figure 3

**Figure 1:**

High rainfall totals were recorded in the Eastern Cape, KwaZulu-Natal, Mpumalanga and parts of Limpopo during January 2023, but the western areas of the country were mostly dry.

**Figure 2:**

Above-normal rainfall occurred over the interior in January, moving south-east towards the midlands and coastal regions of KZN and the Eastern Cape. Similar conditions were observed over parts of Limpopo. Meanwhile, below-normal rainfall occurred over much of the Highveld and western parts of the Northern and Western Cape.

**Figure 3:**

Cumulative rainfall from July 2022 to January 2023, given as a percentage of the long-term mean for the same period, indicates widespread above-normal conditions over greater parts of the country.

**Figure 4:**

Large areas across the country received less rainfall during the period from 1 November 2022 to 31 January 2023, as compared to the same period last season. Certain parts of KZN, the Eastern Cape and Gauteng recorded more rain while the rest of the country received fairly similar rainfall.

**Questions/Comments:**

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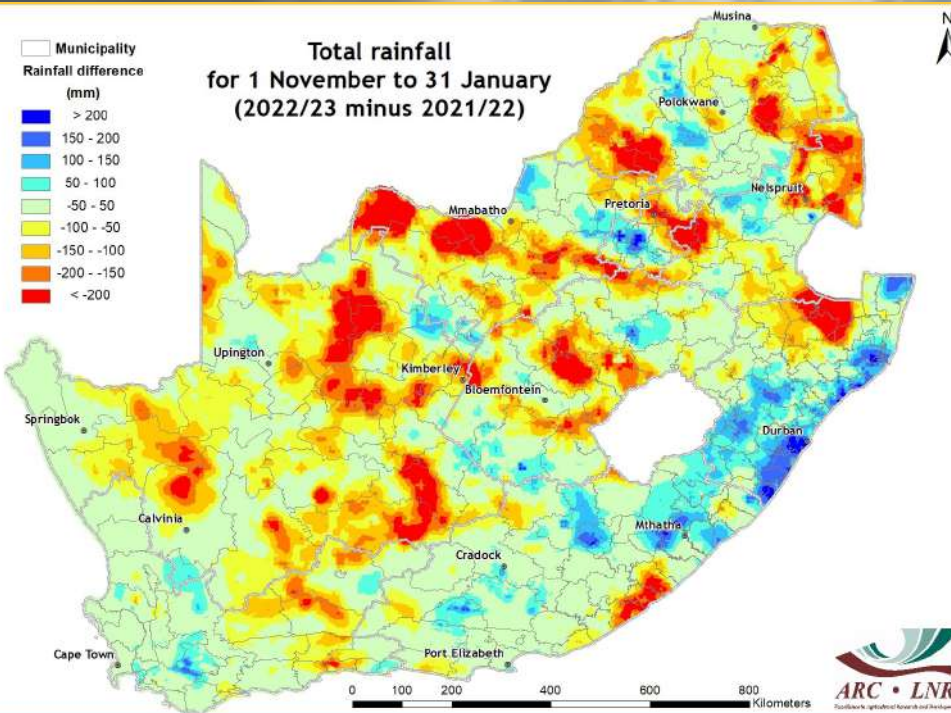


Figure 4

## 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 8<sup>th</sup> 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 January 2023 are shown in Figures 5-8. Given the short-term SPI, high rainfall totals that occurred since November 2022 resulted in wet conditions over the summer rainfall region, but the Lowveld of Mpumalanga is showing signs of mild drought. The winter and all-year rainfall regions are experiencing moderate to severe drought conditions due to below-normal rainfall activity during the previous months. Similar conditions can be noted on the medium- to long-term SPI maps, with more pronounced wet conditions over the interior.

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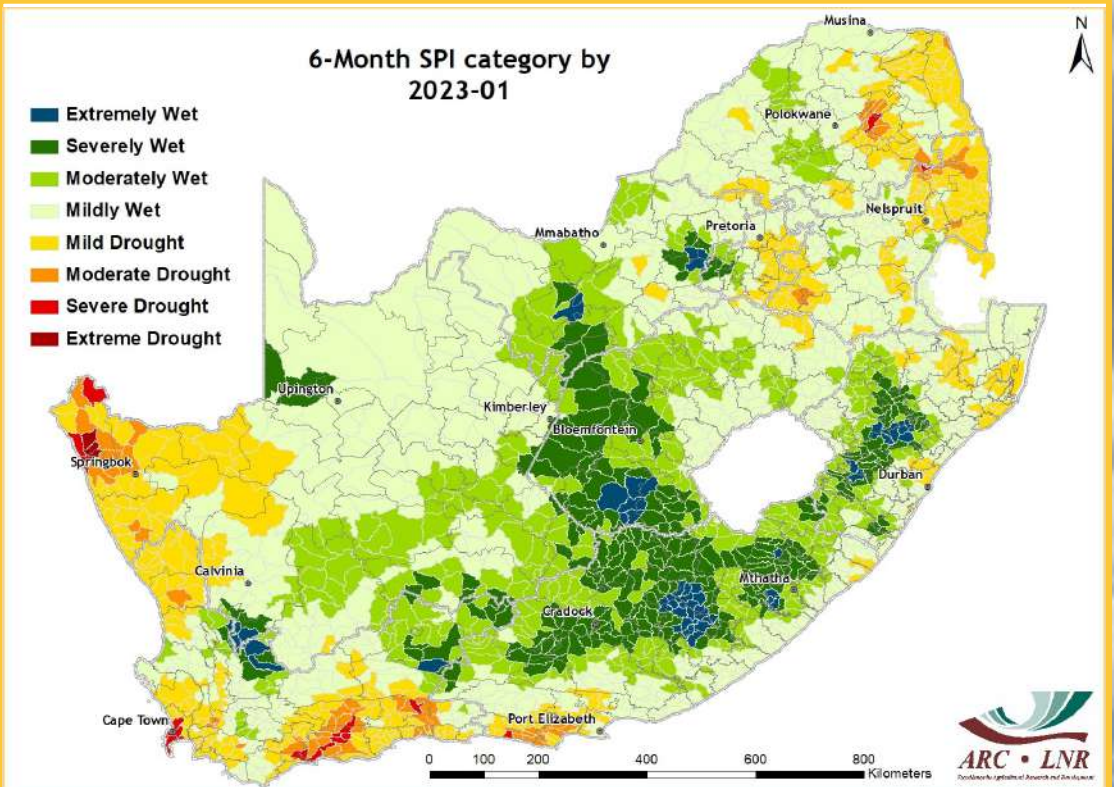


Figure 5

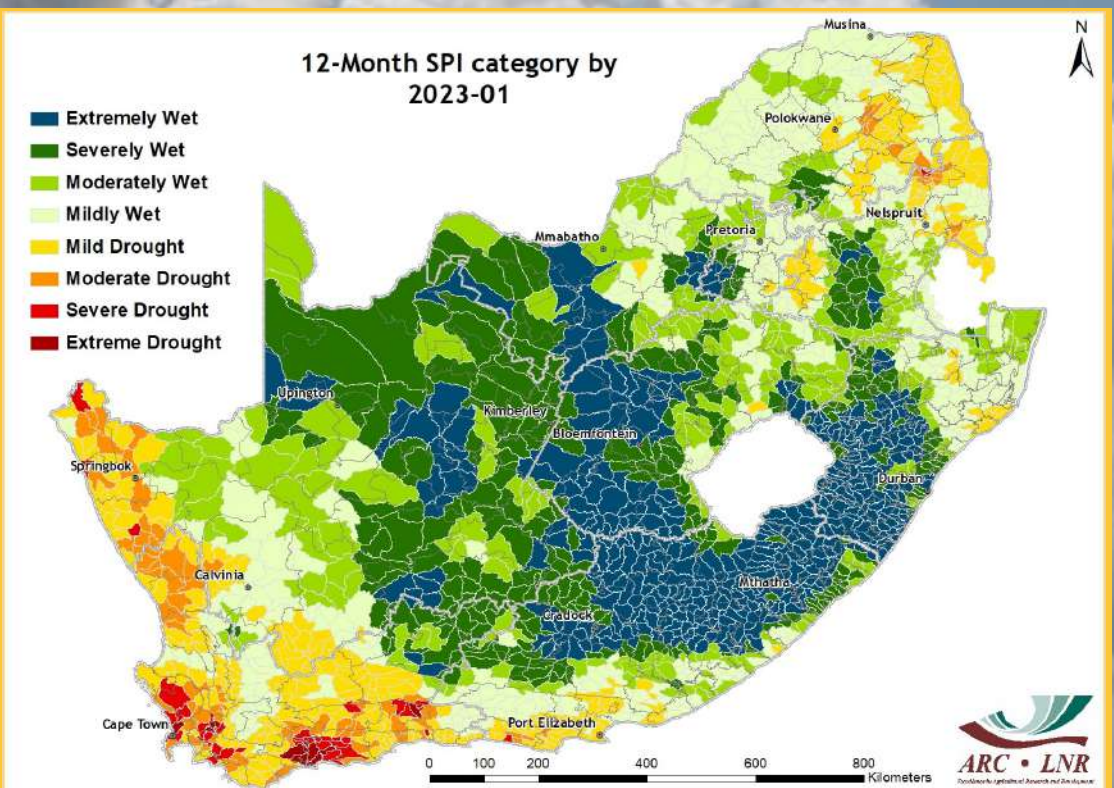


Figure 6

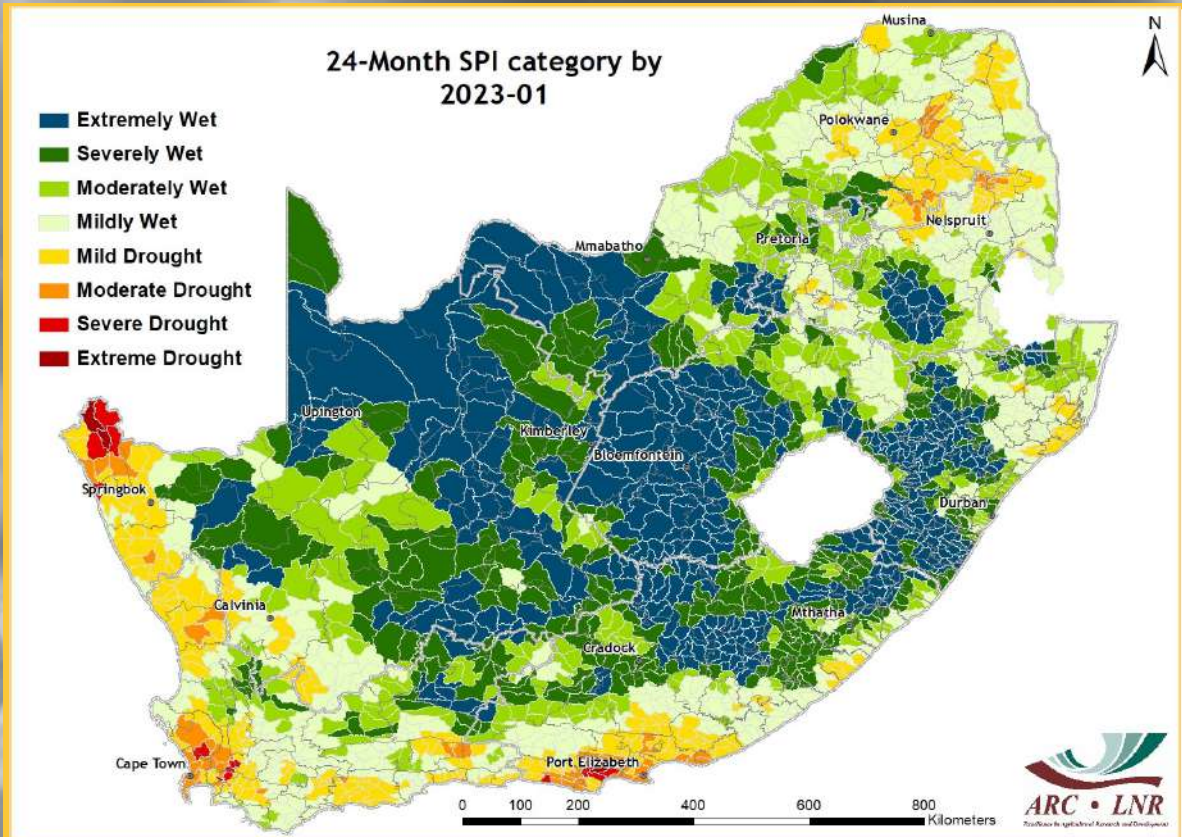


Figure 7

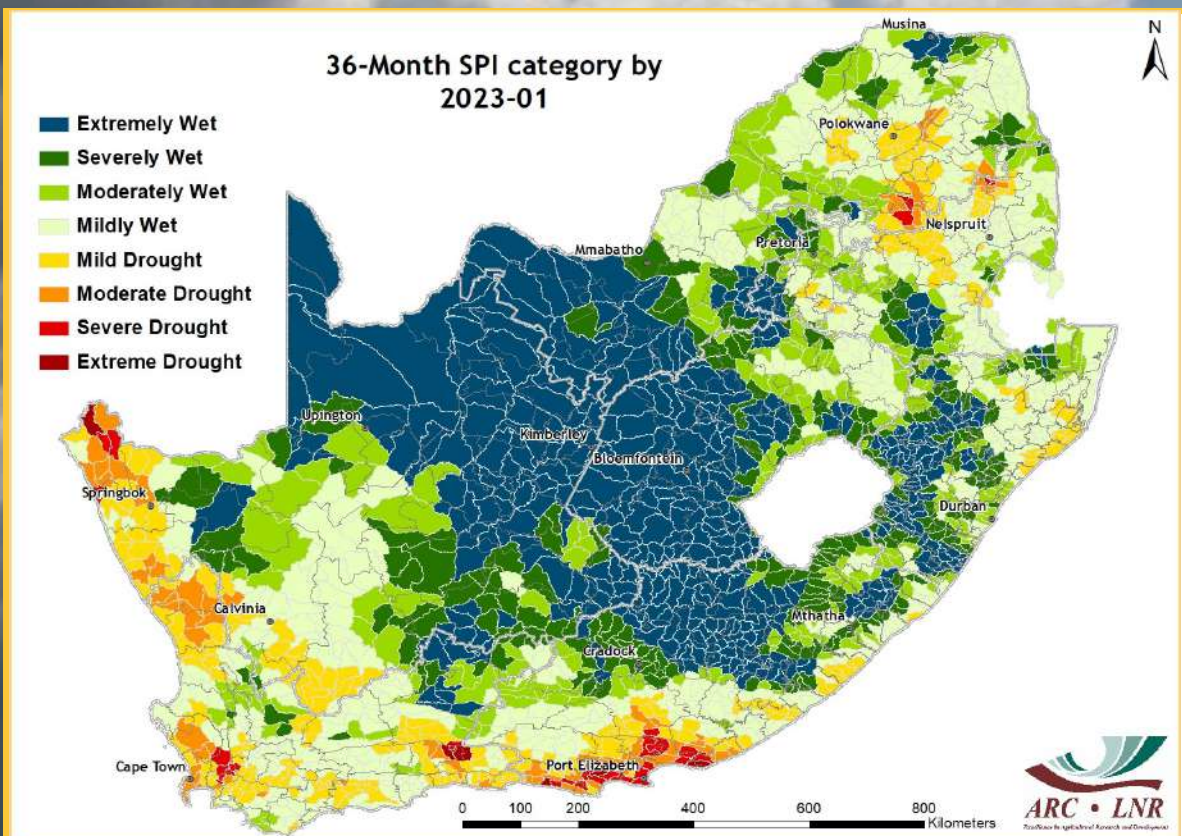


Figure 8

# 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.

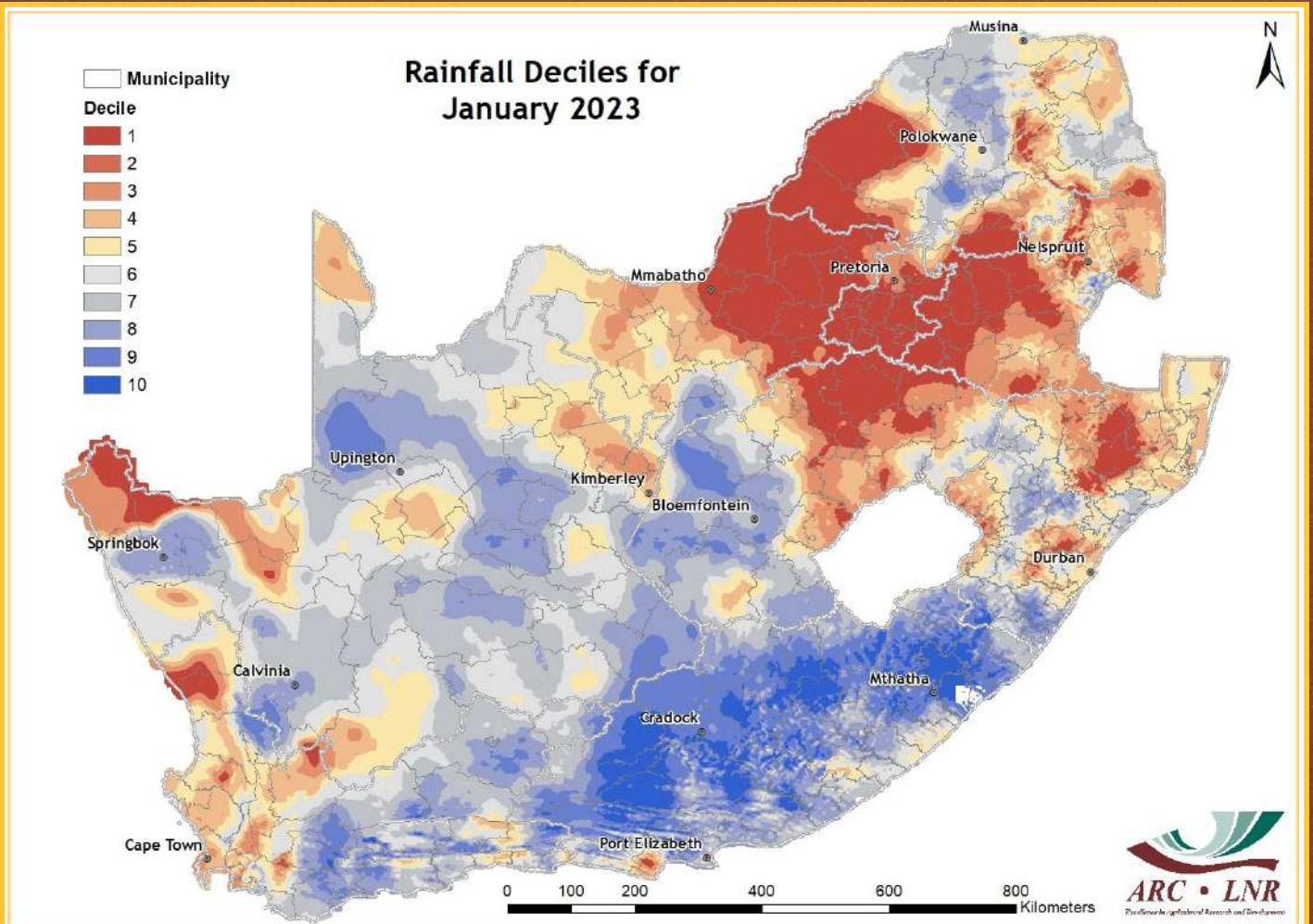


Figure 9

### Figure 9:

In January 2023, the western half of the country, extending eastwards to KwaZulu-Natal and the northeastern parts of Limpopo, received rainfall totals that compare well with historically wet January months, while the Highveld, parts of the Mpumalanga Lowveld and northern KZN were dry.

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## Vegetation Mapping

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

$$NDVI = \frac{(IR - R)}{(IR + R)}$$

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.

# 4. Vegetation Conditions

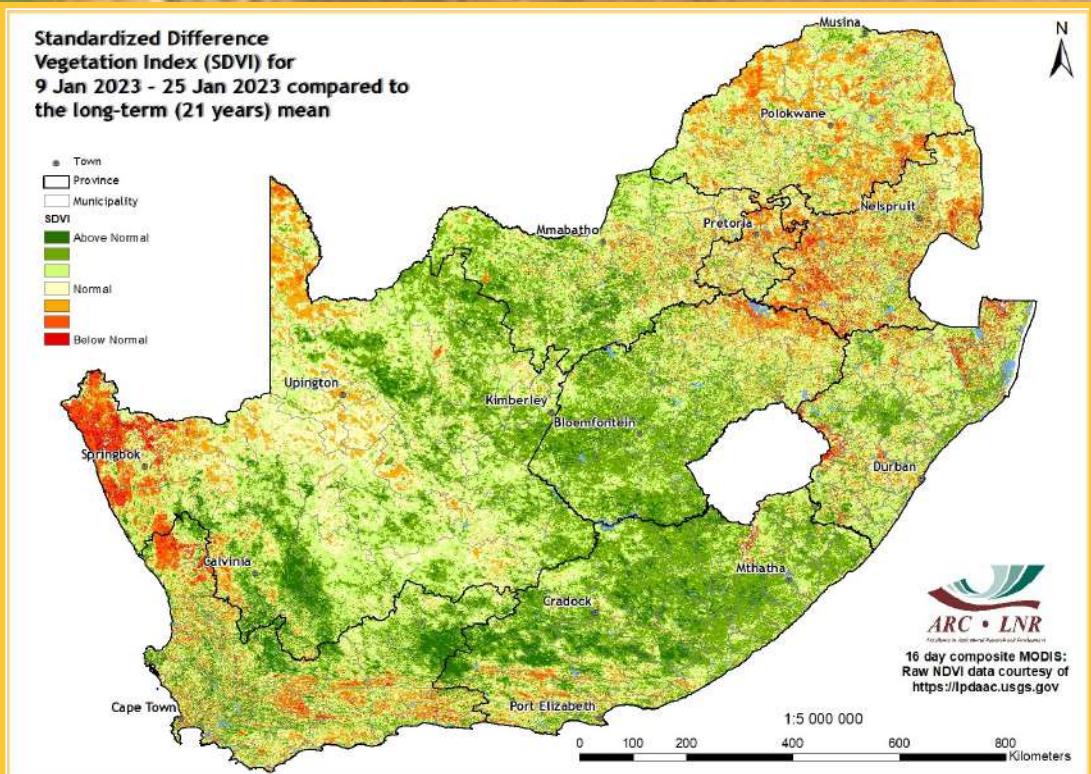


Figure 10

**Figure 10:**

Compared to the historical averaged vegetation conditions, the 16-day SDVI map for January 2023 shows that areas of poor vegetation activity were restricted to the periphery and the northeastern parts of the country.

**Figure 11:**

The 16-day NDVI difference map for January 2023 compared to the preceding 16-day period shows patches of poor vegetation conditions over the northeastern parts and above-normal conditions over the central interior of the country.

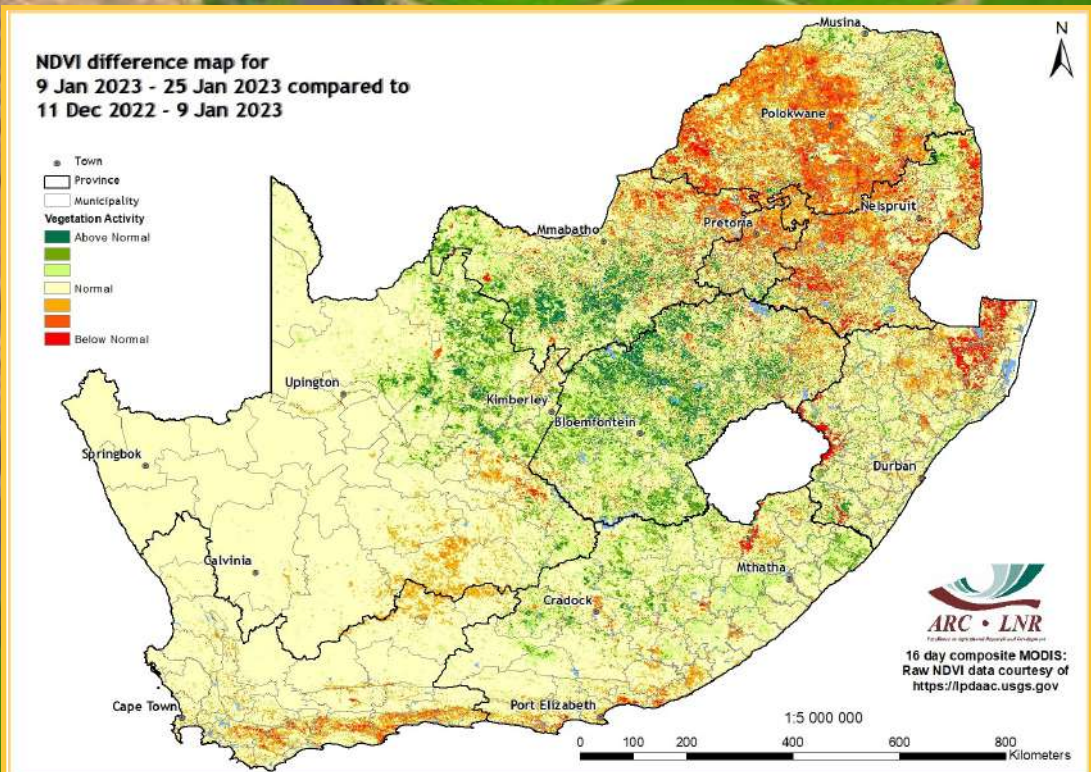


Figure 11

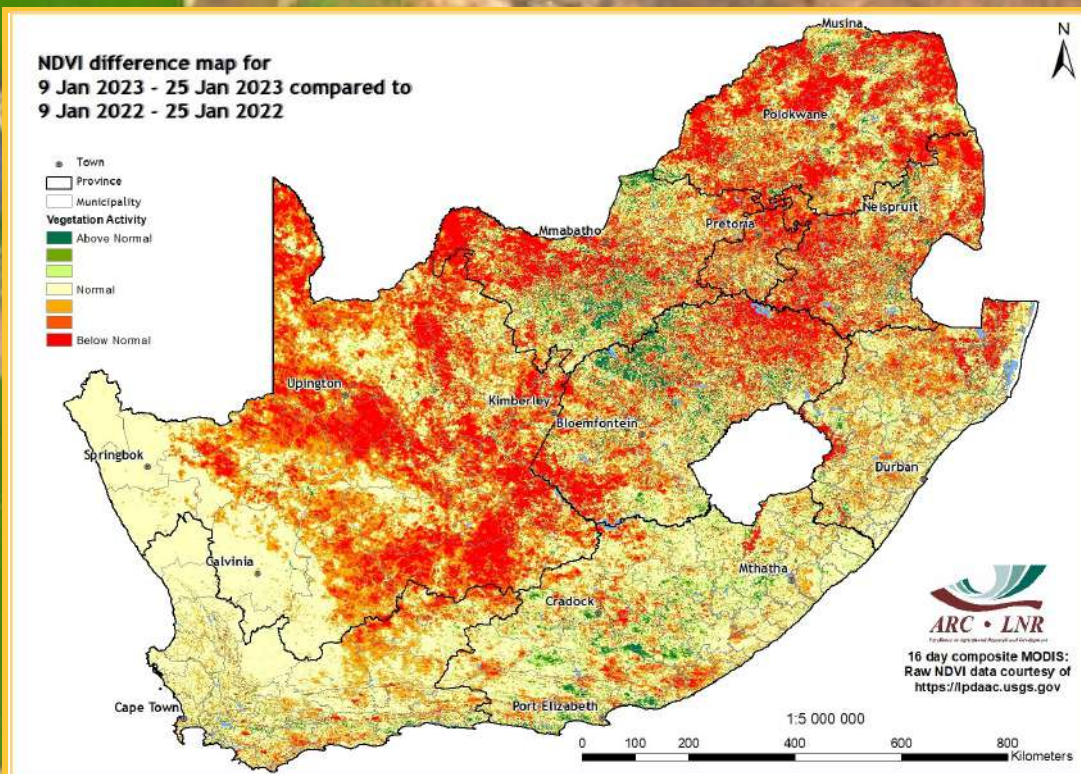


Figure 12

**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
- Summer:** July to June

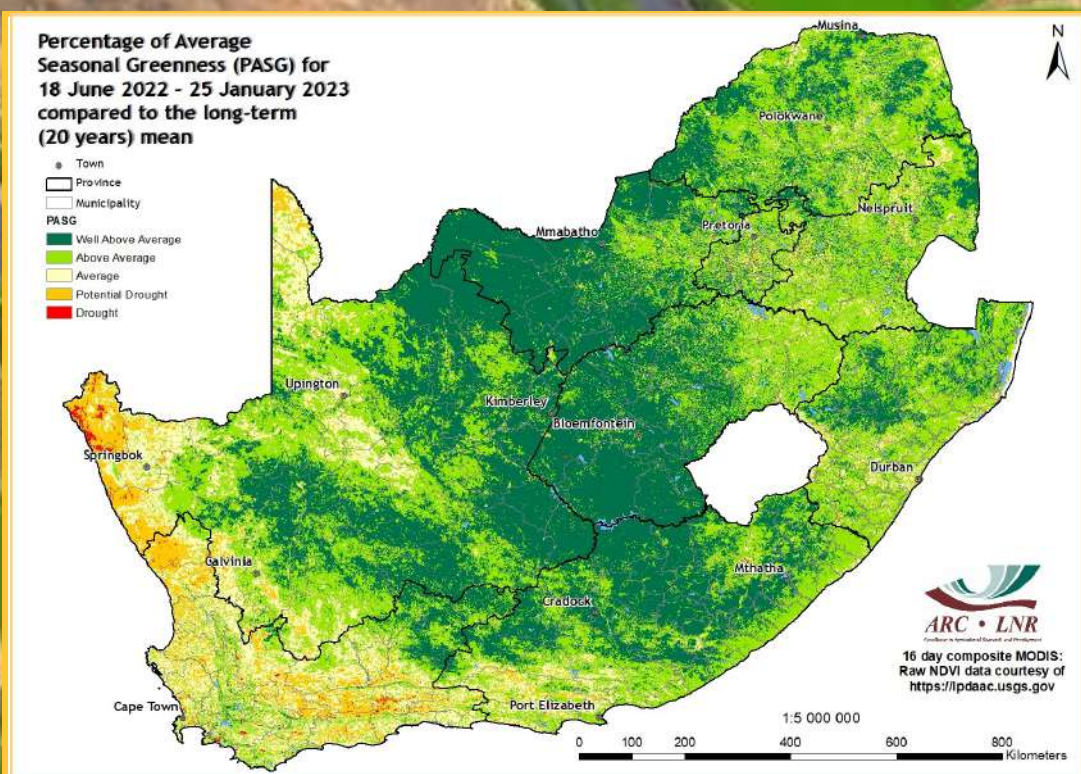


Figure 13

**Figure 12:**

The 16-day NDVI difference map for January 2023 compared to the same period last year shows patches of poor vegetation conditions in many areas of the country.

**Figure 13:**

The Percentage of Average Seasonal Greenness (PASG) map for the past 7 months, compared to the long-term mean, shows high levels of seasonal vegetation greenness in the central, eastern and northern parts of the country, while potential drought conditions persist in the far western parts.

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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.

Vegetation Condition Index (VCI) for 9 Jan 2023 - 25 Jan 2023 compared to the long-term (21 years) mean

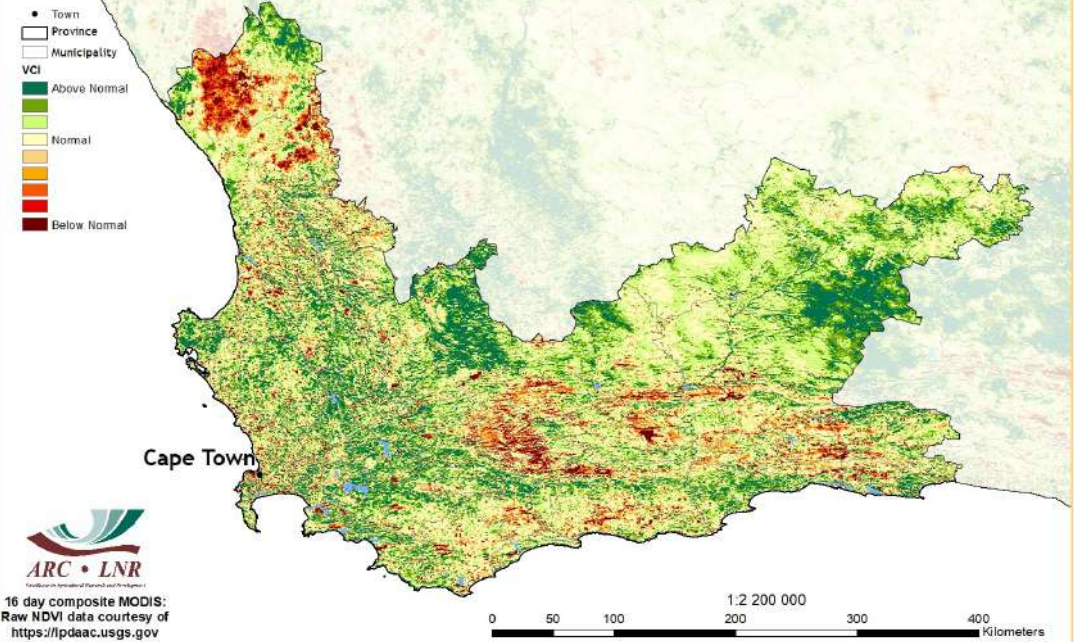


Figure 14

Figure 14:

The 16-day VCI map for January 2023 indicates that near- to below-normal vegetation conditions are prevalent throughout the Western Cape, with good vegetation activity in some areas.

Figure 15:

The 16-day VCI map for January 2023 indicates that most parts of the Northern Cape continued to experience improved vegetation conditions, except for the far western and northern parts, which are still experiencing drought conditions.

Vegetation Condition Index (VCI) for 9 Jan 2023 - 25 Jan 2023 compared to the long-term (21 years) mean

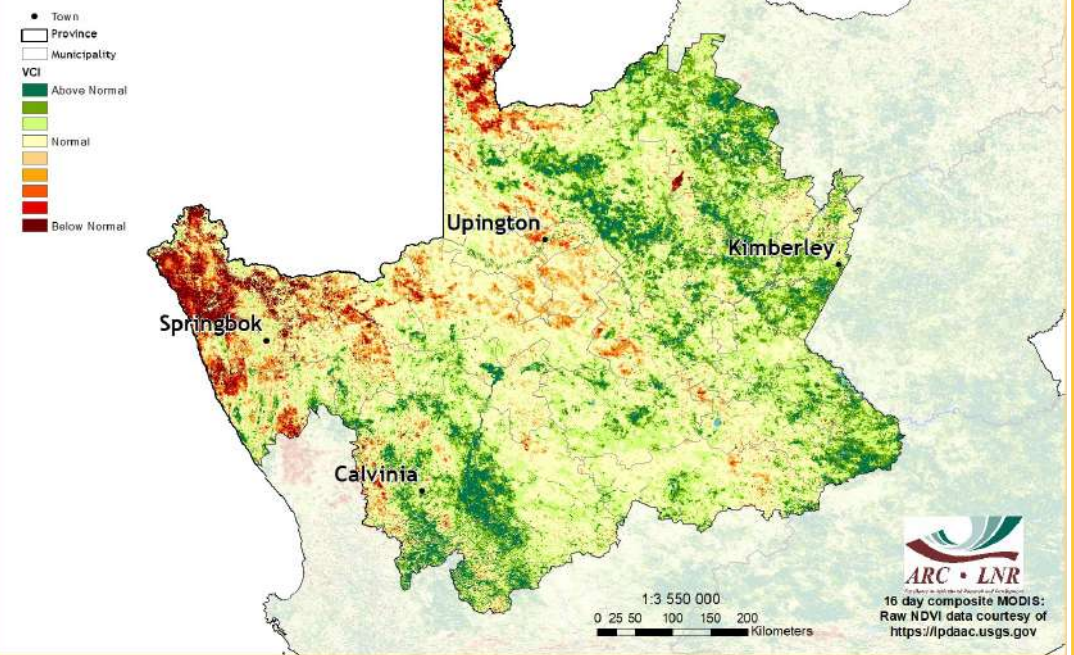


Figure 15

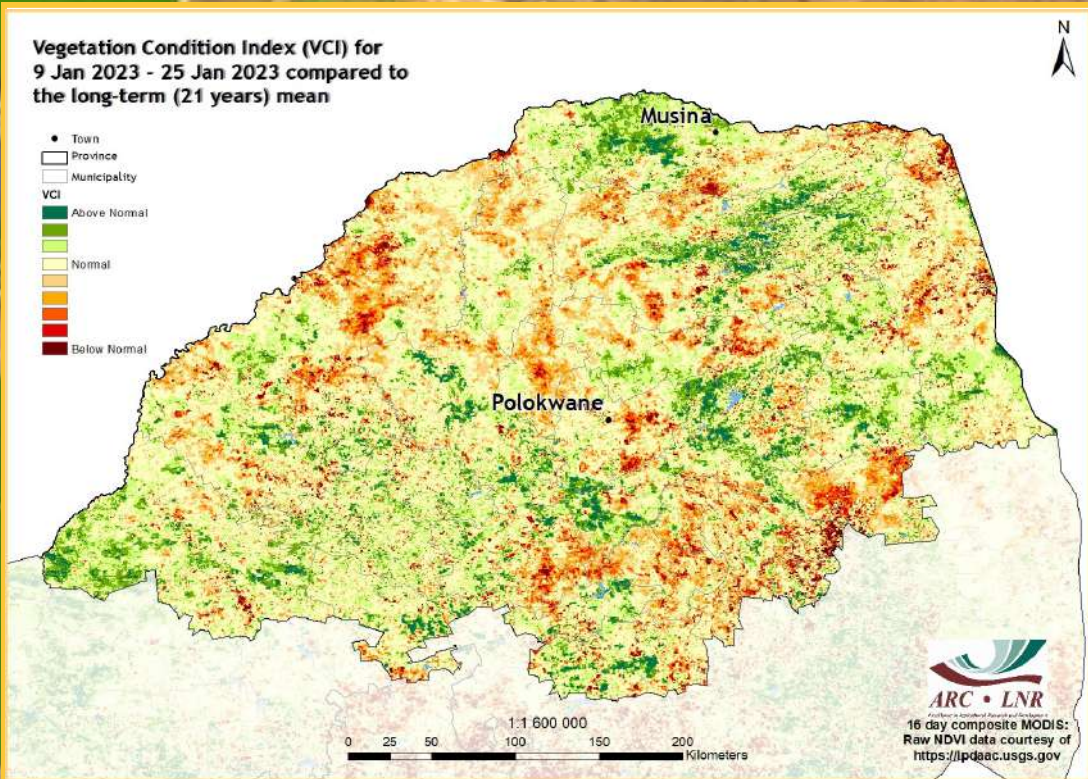


Figure 16

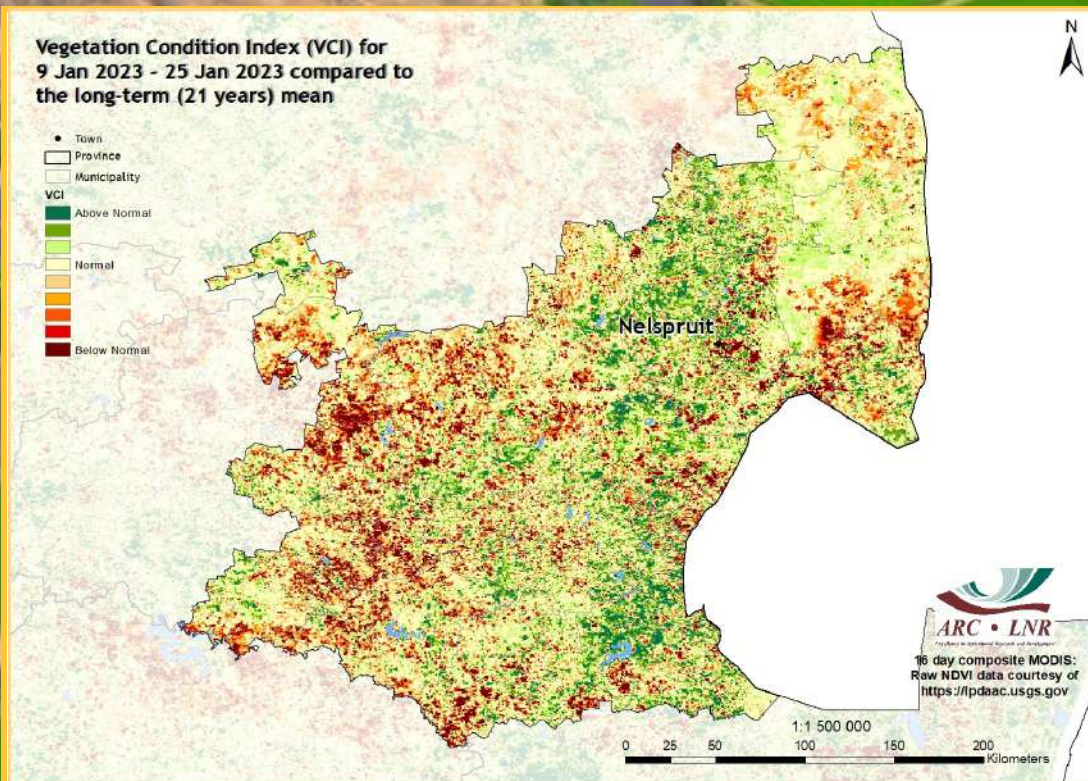


Figure 17

**Figure 16:**

The 16-day VCI map for January 2023 indicates a mixture of above-normal, near-normal and below-normal vegetation activity throughout Limpopo.

**Figure 17:**

The 16-day VCI map for January 2023 indicates a mixture of above-normal, near-normal and below-normal vegetation activity throughout Mpumalanga.

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# 6. Vegetation Conditions & Rainfall

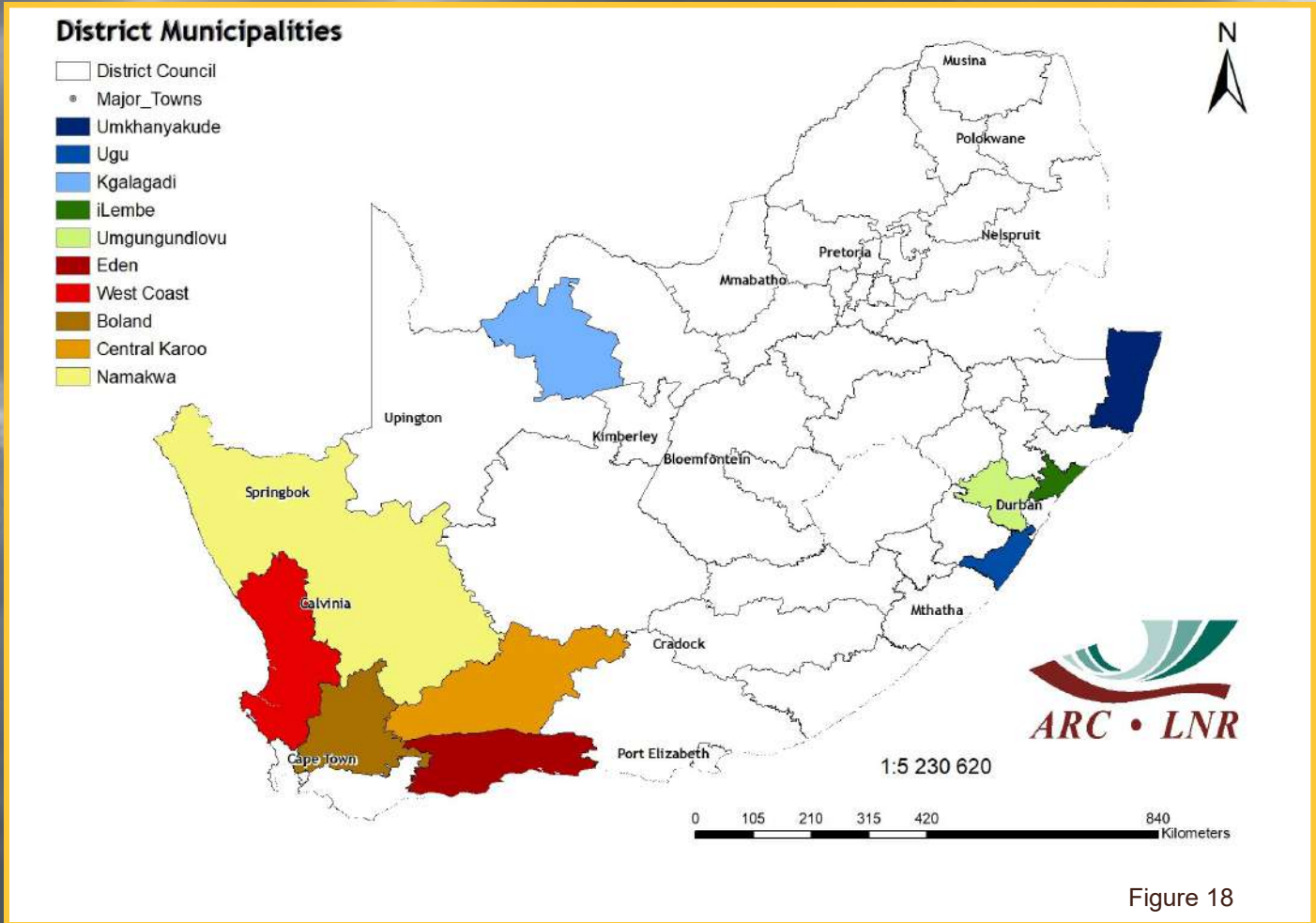


Figure 18

## Rainfall and NDVI Graphs

**Figure 18:** Orientation map showing the areas of interest for January 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.

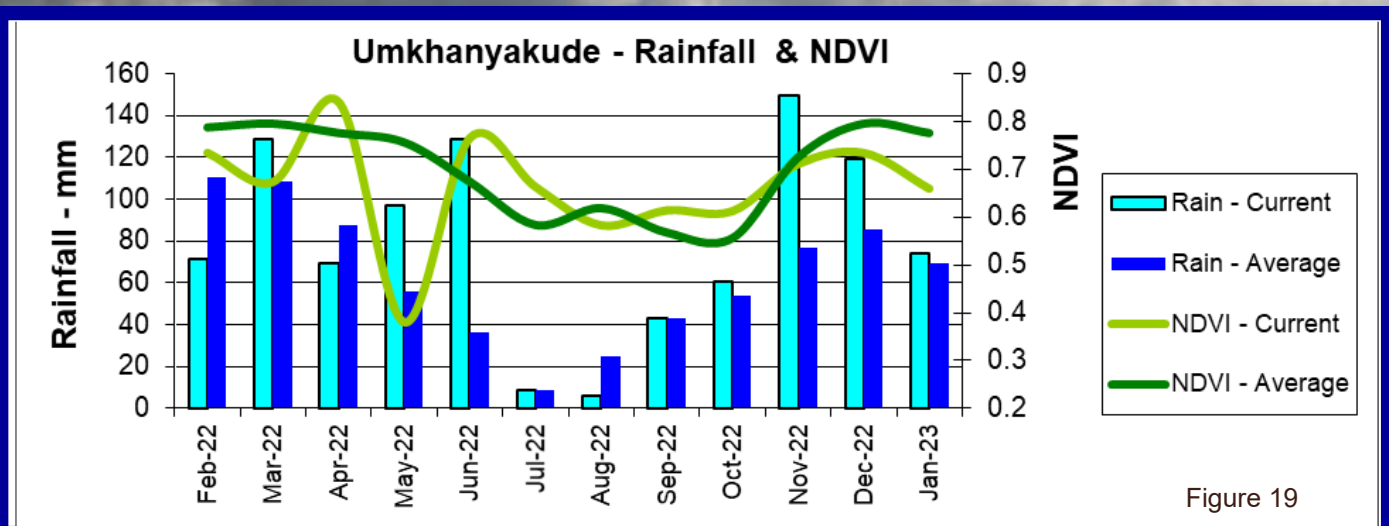


Figure 19

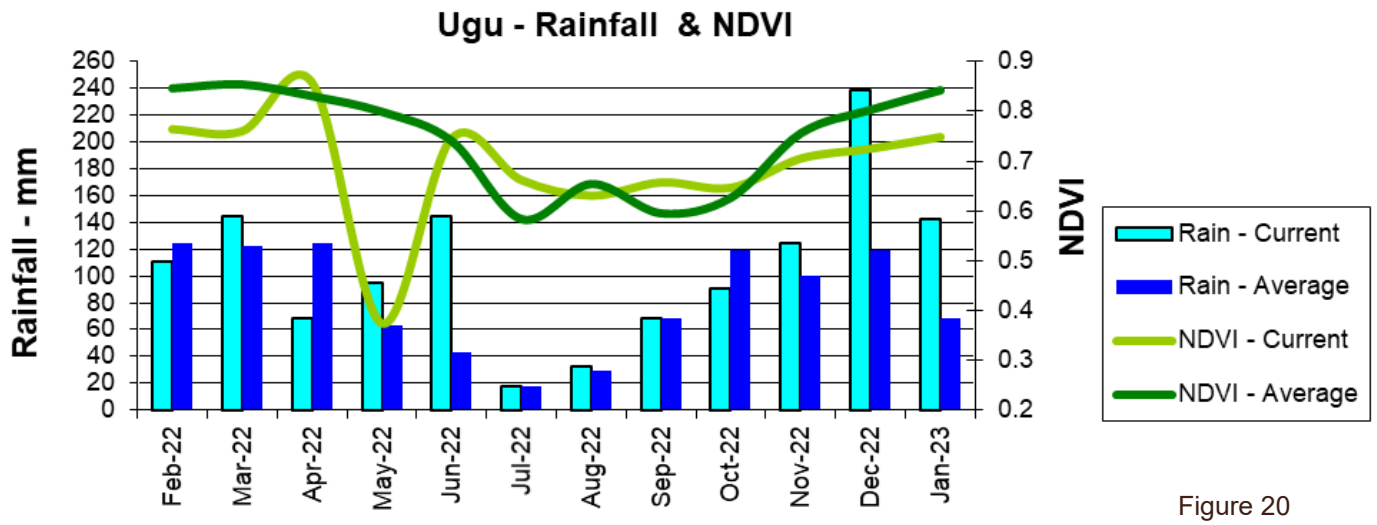


Figure 20

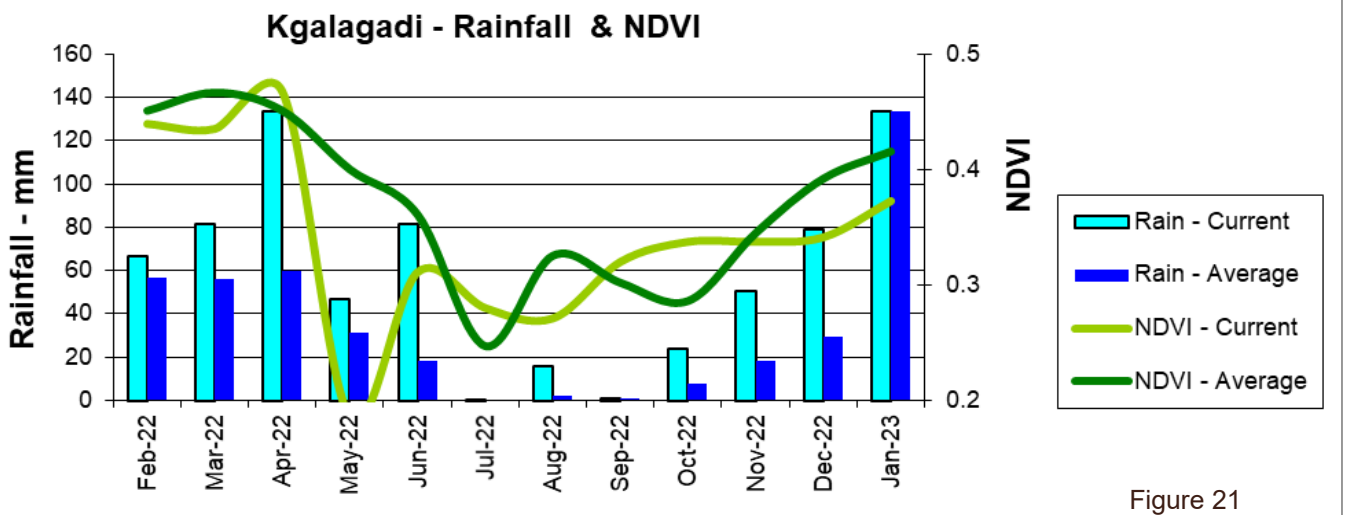


Figure 21

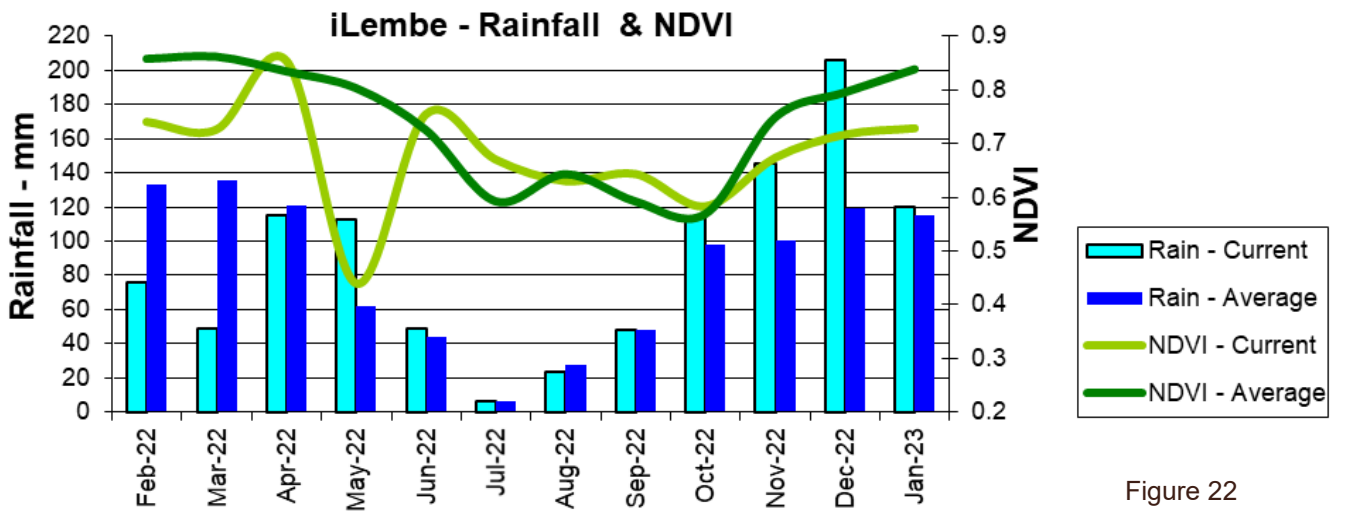


Figure 22

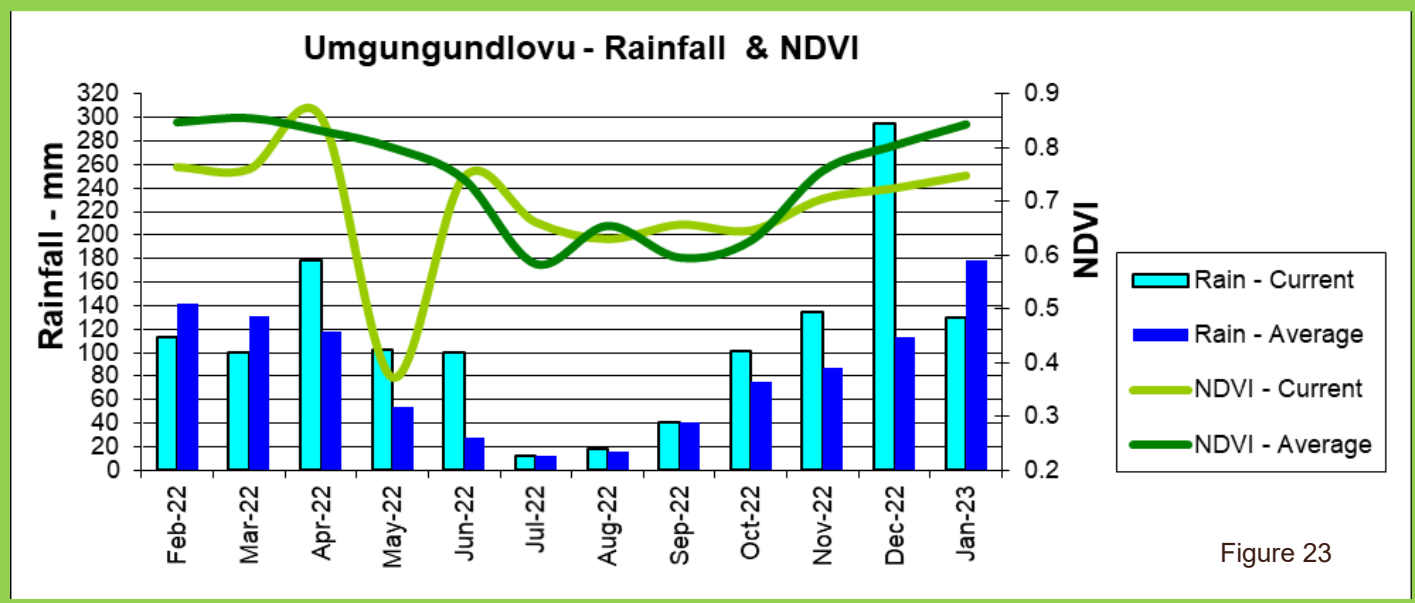


Figure 23

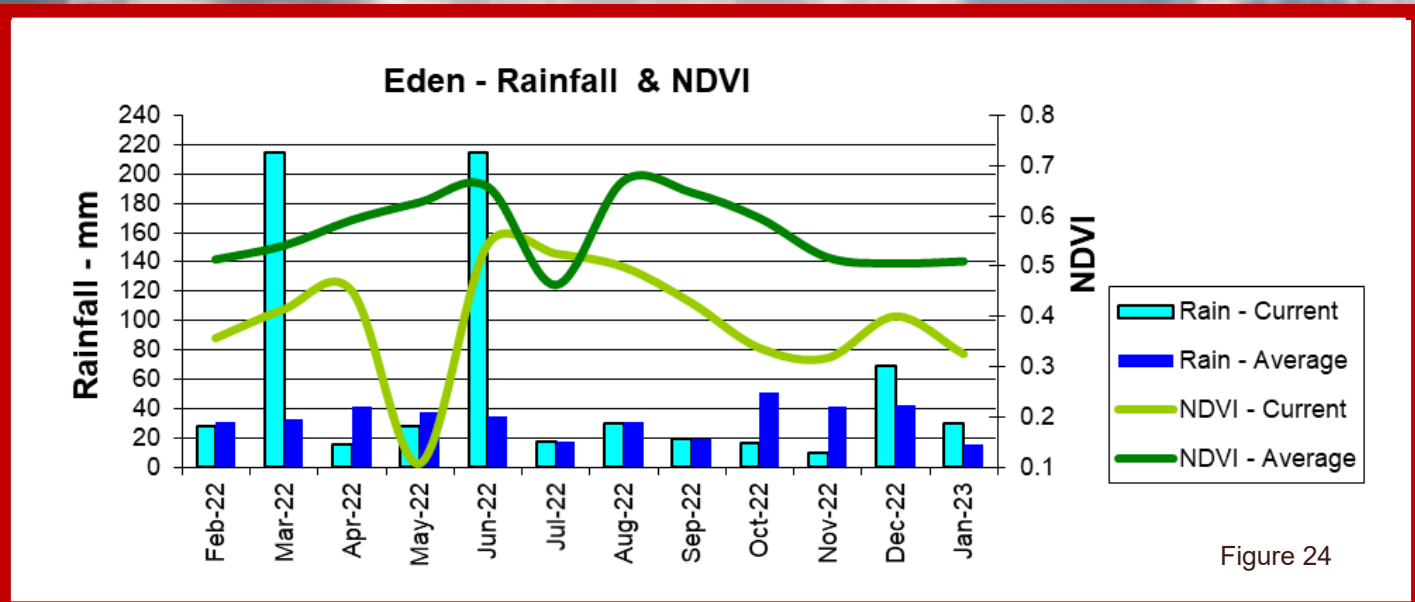


Figure 24

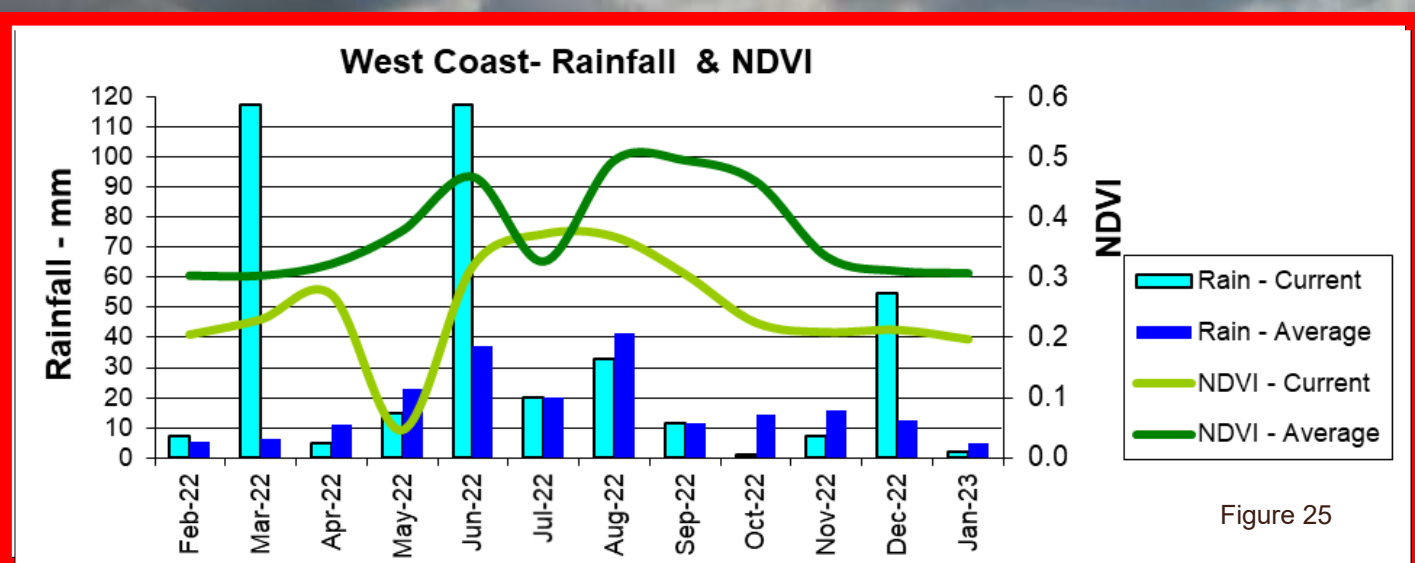
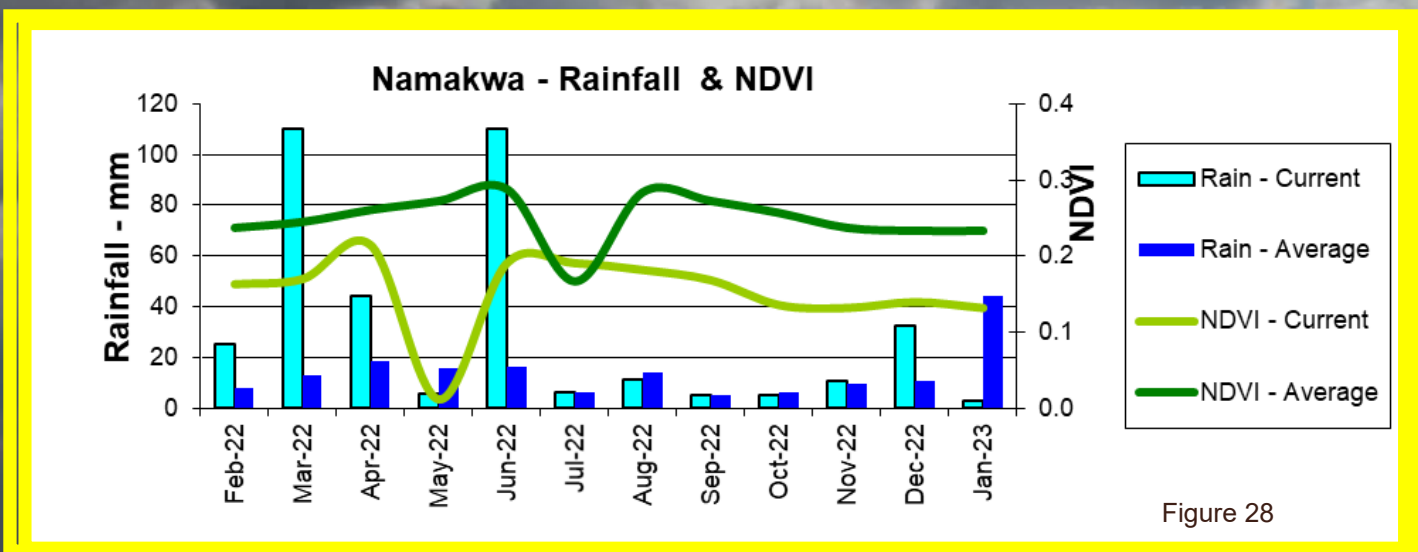
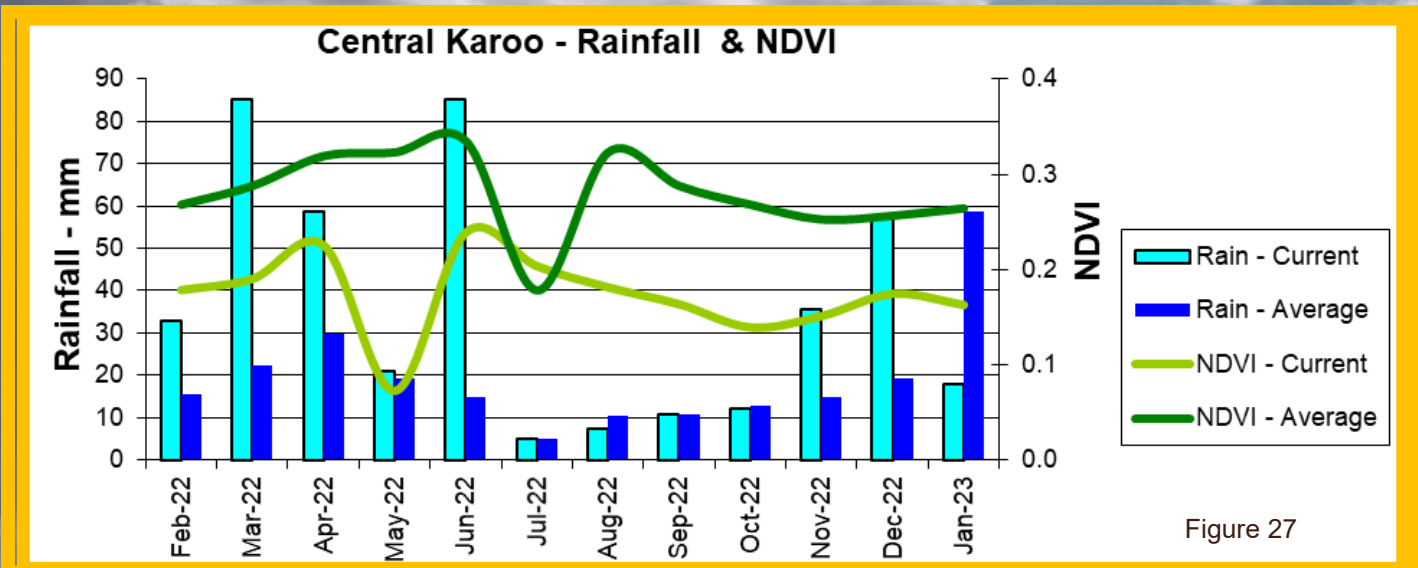
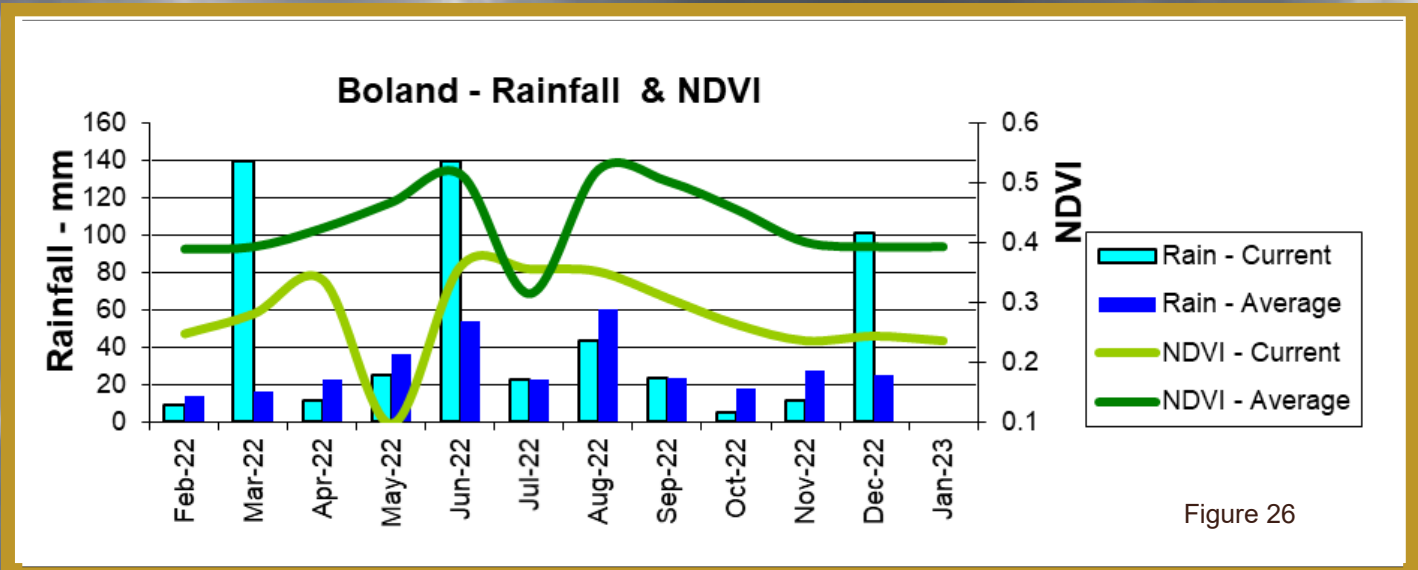


Figure 25



# 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  $\mu\text{m}$ . For an ambient temperature of 290 K, the peak of radiance emission is located at approximately 11  $\mu\text{m}$ . 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 1 January to 2 February 2023 per province. Fire activity was higher in Gauteng, the Northern Cape, Limpopo, North West and KwaZulu-Natal compared to the long-term average.

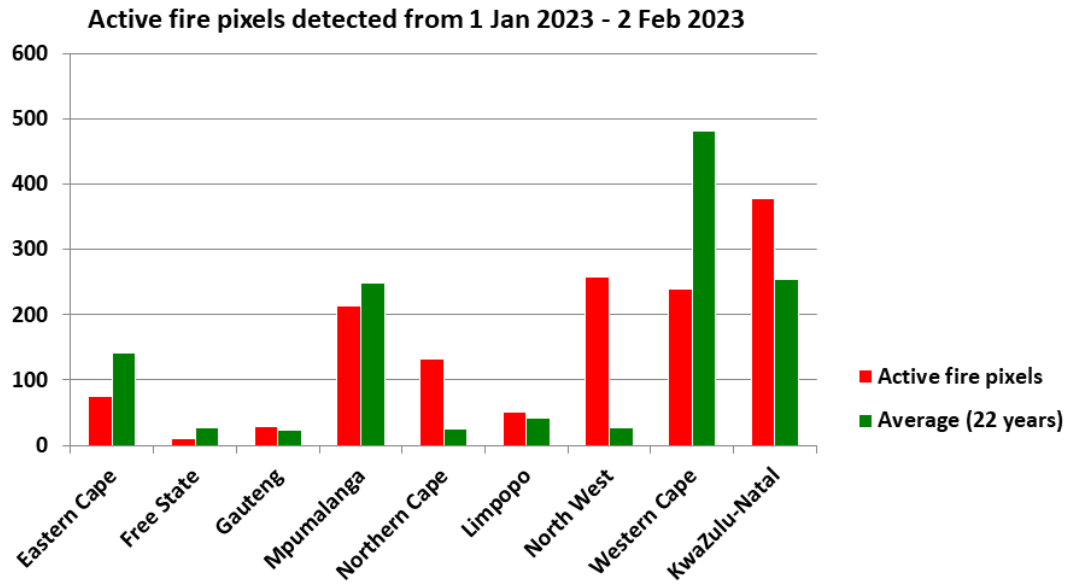


Figure 29

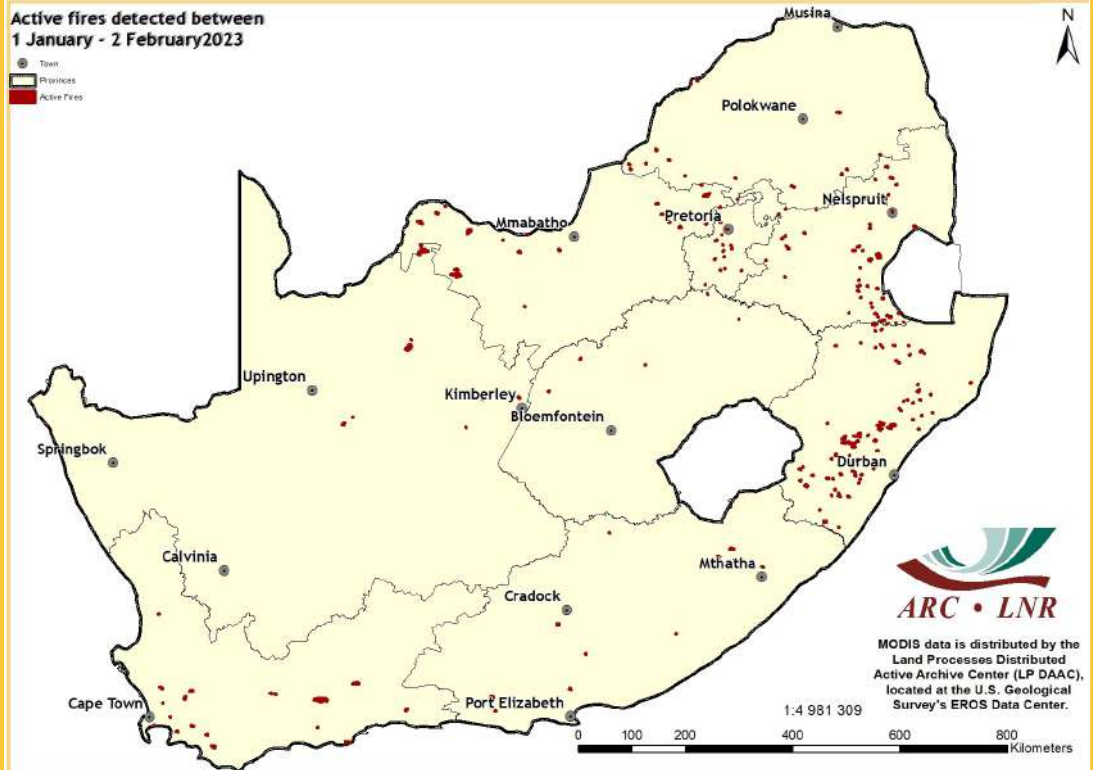


Figure 30

### Figure 30:

The map shows the location of active fires detected between 1 January and 2 February 2023.

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 31 represents a comparison between the area of water available now and the maximum area of surface water recorded in the last 6 years. This 6-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 months total surface water is less than the maximum extent recorded for the same area since the end of 2015.

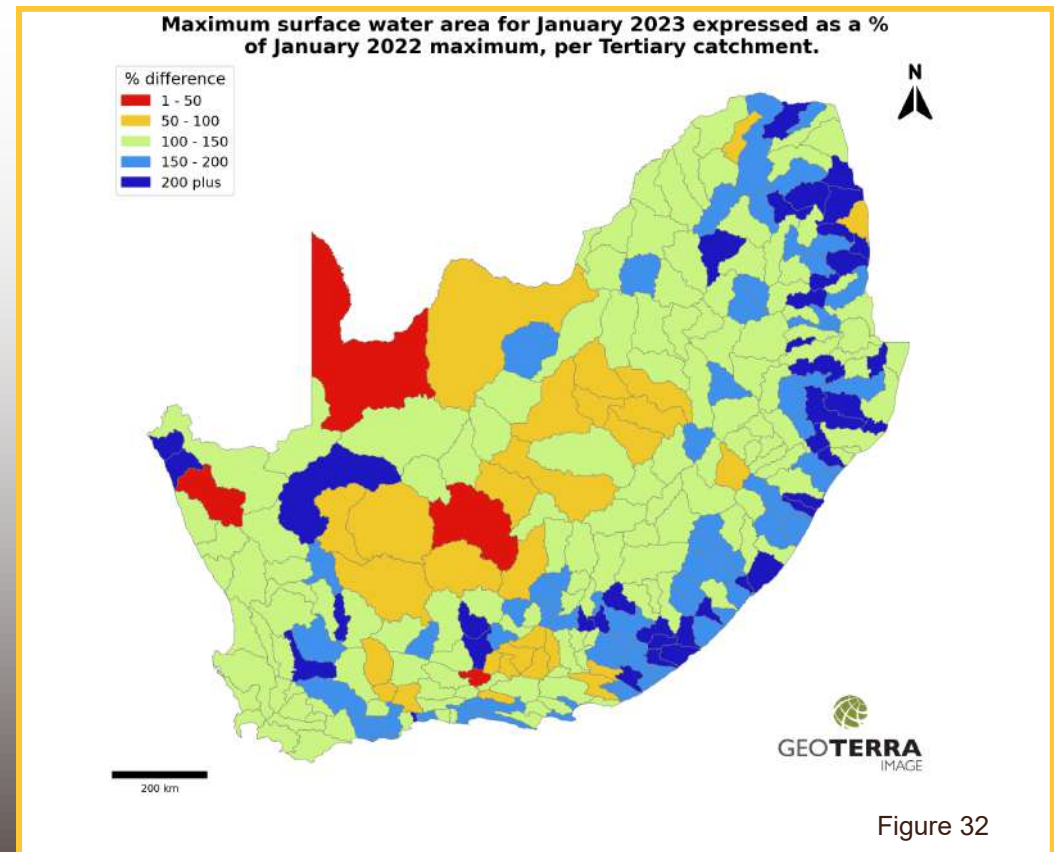
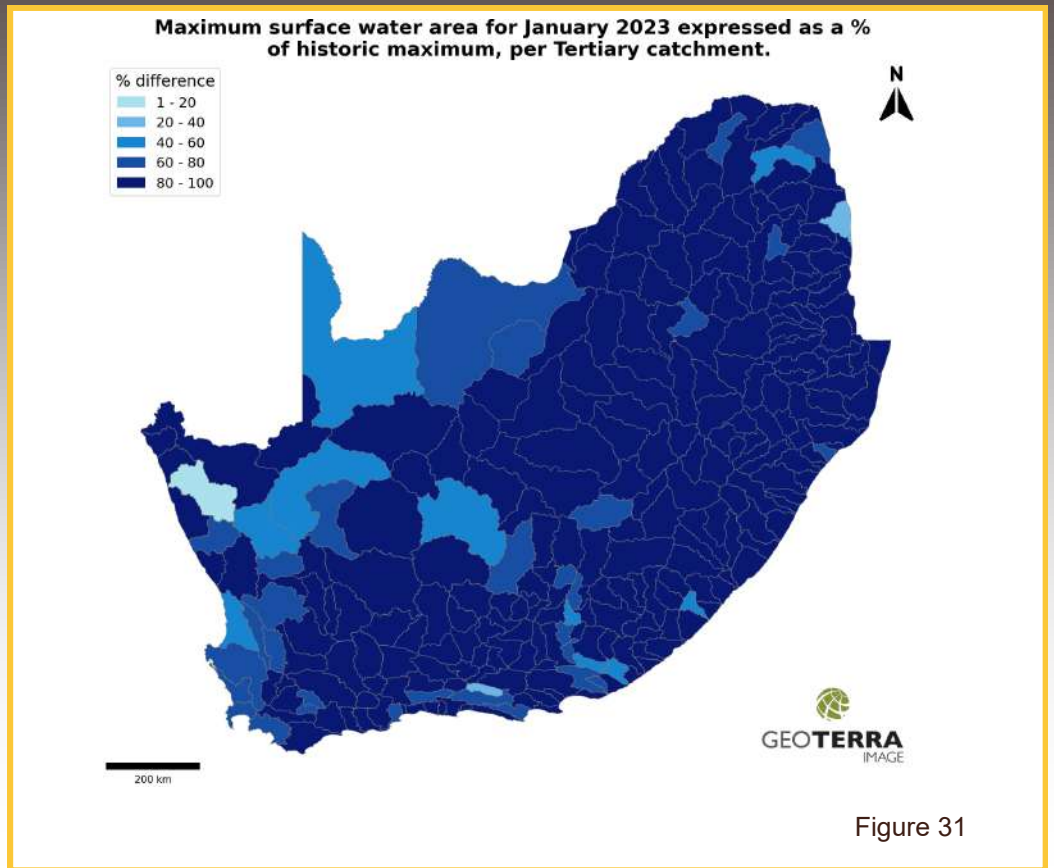
Figure 32 represents a comparison between the area of surface water now and for the same month last year. In this map, any value less than 100 represents water catchments within which the current months total surface water is less than that recorded in the same water catchment, in the same month, last year.

The long-term map for January 2023 shows a near identical distribution pattern to the previous month. This continues to illustrate the significant impact of the high rainfall experienced over most of the country during the past year. The majority of Tertiary catchments continue to show water levels equivalent to 80-100% of the 6-year, long-term maximum water, similar to the previous 2022 long-term maps.

The comparison between January 2023 and January 2022 indicates that the majority of inland catchments across the country are now deviating from the pattern shown in the previous month by showing a significant decrease in water levels.

*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>*

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## 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

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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



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SOIL, CLIMATE AND WATER



# 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**  
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**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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## SOIL, CLIMATE AND WATER



# 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**

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***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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# 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<sup>2</sup> to 1 km<sup>2</sup>) 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>

## VG4AFRICA 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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**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.