

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

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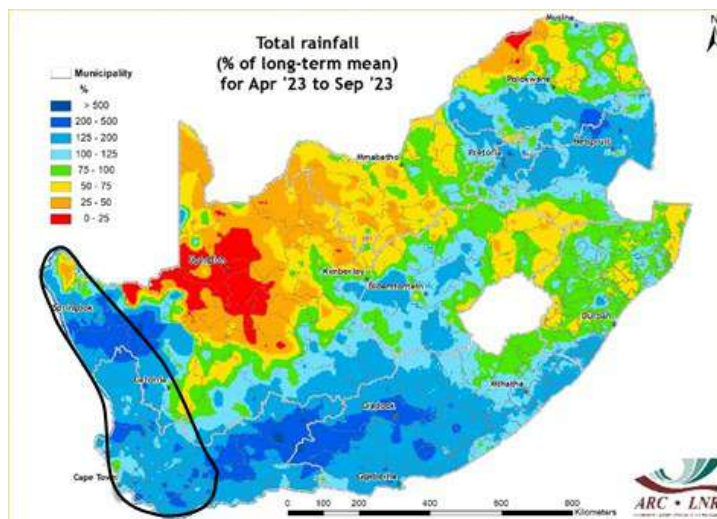
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## Images of the Month

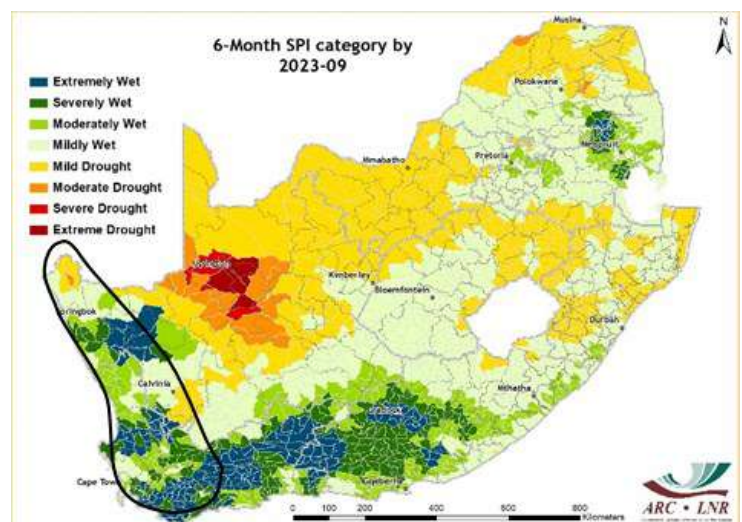
### Winter 2023 characterized by favourable rainfall conditions

The rainfall observed in May 2023 clearly marked the beginning of the winter rainfall season. Subsequently, the winter rainfall region has consistently experienced a series of favourable weather conditions due to the recurrent passage of numerous cold fronts across the south-western parts of the country.

This meteorological pattern persisted throughout the month of September, as demonstrated by the rainfall map for April-September 2023, expressed as a percentage of the long-term average.



Similarly, the 6-month Standardized Precipitation Index (SPI) map, ending in September, depicts widespread wet conditions. Areas such as the southern regions of the West Coast, the adjacent Winelands and the Overberg district are experiencing severe to extremely wet conditions. This bodes well for the performance of winter crops, which should yield favourable outcomes. Furthermore, livestock farmers can also look forward to the benefits of increased dam levels and improved soil moisture contents, which will result in higher pasture yields.



## Overview:

Following the substantial rainfall in parts of the winter rainfall region in August, September 2023 produced similar conditions, but with a notable improvement in rainfall over the summer rainfall region. These early spring rains led to above-normal conditions in the southern interior, extending towards the Karoo and parts of the Eastern Cape. Coastal areas of the Eastern Cape and KwaZulu-Natal received totals ranging from 50-150 mm and moving further north, the Lowveld regions of Limpopo and Mpumalanga, as well as Gauteng, also experienced similar conditions. For instance, the Vhembe district in Limpopo and the Ehlanzeni district in Mpumalanga received up to 50 mm of rainfall, exceeding 125% of their typical September totals. In contrast, central areas of the Northern Cape, neighbouring North West and the Free State, as well as the western parts of Limpopo, remained relatively dry during this period. However, it is worth noting that rainfall over the summer rainfall region should start to increase from October 2023.

# 1. Rainfall

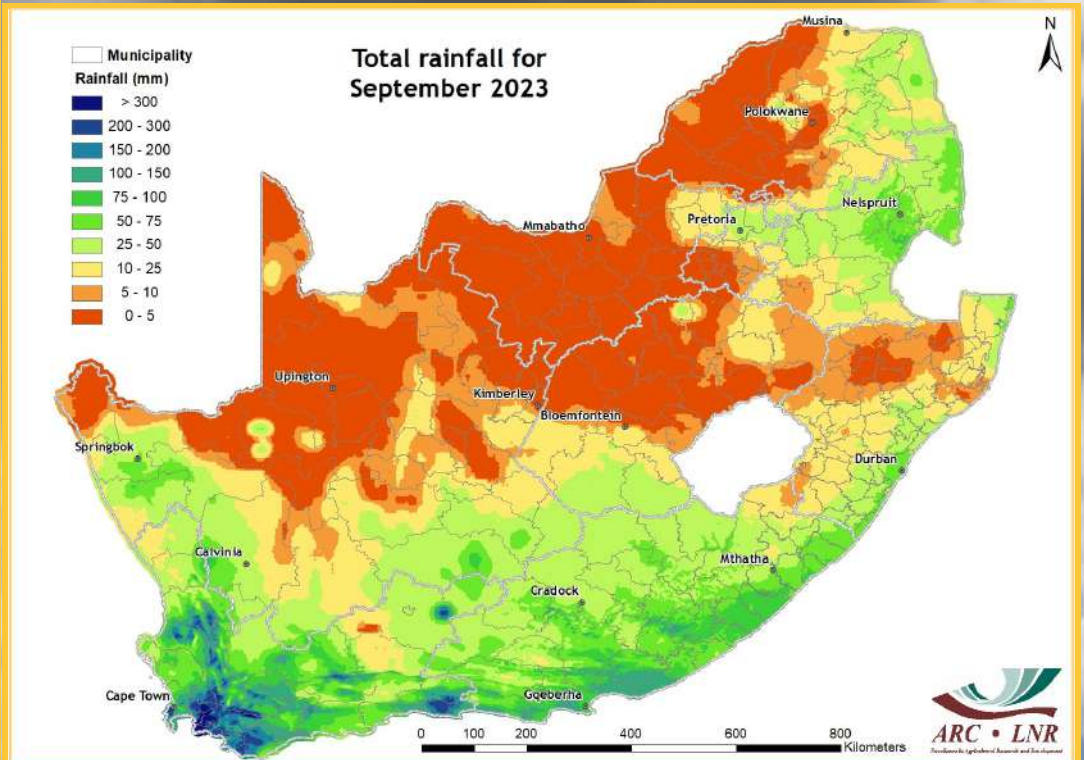


Figure 1

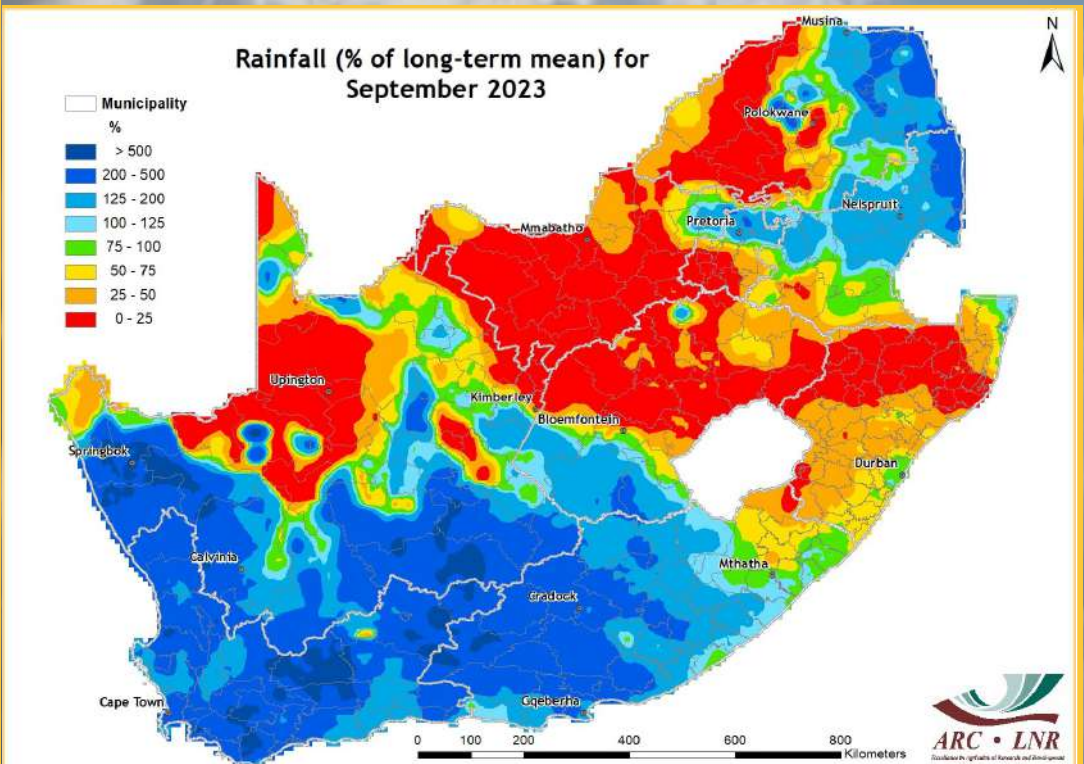


Figure 2

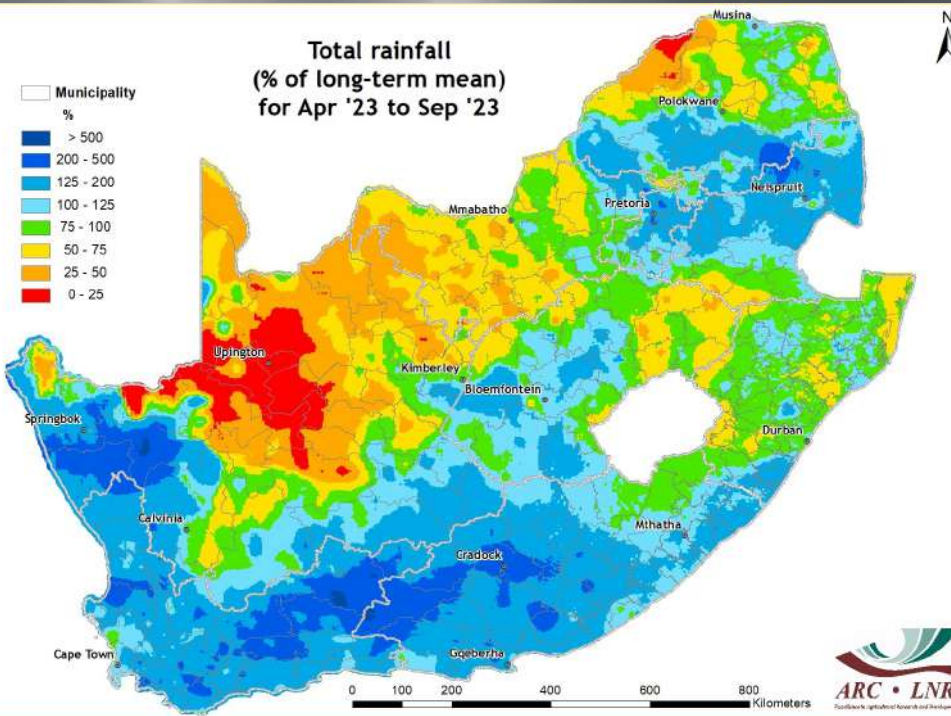


Figure 3

**Figure 1:**

Rainfall during September 2023 occurred strongly over the winter rainfall region, as well as parts of the summer rainfall region, including the southern interior, towards KwaZulu-Natal, Mpumalanga, Gauteng and Limpopo.

**Figure 2:**

Above-normal rainfall was experienced over the winter rainfall region and adjacent areas in the Western Cape, Eastern Cape and southern parts of the Northern Cape in September. Similar conditions were observed in the summer rainfall region, including parts of Limpopo, Mpumalanga and Gauteng. However, the rainfall received in KZN resulted in below-normal conditions during this period.

**Figure 3:**

Between April and September 2023, greater parts of the country experienced near- to above-normal rainfall, with below-normal conditions observed over the Northern Cape.

**Figure 4:**

A comparison between July-September 2023 and the same period last year shows that most regions received comparable amounts of rainfall. The winter and all-year rainfall regions received more rain while parts of the Eastern Cape received less rain.

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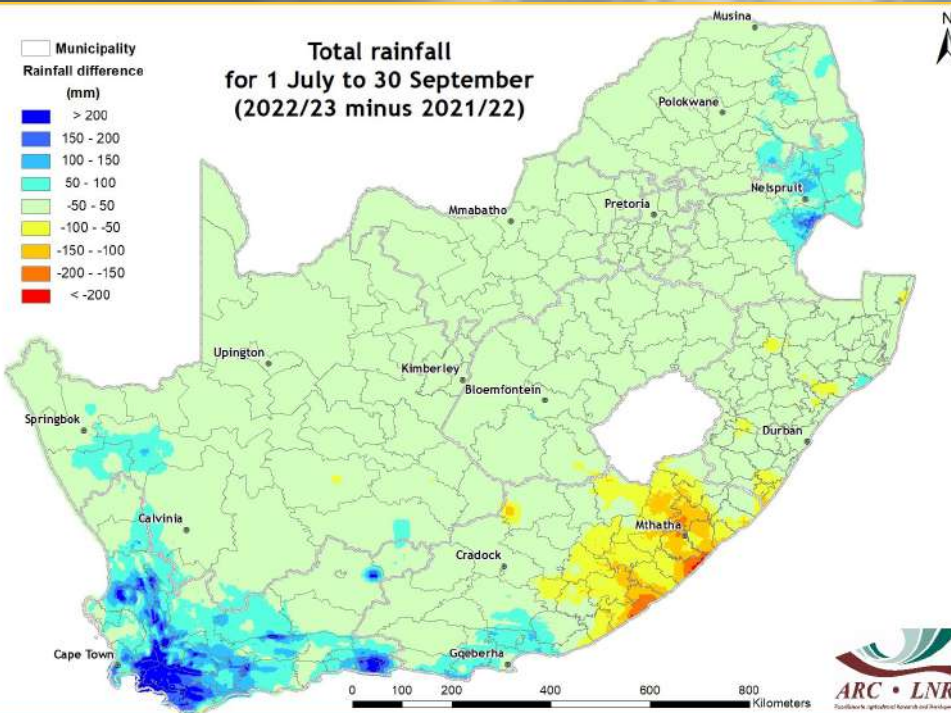


Figure 4

## 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 September 2023 are shown in Figures 5-8. The short-term SPI map indicates predominantly mild to moderate drought over greater parts of the summer rainfall region, while moderate to extremely wet conditions can be noted over the Western Cape, adjacent Eastern Cape, and some parts of Mpumalanga. At this time scale, moderate to severe drought can be noted over some parts of the Northern Cape. Meanwhile, the medium and long-term SPI maps indicate near-normal and wet conditions, respectively, over greater parts of the country.

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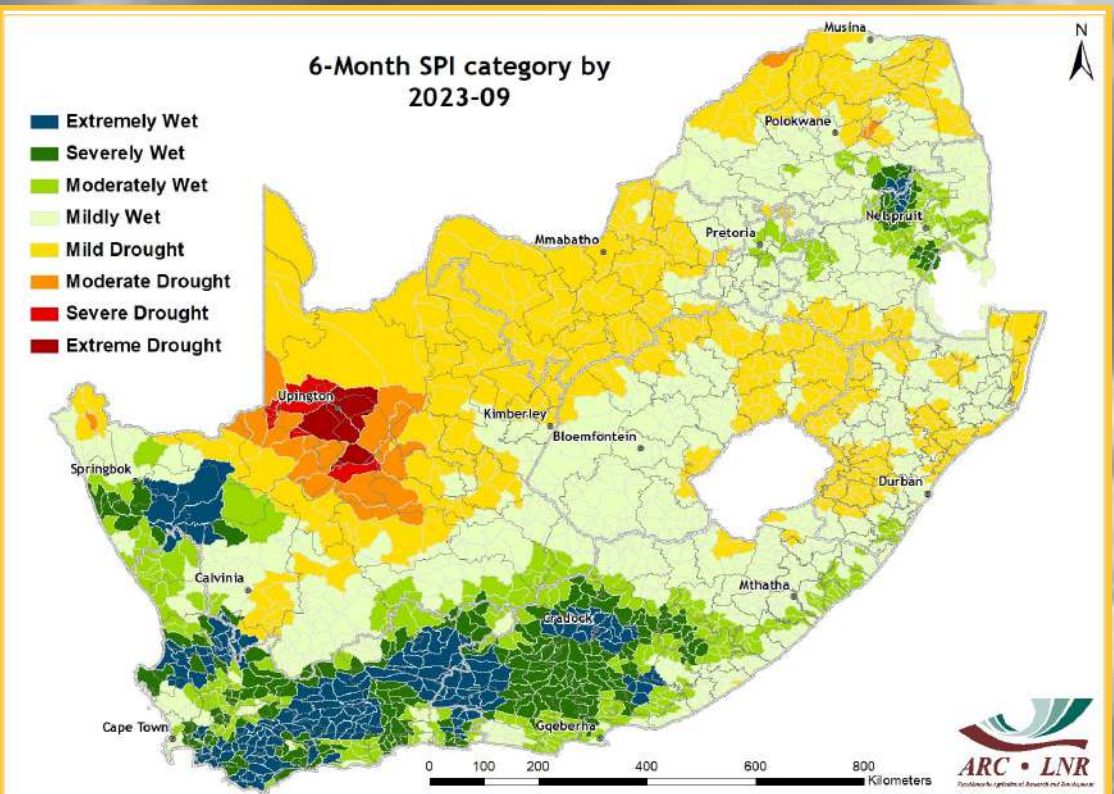


Figure 5

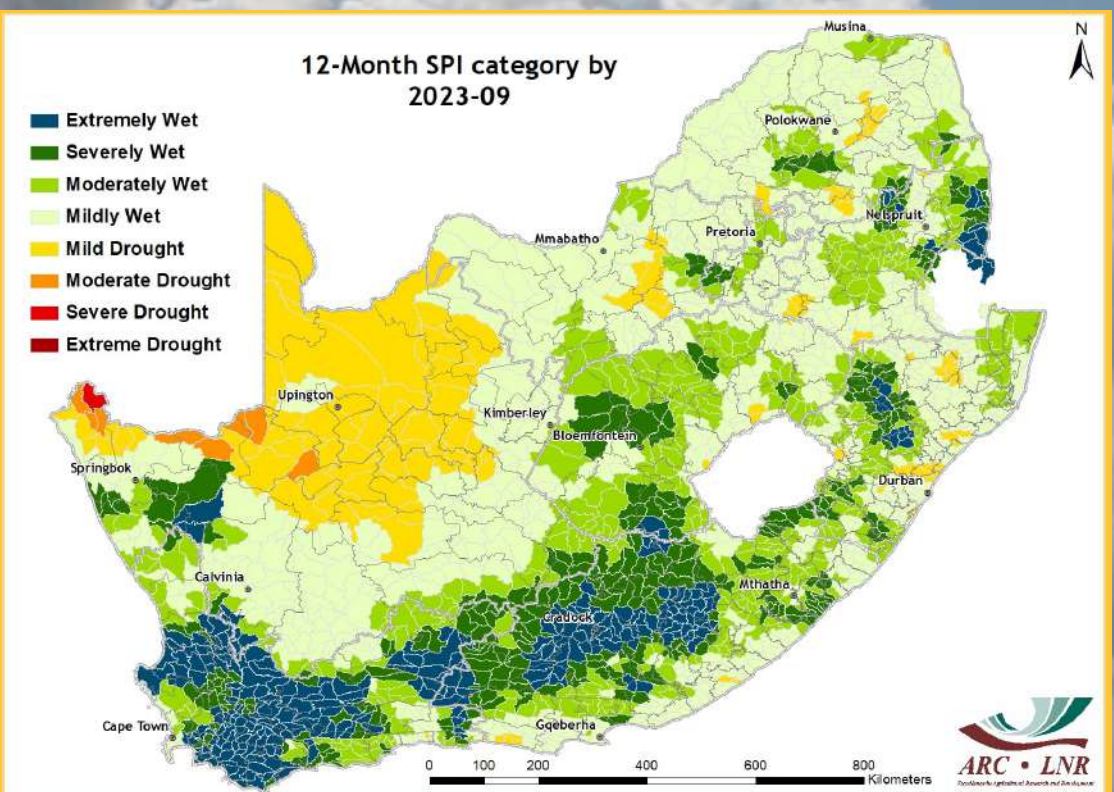


Figure 6

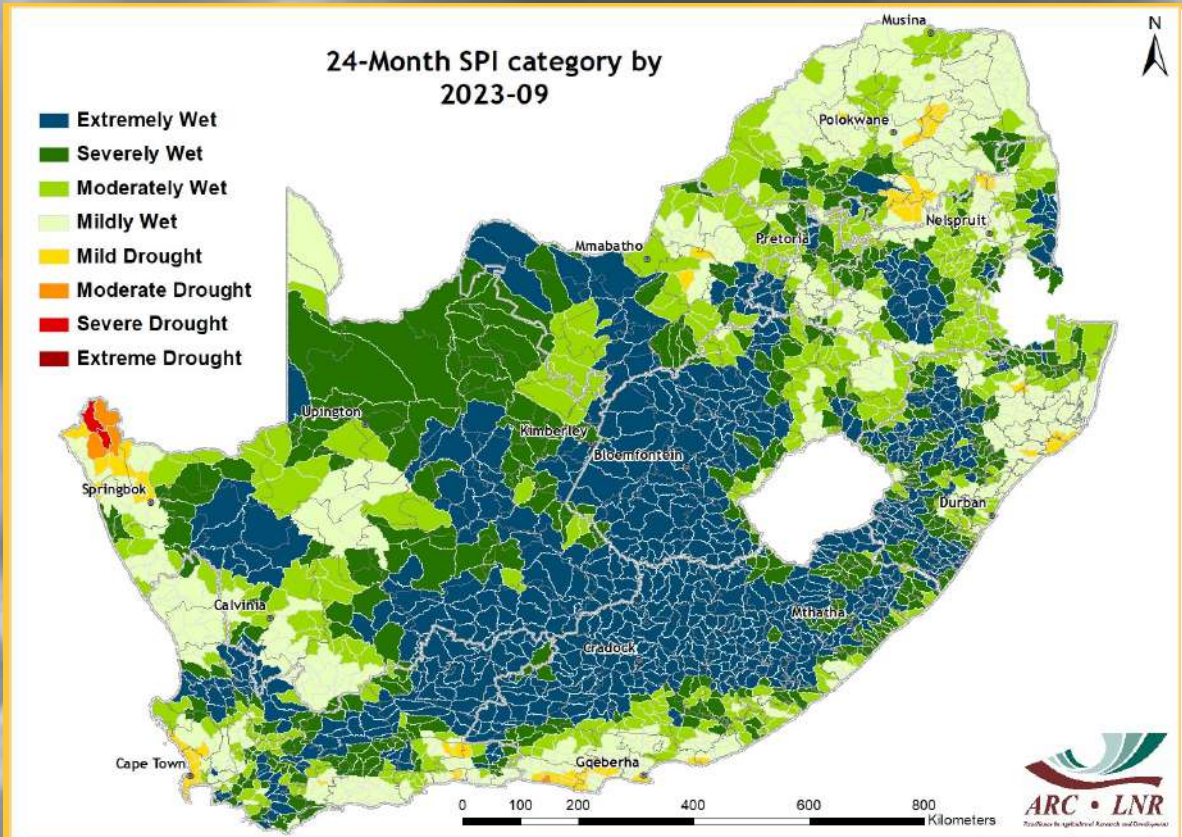


Figure 7

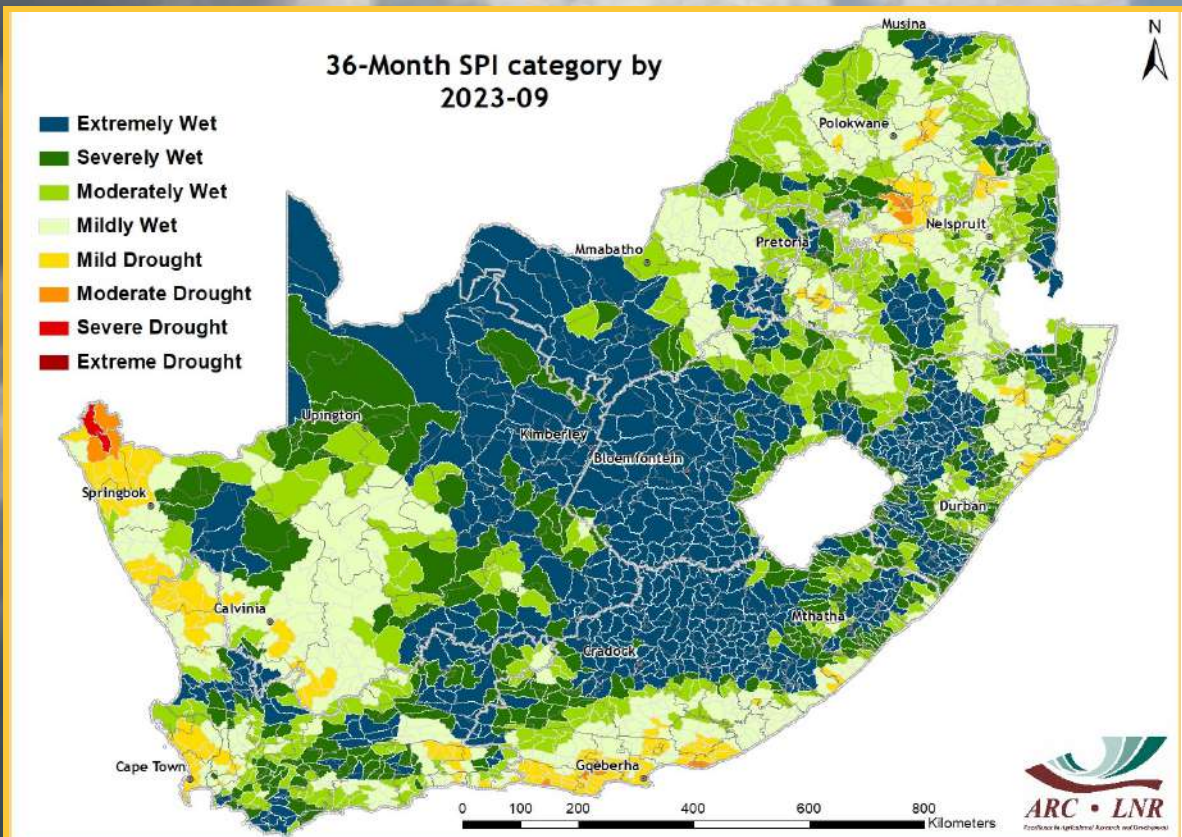


Figure 8

# 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.

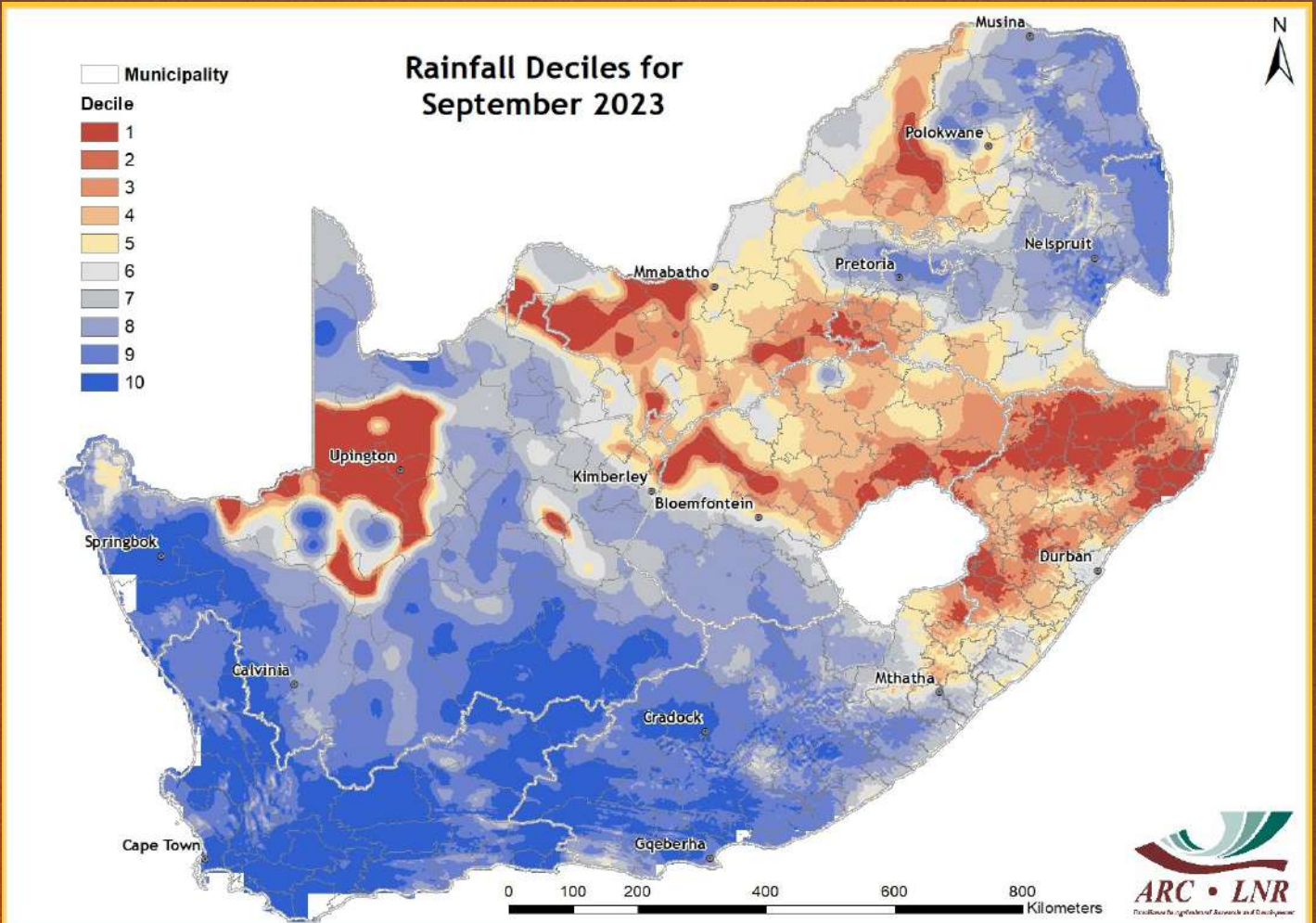


Figure 9

### Figure 9:

In September 2023 greater parts of the western half of the country as well as parts of Limpopo, Mpumalanga and Gauteng received rainfall totals that compare well with historically wetter September months, while the rest of the country remained 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

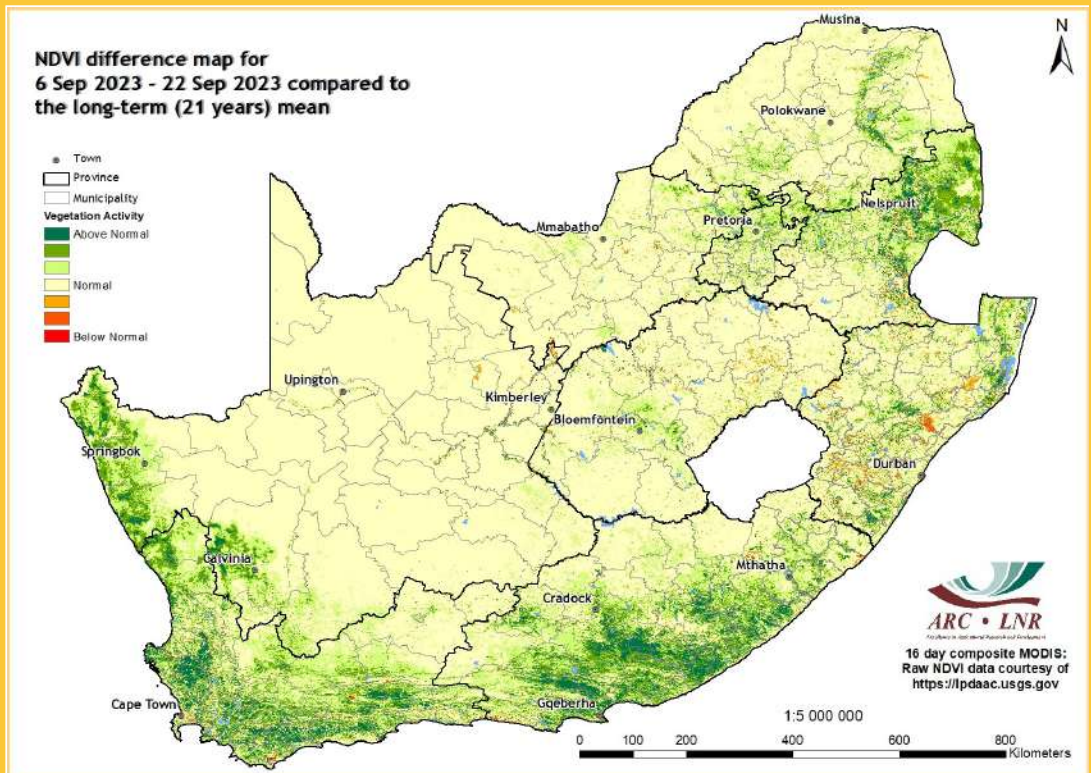


Figure 10

Figure 10:

Compared to the historical averaged vegetation conditions, the 16-day NDVI map for September 2023 shows that many parts of the country continue to experience normal to above-normal vegetation activity.

Figure 11:

The 16-day NDVI difference map for September 2023 compared to the preceding 16-day period shows that many parts of the country continue to experience normal vegetation activity with patches of below-normal activity in isolated areas.

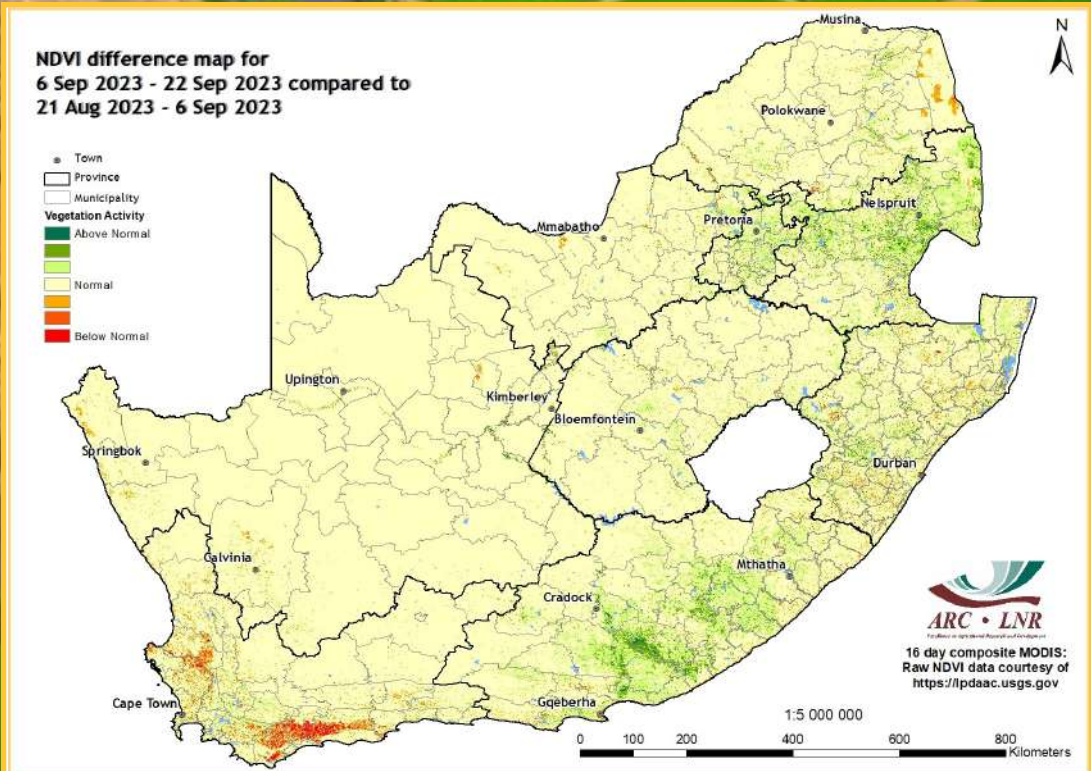


Figure 11

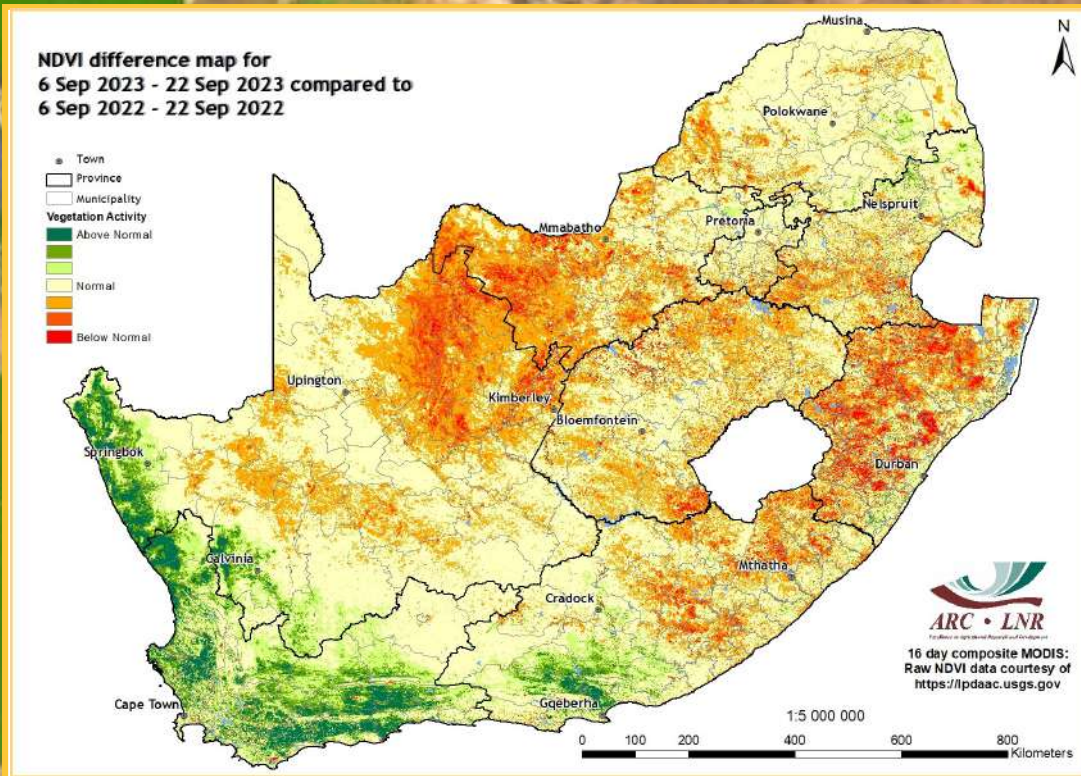


Figure 12

**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

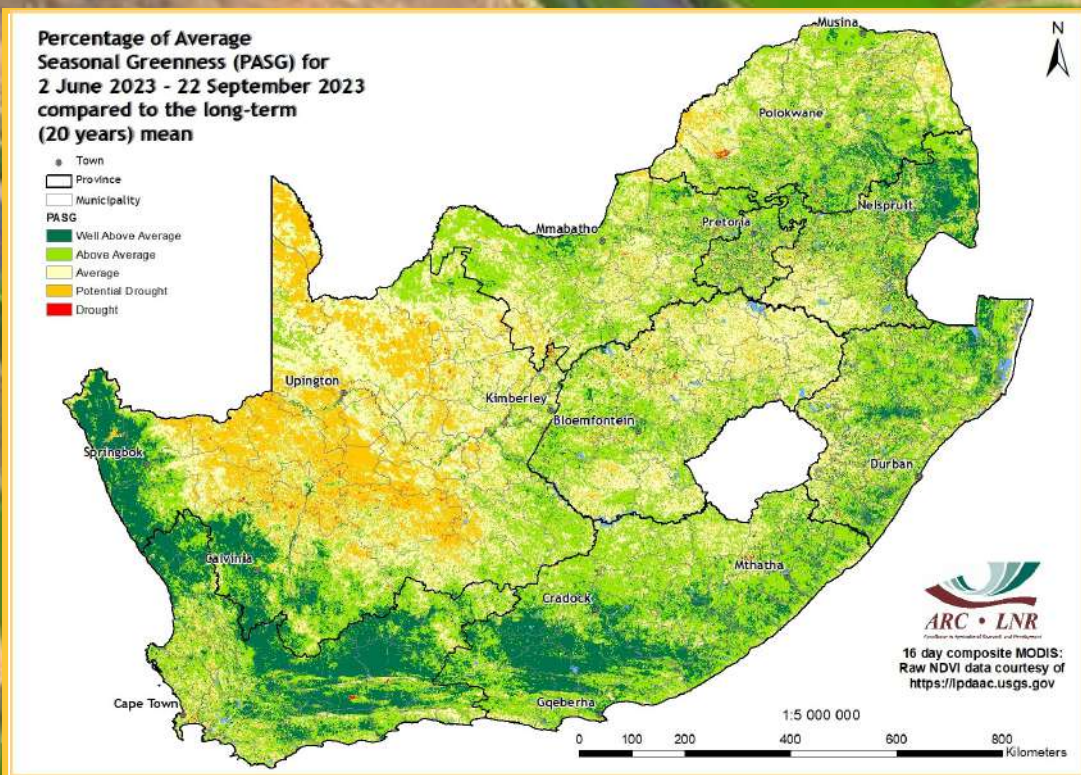


Figure 13

**Figure 12:** The 16-day NDVI difference map for September 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 western parts.

**Figure 13:** The Percentage of Average Seasonal Greenness (PASG) map for the past 4 months, compared to the long-term mean, shows that above-normal seasonal vegetation greenness prevails in most parts of the country, but potential drought prevails in many parts of the Northern Cape.

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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 6 Sep 2023 - 22 Sep 2023 compared to the long-term (21 years) mean

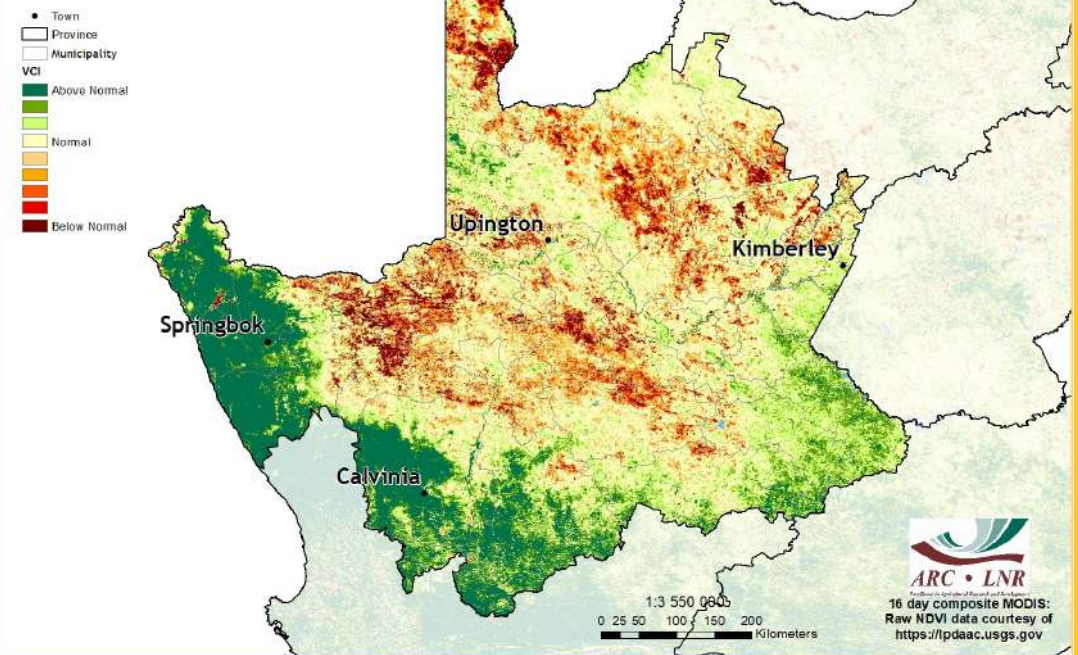


Figure 14

Figure 14:

The 16-day VCI map for September 2023 indicates that the central parts of the Northern Cape experienced below-normal vegetation conditions, with patches of above-normal activity in remote areas.

Figure 15:

The 16-day VCI map for September 2023 indicates that many parts of Limpopo experienced normal to above-normal vegetation conditions, with patches of below-normal activity in isolated areas of the province.

Vegetation Condition Index (VCI) for 6 Sep 2023 - 22 Sep 2023 compared to the long-term (21 years) mean

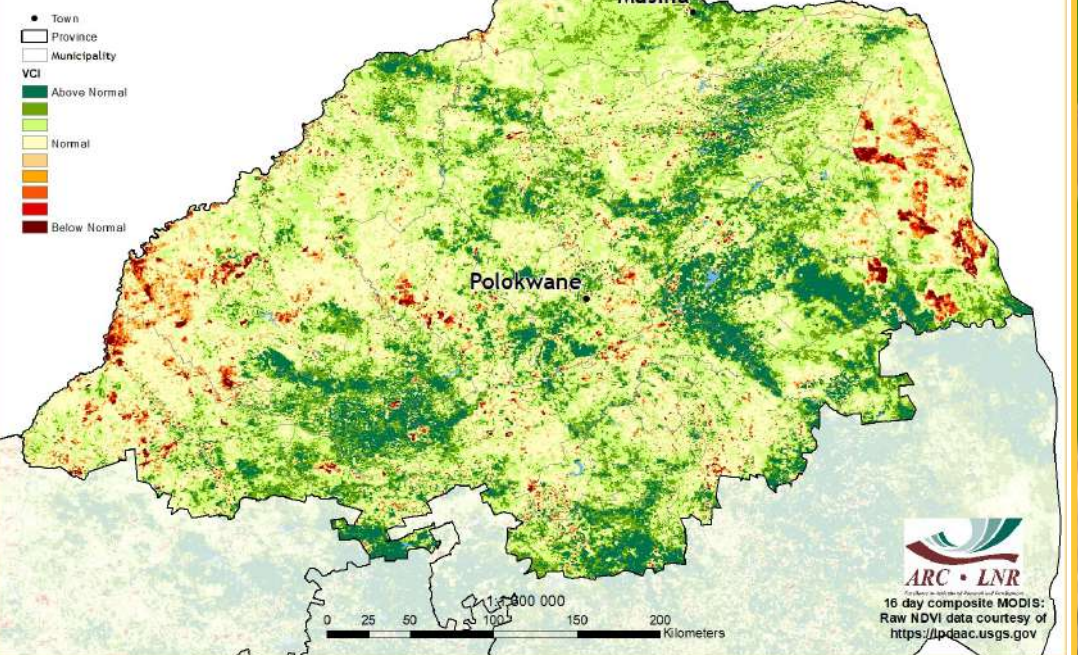


Figure 15

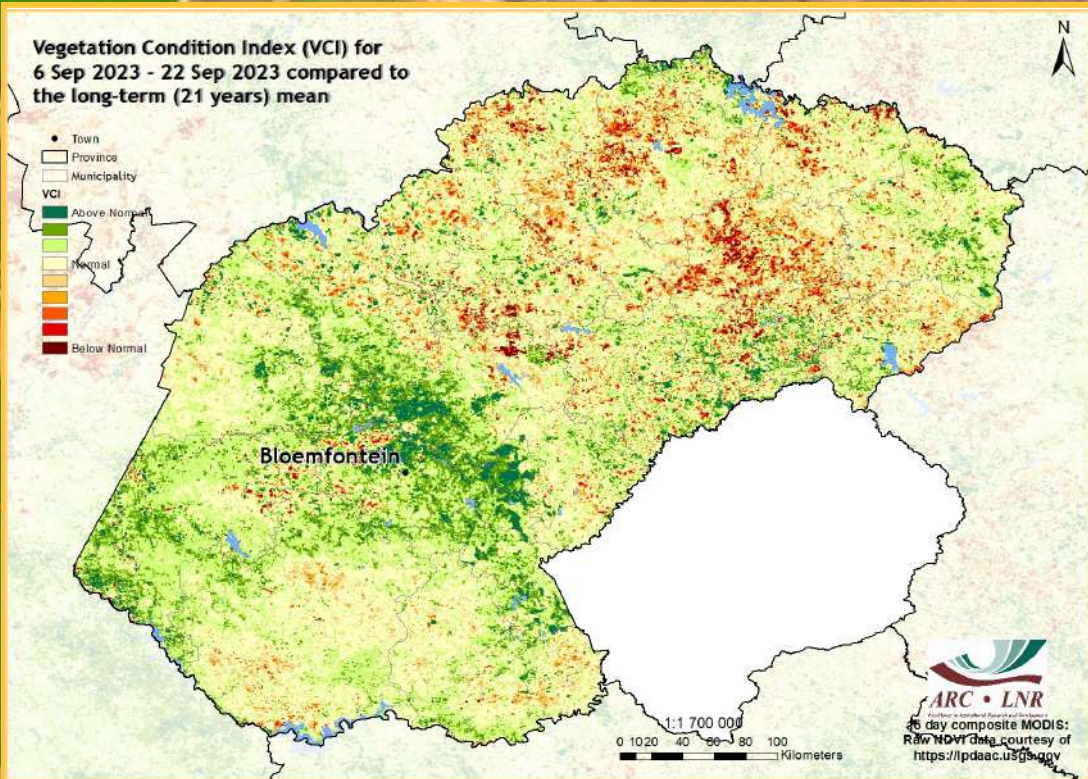


Figure 16

**Figure 16:** The 16-day VCI map for September 2023 indicates that normal to above-normal vegetation conditions prevail over many parts of the Free State, with patches of below-normal activity spread across the province.

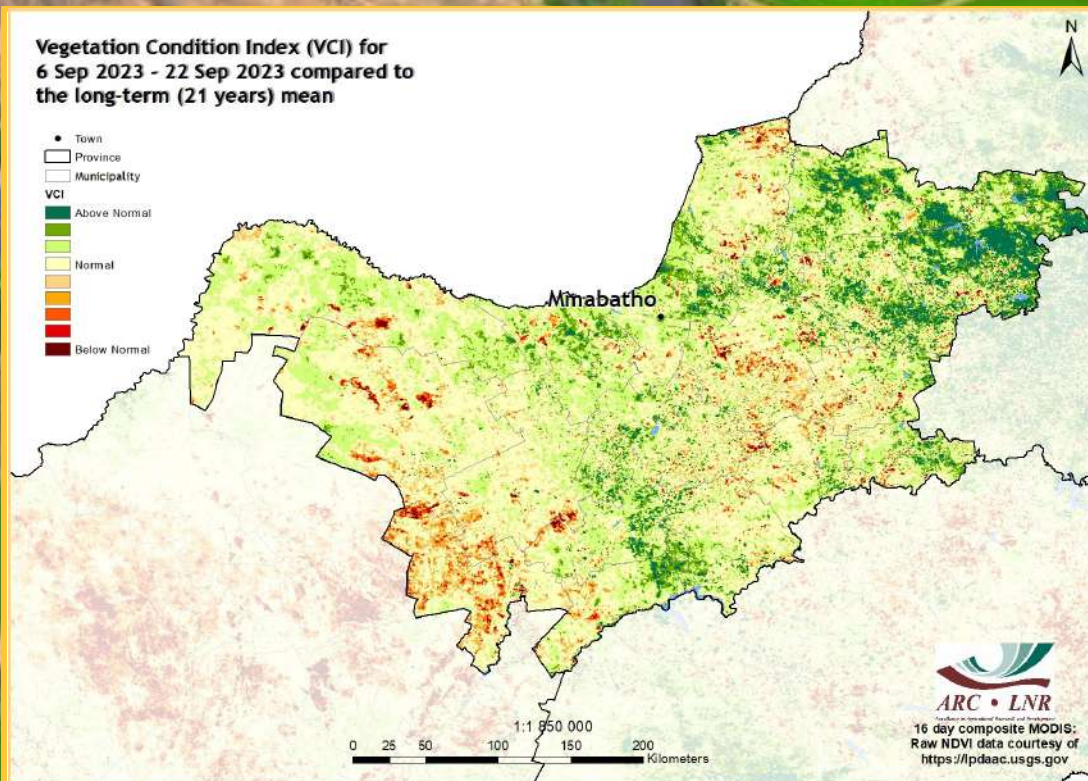


Figure 17

**Figure 17:** The 16-day VCI map for September 2023 indicates that normal to above-normal vegetation conditions prevail over most parts of North West, with patches of below-normal activity spread across the province.

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# 6. Vegetation Conditions & Rainfall

## District Municipalities

- District Council
- Major\_Towns
- Umkhanyakude
- Ugu
- Amatole
- O.R. Tambo
- Motheo
- Cacadu
- Pixley ka Seme
- Central Karoo
- Siyanda
- Namakwa

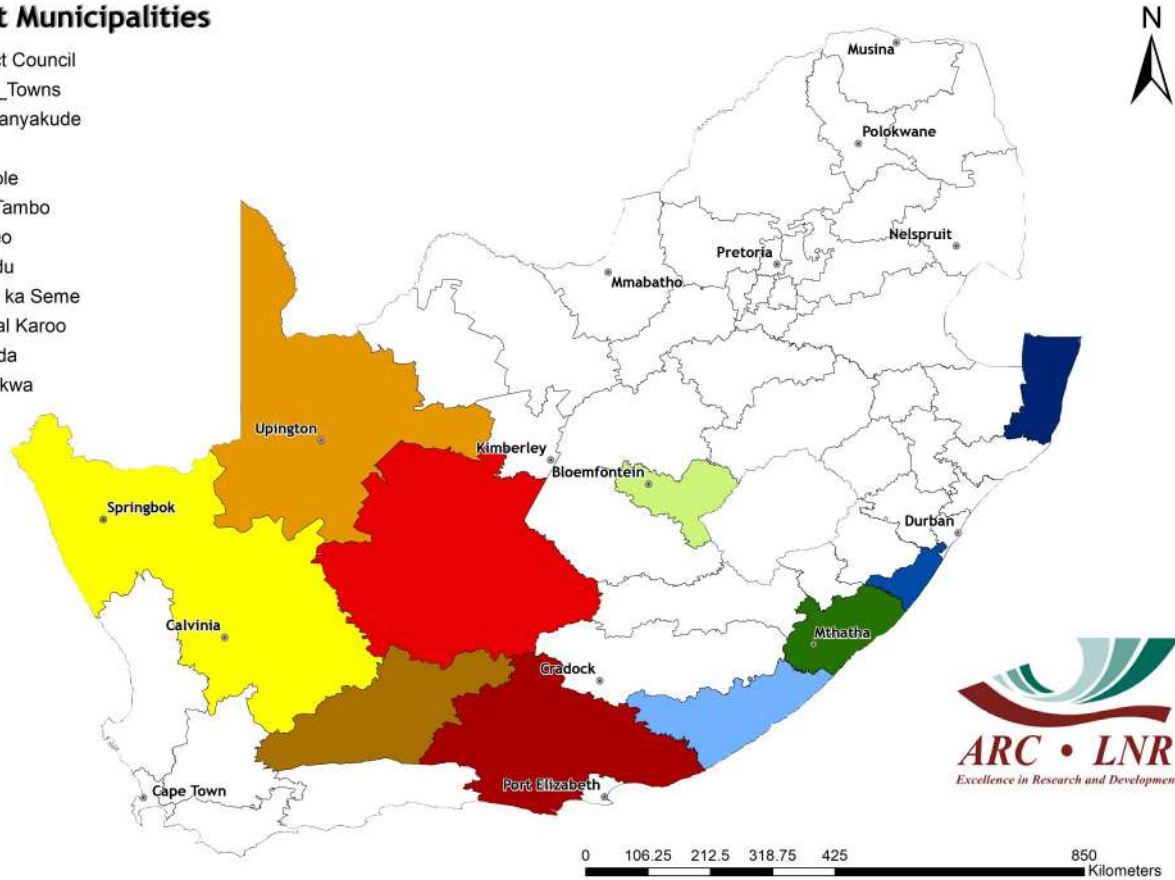


Figure 18

## Rainfall and NDVI Graphs

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

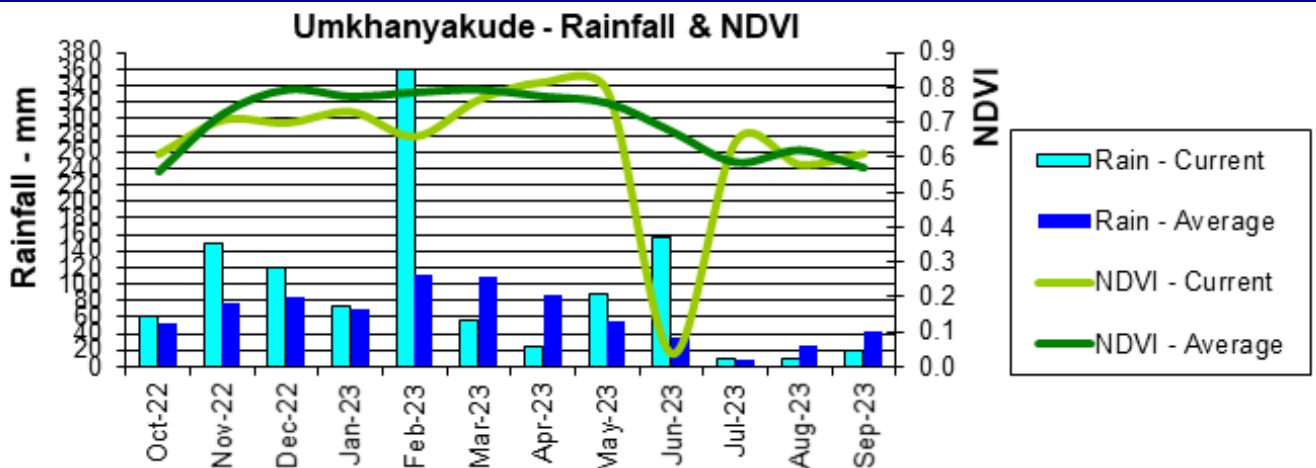


Figure 19

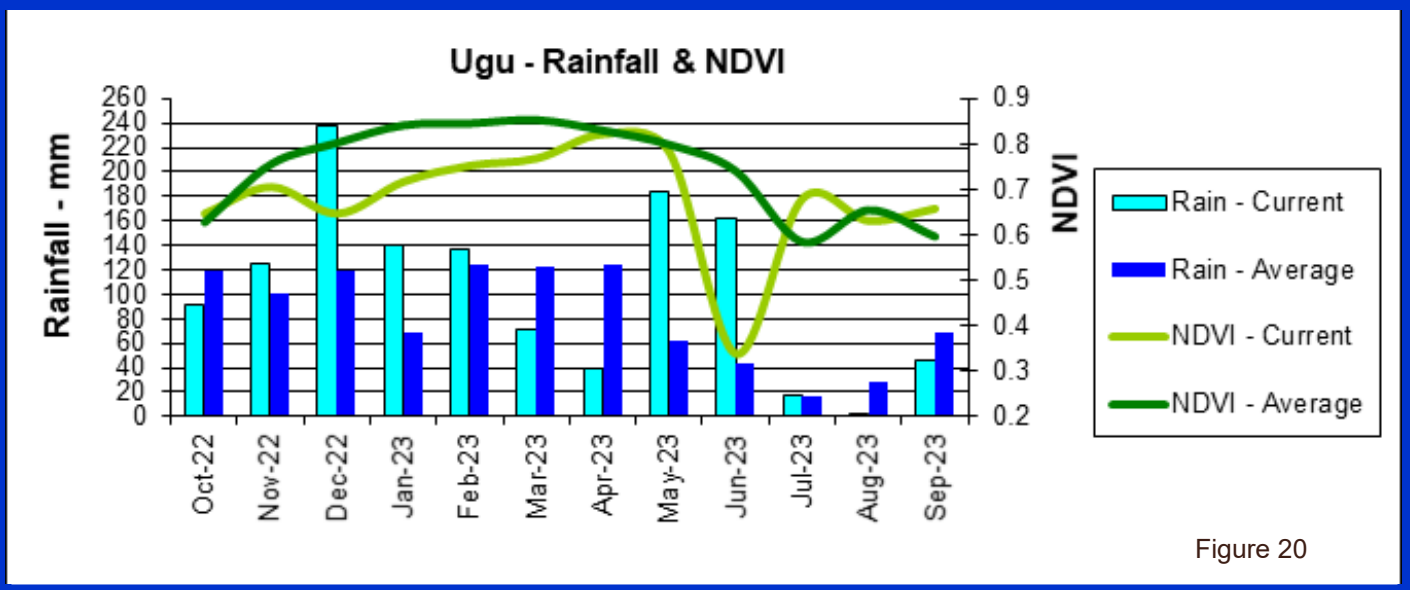


Figure 20

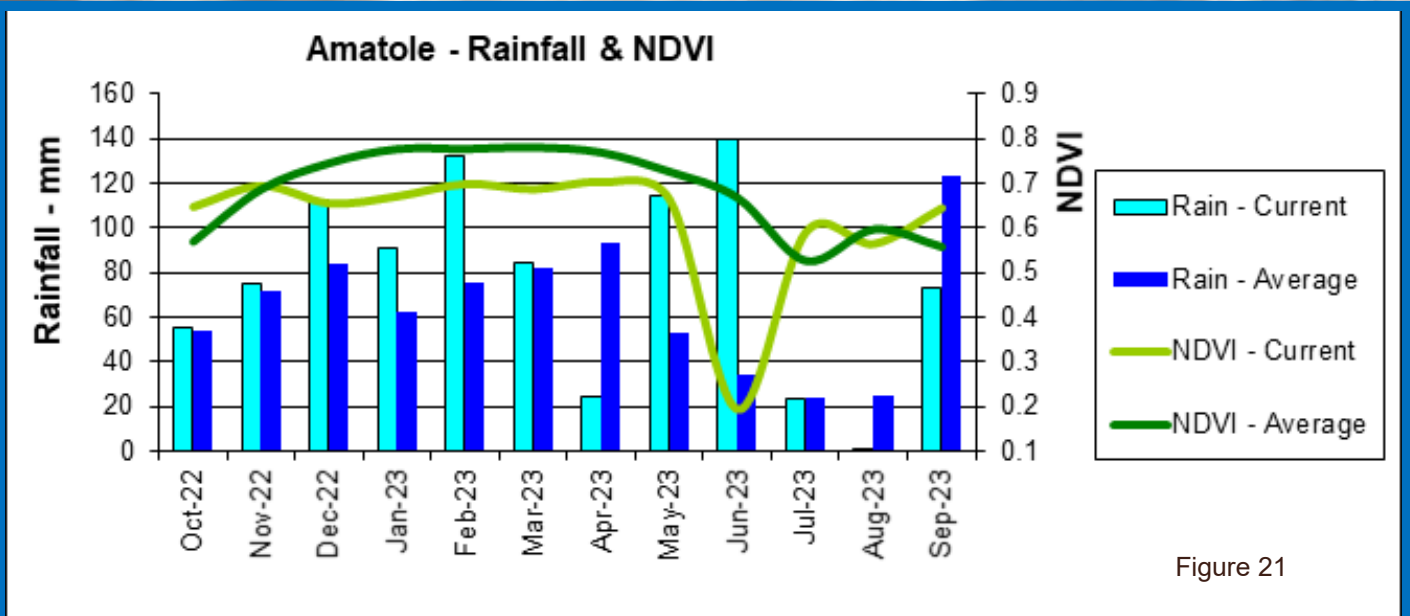


Figure 21

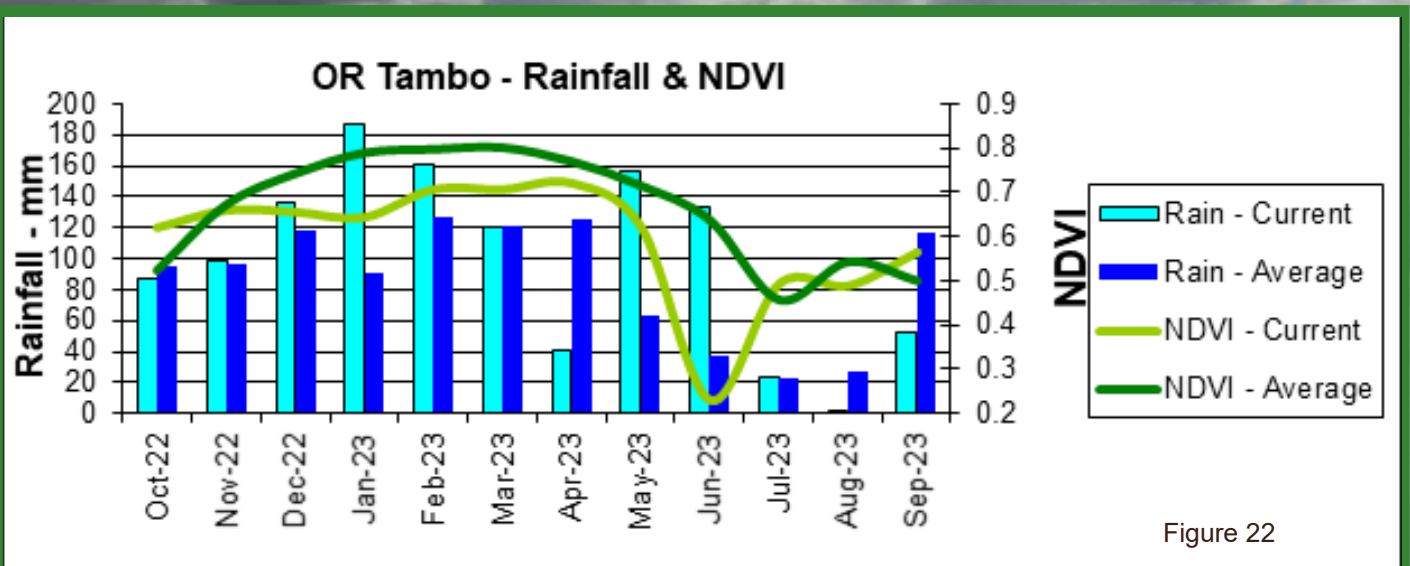


Figure 22

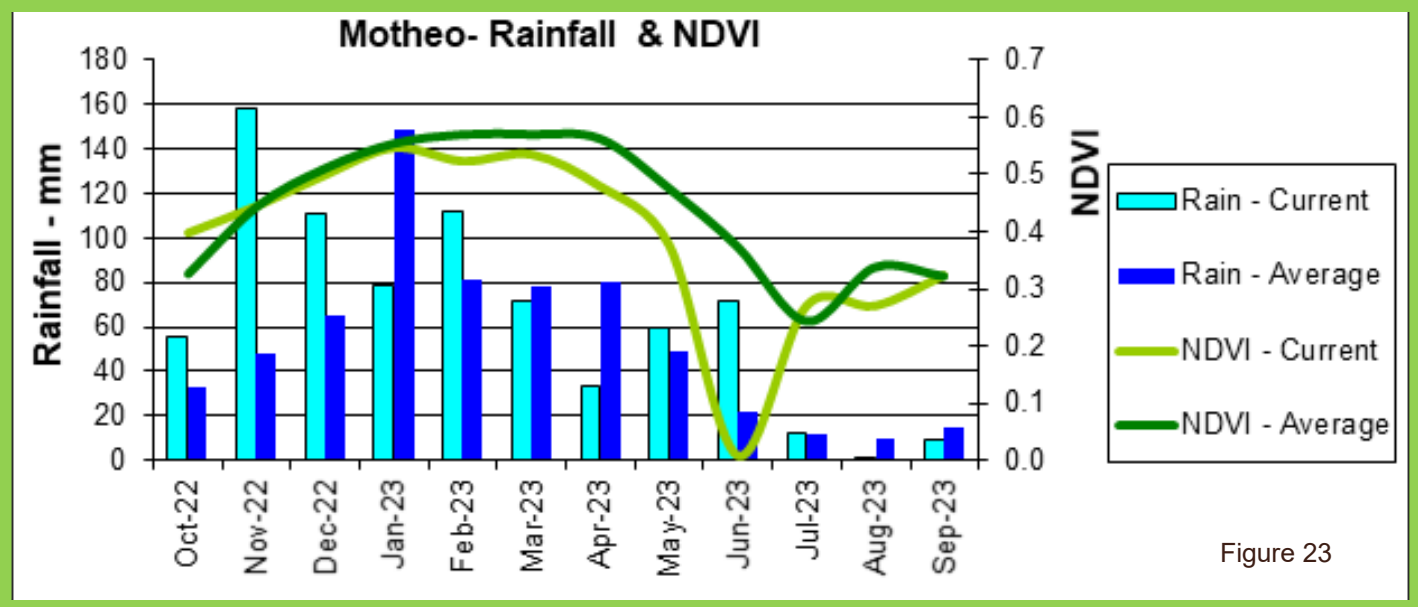


Figure 23

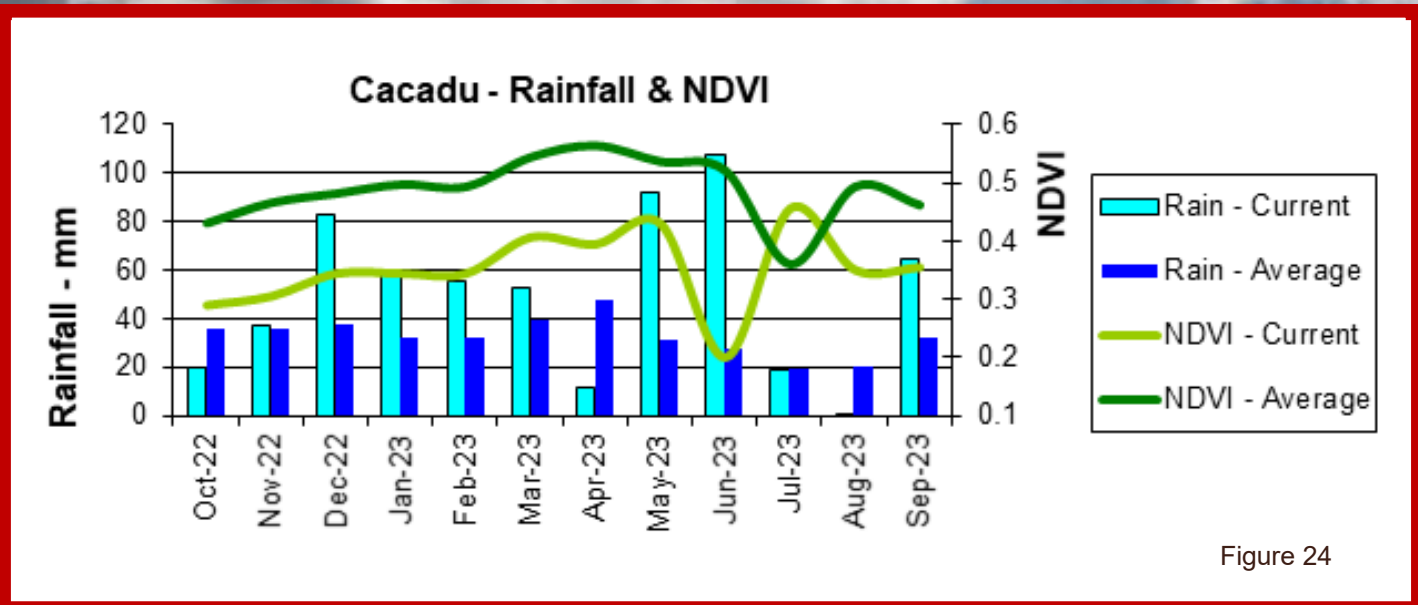


Figure 24

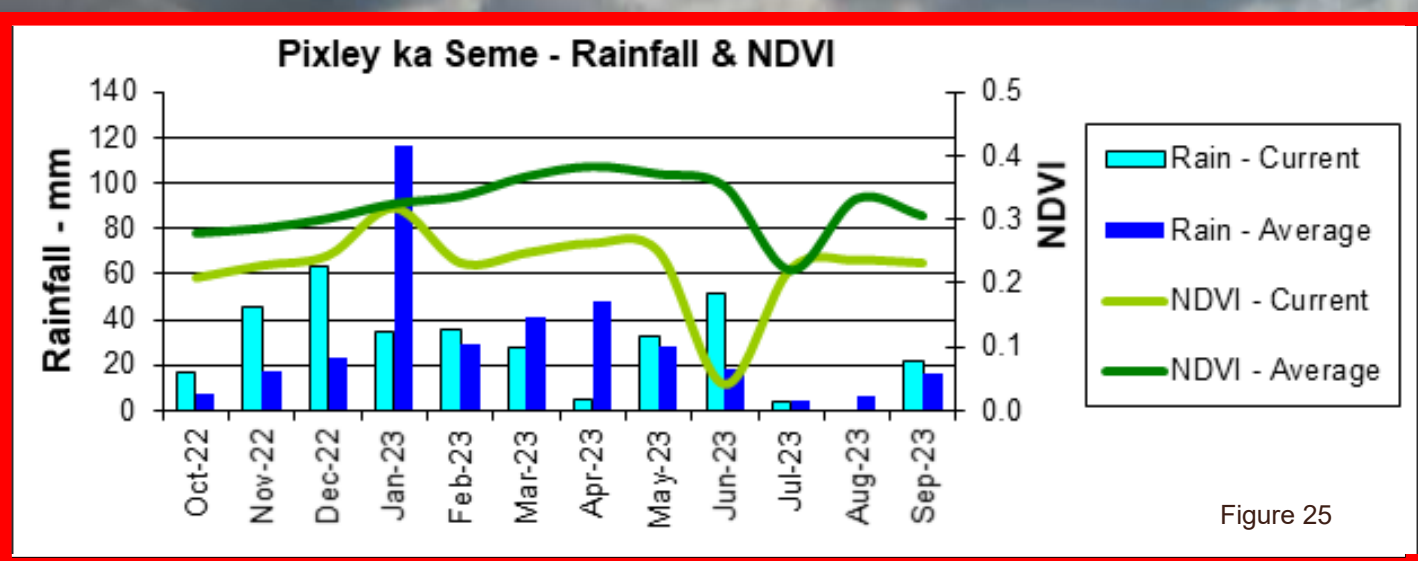


Figure 25

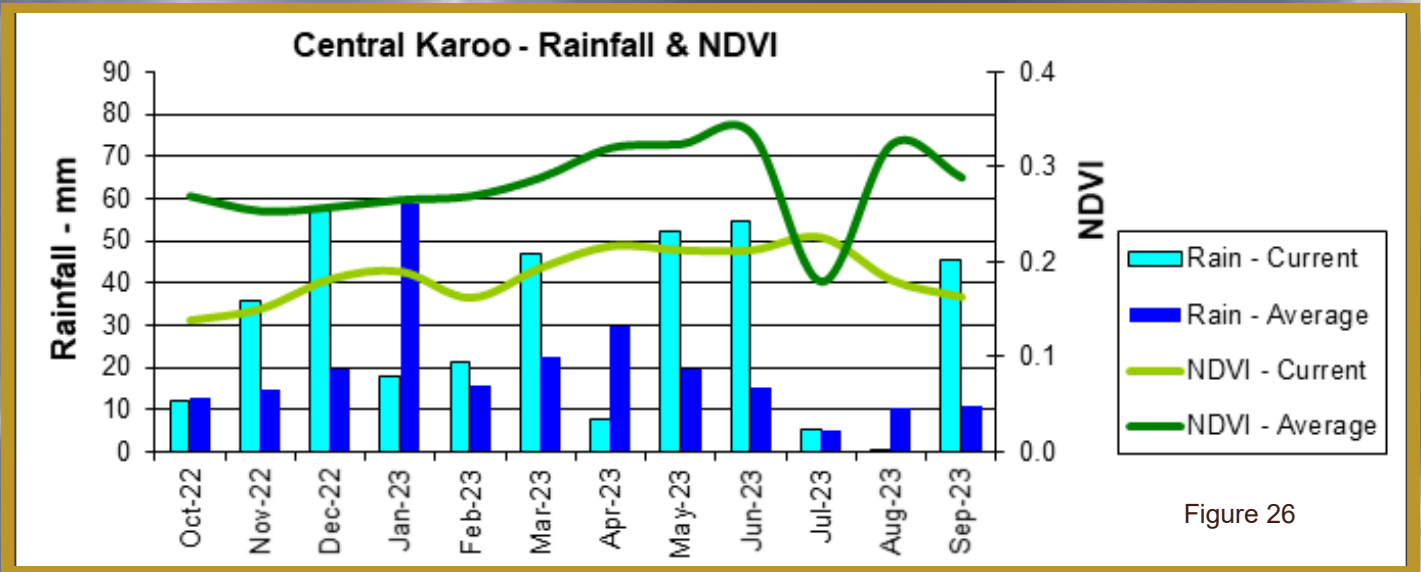


Figure 26

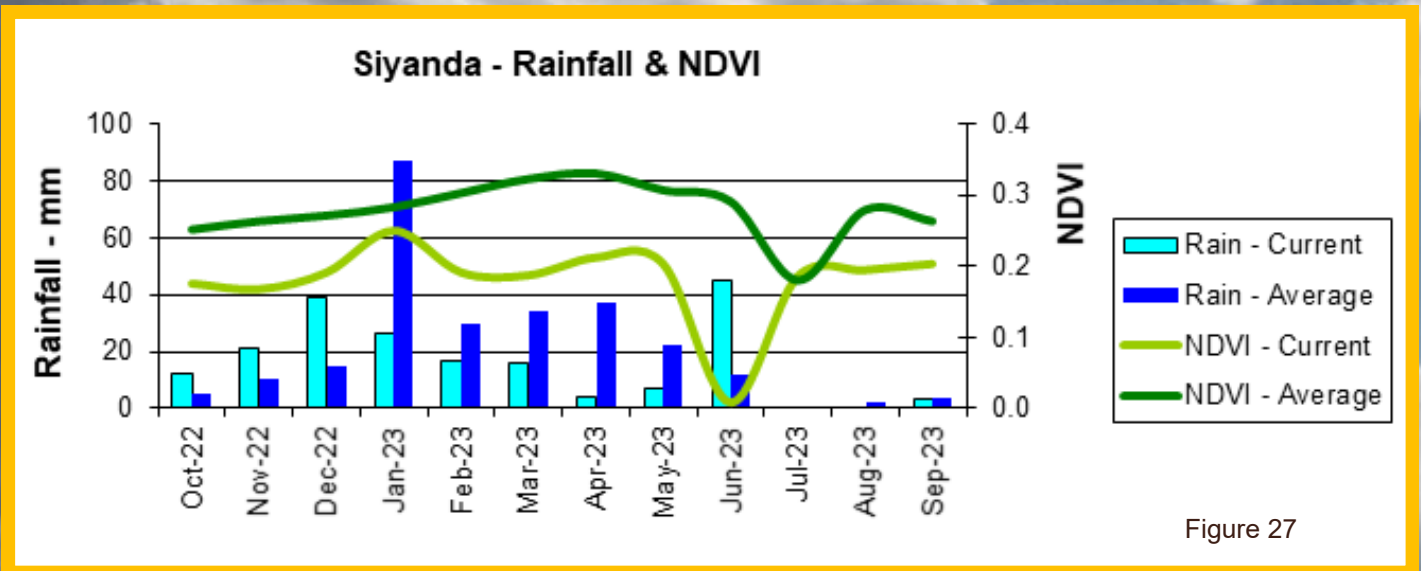


Figure 27

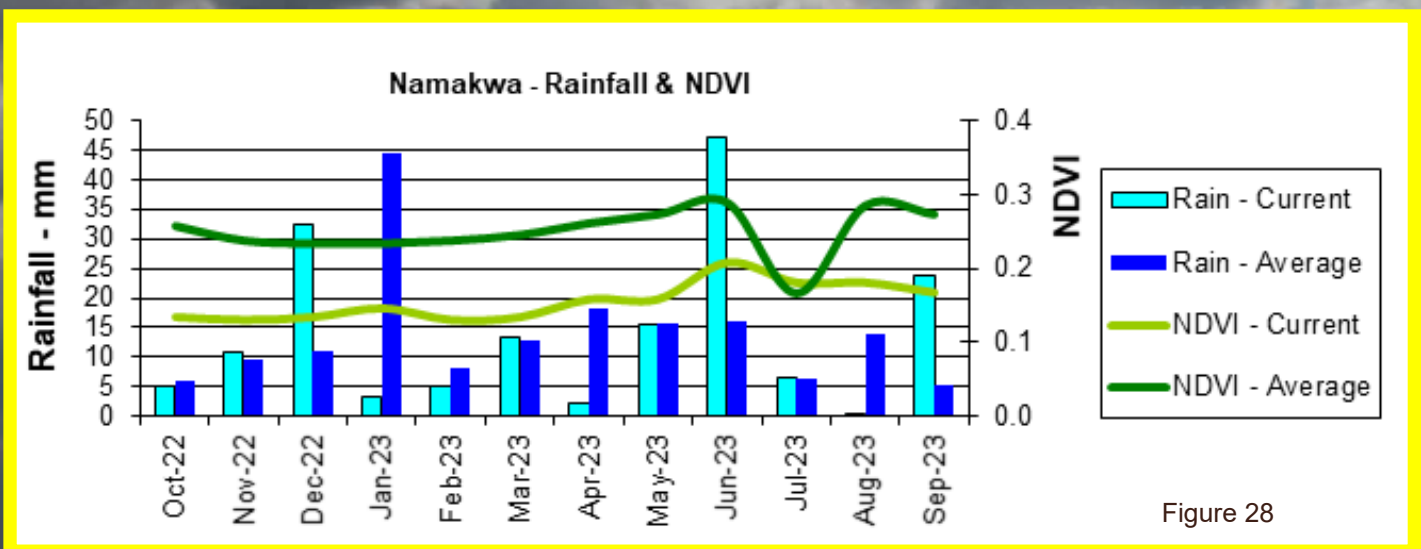


Figure 28

# 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  $\mu\text{m}$ . 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 29 August to 30 September 2023 per province. Fire activity was higher in all provinces, except for the Western Cape, compared to the long-term average.

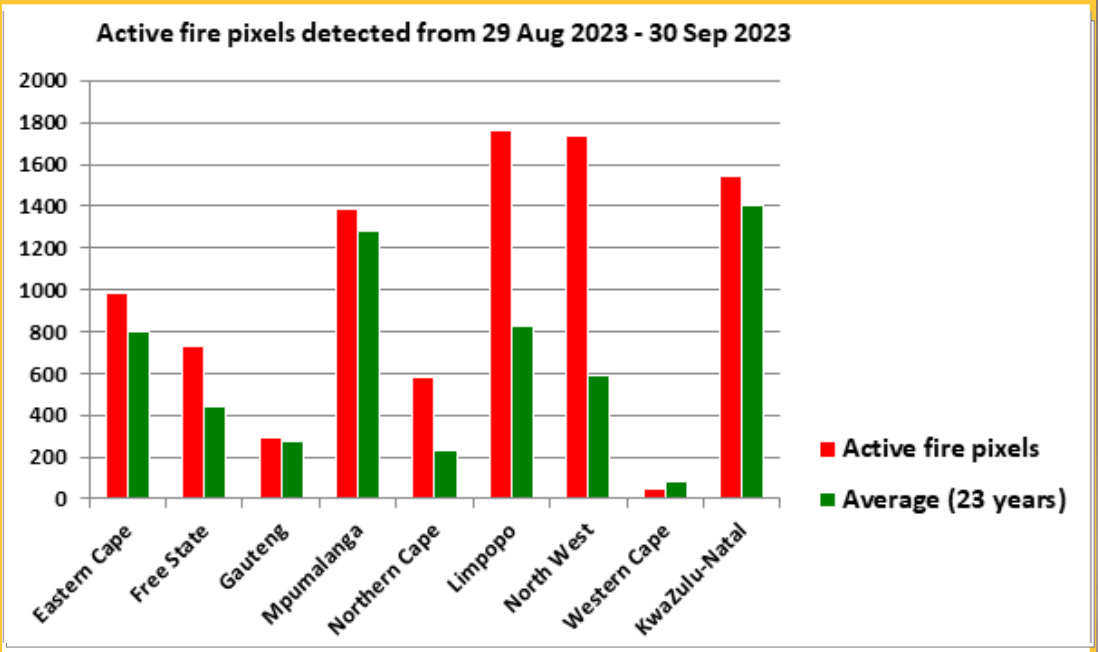


Figure 29

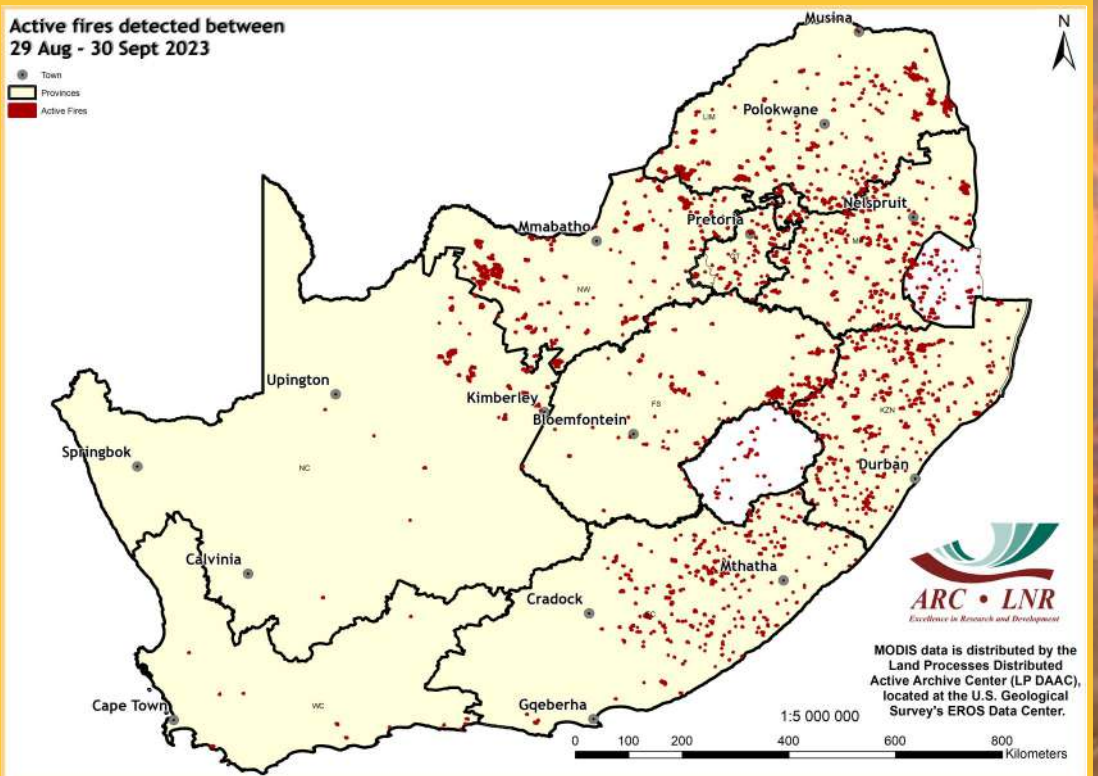
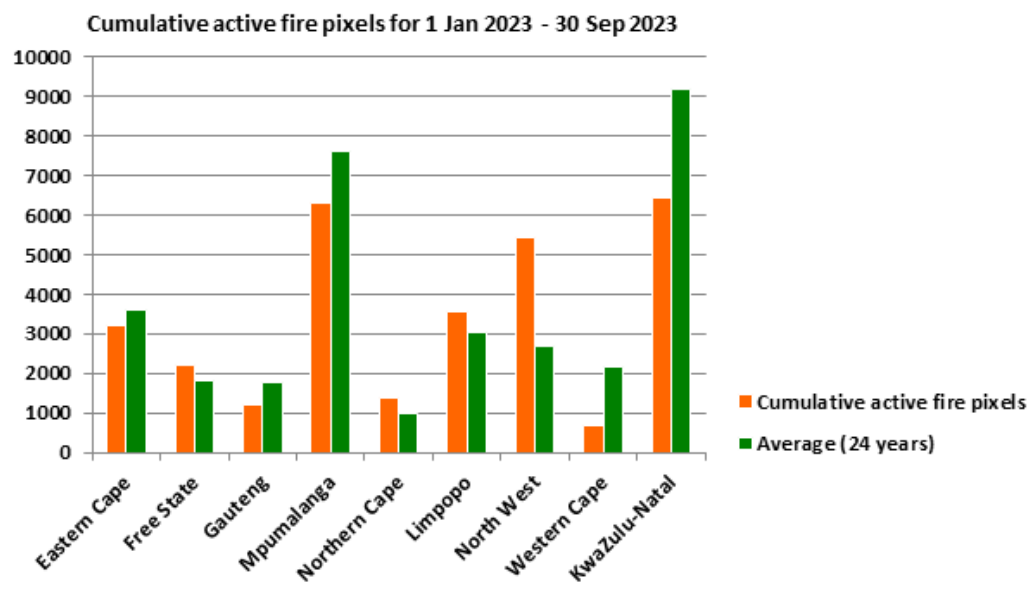


Figure 30

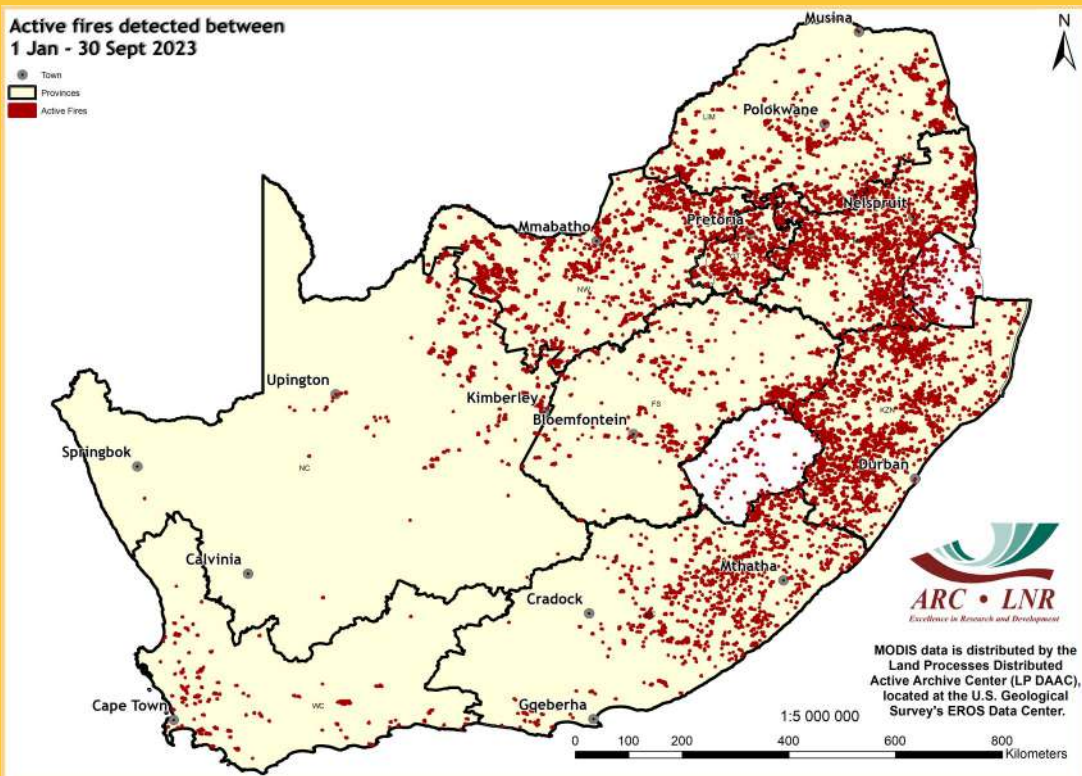
### Figure 30:

The map shows the location of active fires detected between 29 August and 30 September 2023.



**Figure 31:**  
The graph shows the total number of active fires detected from 1 January to 30 September 2023 per province. Fire activity was higher in the Free State, Northern Cape, Limpopo and North West compared to the long-term average.

Figure 31



**Figure 32:**  
The map shows the location of active fires detected between 1 January and 30 September 2023.

Figure 32



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 September 2023 shows a near identical water distribution pattern to last month and a similar pattern to that since April. This continues to illustrate the significant impact of the high rainfall experienced over most of the country during the 2022/23 summer and 2023 winter seasons. The majority of Tertiary catchments continue to show water levels equivalent to 80-100% of the 7-year, long-term maximum water. The whole of the Western Cape and west coast region of the Northern Cape are now showing maximum (80-100%) water levels.

The comparison between September 2023 and September 2022 shows a near identical pattern to the previous few months but with a significant improvement in the Northern Cape. The Western Cape coastal and mountainous regions continue to show high water levels, resulting from recent good winter rainfall.

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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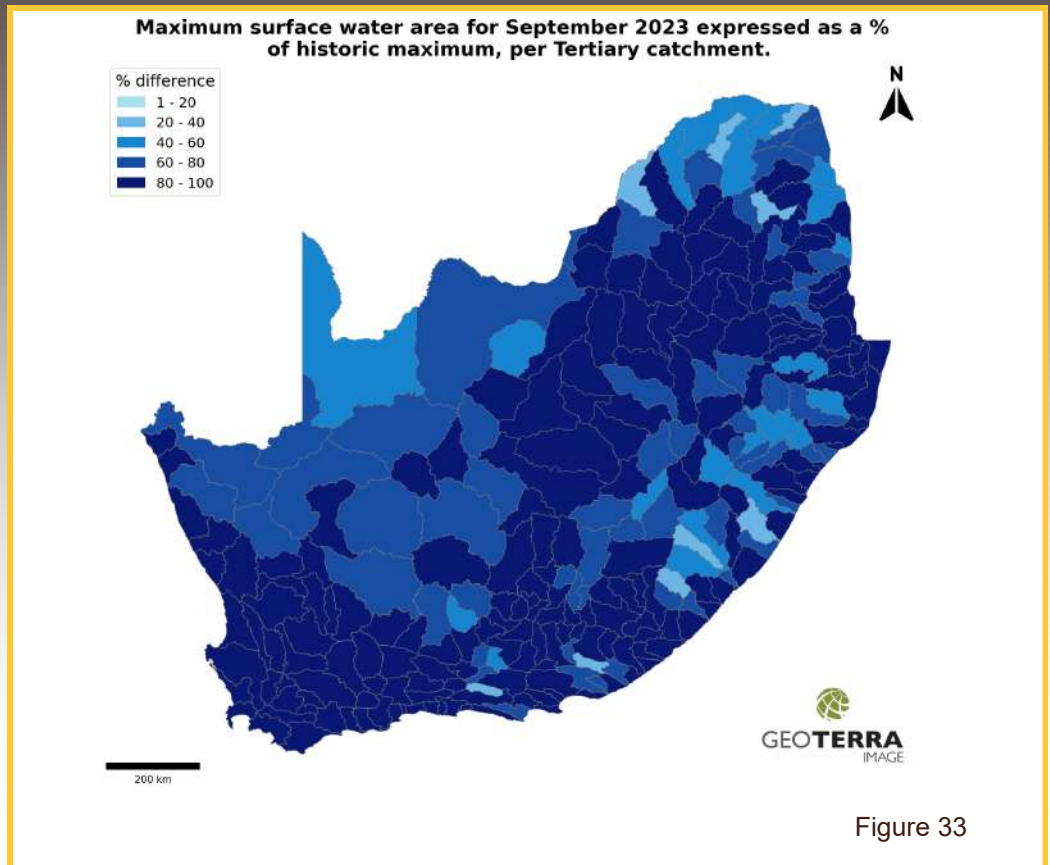


Figure 33

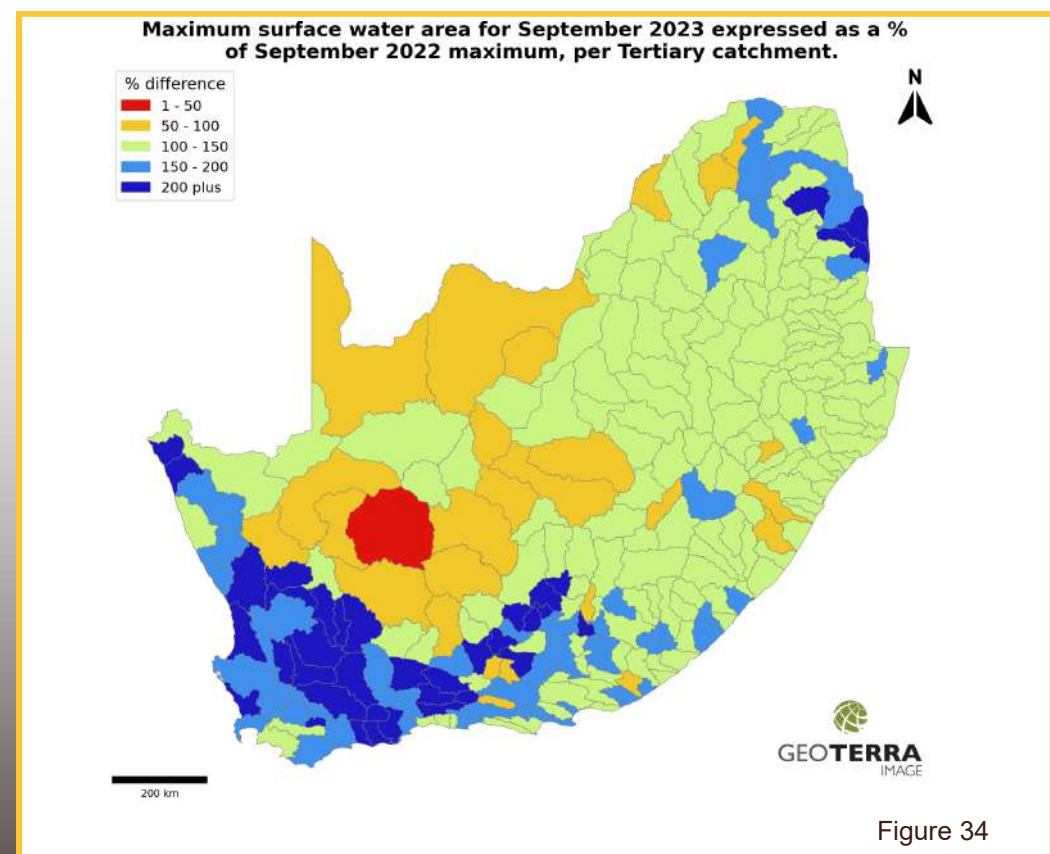


Figure 34



## 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**  
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.**

**ARC-Natural Resources and Engineering  
Soil, Climate and Water Campus**

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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**

*Dr Ashira Roopnarain*

Tel: 012 310 2650 • E-mail: [RoopnarainA@arc.agric.za](mailto: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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# 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>.



## NATURAL RESOURCES AND ENGINEERING Soil, Climate and Water

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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.

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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.