

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

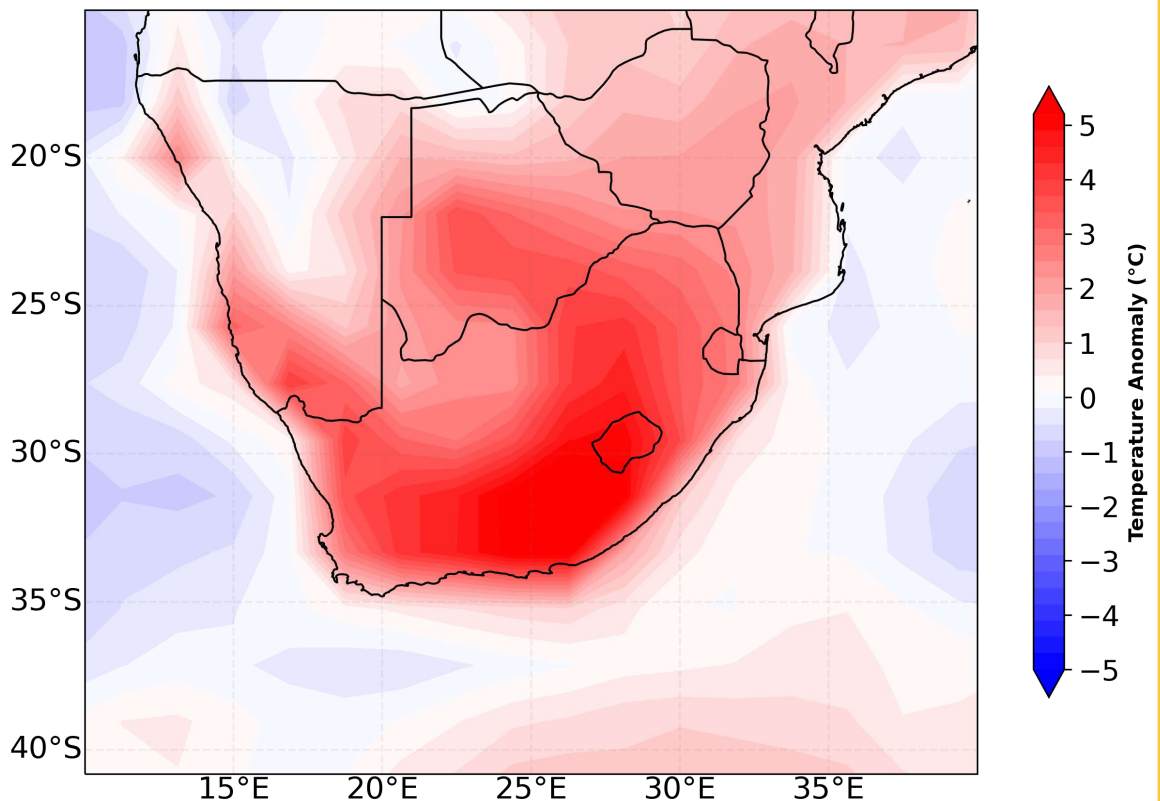
South African Weather Service

223rd Edition

Image of the Month

Heatwave conditions characterize the beginning of 2023

With the commencement of the summer rainfall season during the latter half of October 2022, the summer rainfall region has experienced above-normal rains as expected. During the first week of January 2023, rainy conditions occurred over most parts of the country, before dry and anomalously warm conditions set in from the 8th. The average maximum temperature during the period from 1-20 January was up to 4°C higher than normal over parts of the maize production regions (see temperature anomaly map below). During the same period, rainfall was very limited with a number of consecutive dry days. The only areas that received somewhat significant rainfall include the northeastern parts of Limpopo, with areas in and around Tzaneen recording >70 mm during 17-18 January. This raises concerns for agricultural production as the conditions are most likely to affect crops (which are still in their early growth stages) and livestock (which may be exposed to heat stress).



Overview:

The meteorological summer began in December 2022, with La Niña weather conditions continuing to cause above-normal rainfall over greater parts of the country. Numerous rainy days resulted in widespread rainfall during the month, mainly confined to the summer rainfall region. High totals (>200 mm) were observed over parts of Limpopo, Gauteng, Mpumalanga and KwaZulu-Natal, as climatologically expected. Stations that recorded ≥ 300 mm for the month include Barberton (309 mm) in Mpumalanga and Pennington (318 mm) in KZN. Positive deviations over the major maize production regions (mostly in the Free State and North West) were also noted, and many of these rainfall events triggered localized flooding over certain areas. The southwestern parts of Gauteng similarly experienced heavy downpours that resulted in flooding of roads and low-lying areas, damaging infrastructure. Furthermore, the Western Cape welcomed short-term recovery from the drought due to rainfall activity that occurred throughout the month. Moderately frequent rainfall events resulted in totals reaching ± 100 mm in places, which is noteworthy considering that December is climatologically a dry month for that province. Meanwhile, the adjacent all-year rainfall region recorded somewhat similar conditions and the northwestern corner of the country, towards Springbok, was the only area that remained dry during December.

1. Rainfall

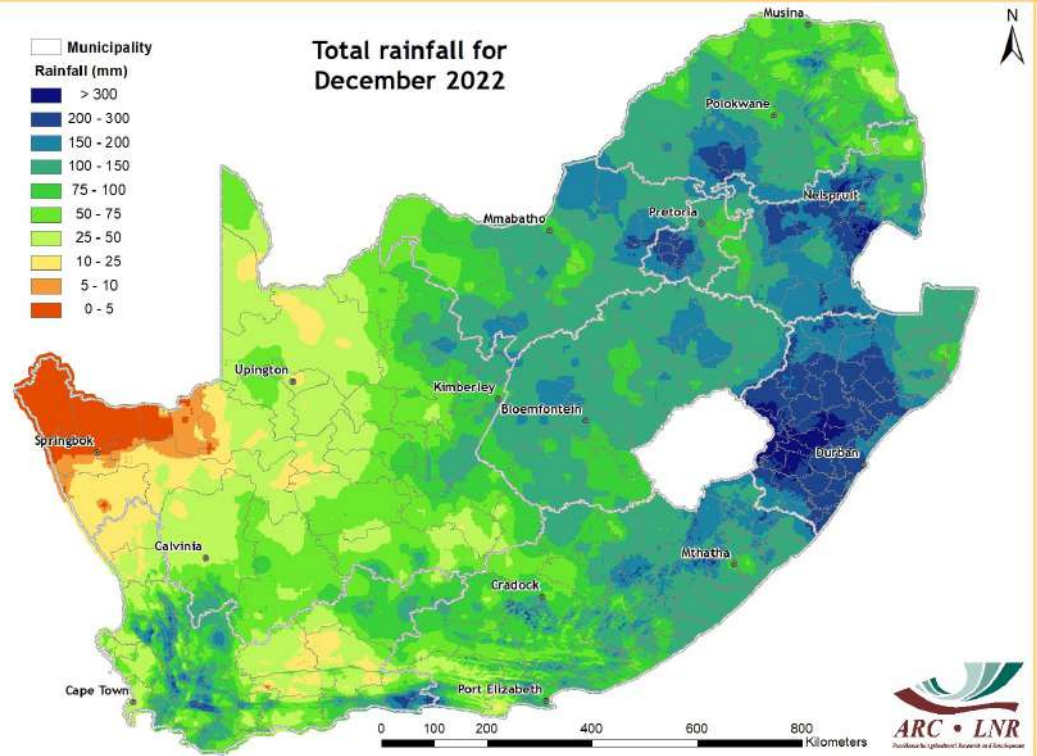


Figure 1

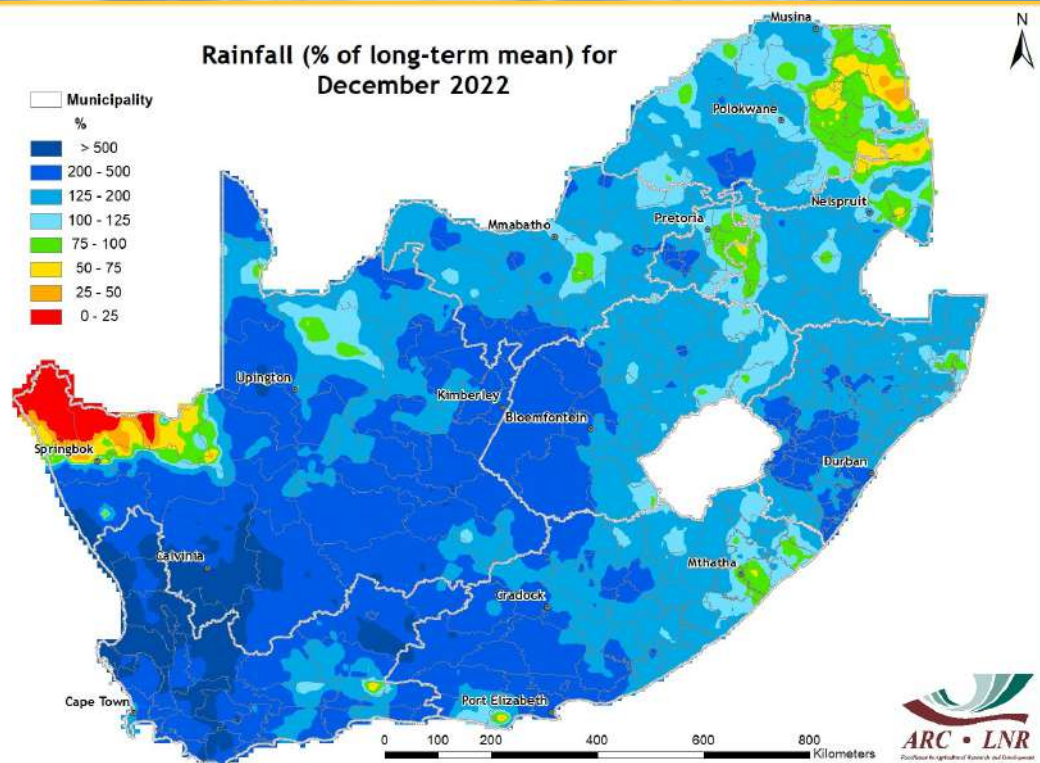


Figure 2

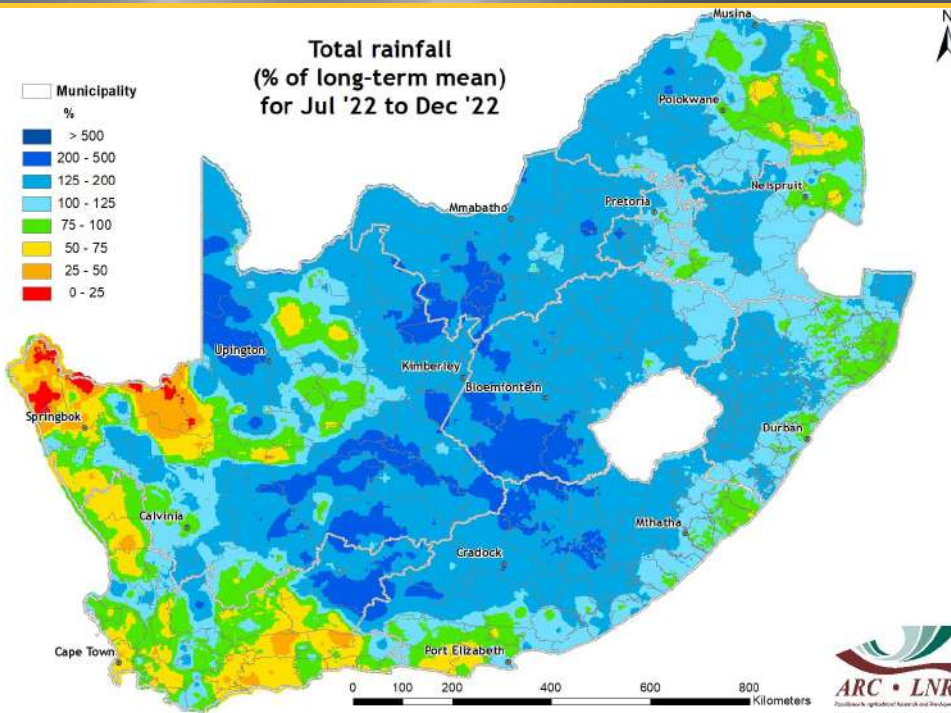


Figure 3

Figure 1:

Most significant rainfall activity in December 2022 occurred over the interior, towards the eastern and northern provinces. Certain areas in KwaZulu-Natal, Gauteng, Mpumalanga and Limpopo recorded totals of more than 200 mm for the month. Parts of the Northern and Western Cape experienced a wet December, accumulating totals of >100 mm in places, in contrast to the previous dry months.

Figure 2:

Widespread above-normal rainfall occurred over the country during December, with the far western parts of the Northern Cape being the only area to remain dry.

Figure 3:

Cumulative rainfall from July to December 2022, given as a percentage of long-term mean, shows that greater parts of the country, particularly the interior, have experienced above-normal rains. Meanwhile, certain areas of Limpopo, the Northern Cape, Western Cape and adjacent areas in the all-year rainfall region received near- to above-normal rainfall.

Figure 4:

Contrasting conditions can be noted on this map, as it depicts that various isolated areas across the country received less rainfall during October-December 2022, as compared to the same period the previous year, while most parts of the eastern half of the country received more rain. The latter include parts of KZN, Free State, North West, Gauteng, Mpumalanga and Limpopo.

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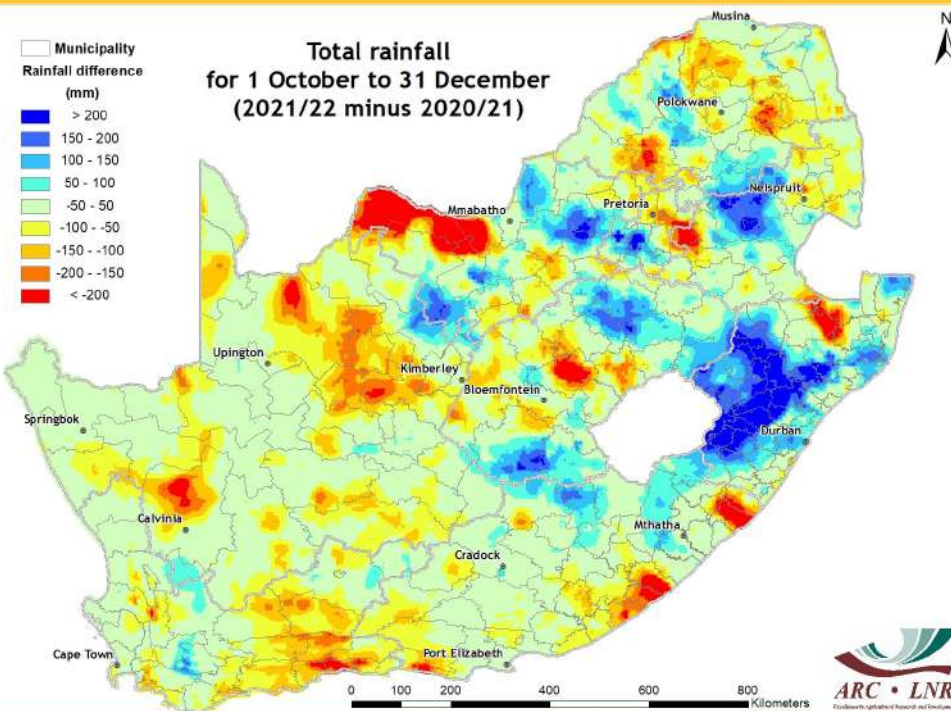


Figure 4

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 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 2022 are shown in Figures 5-8. Given the short-term SPI, high rainfall totals resulted in wet conditions over the summer rainfall region, with parts of Limpopo and Mpumalanga showing signs of mild drought. The winter and all-year rainfall regions observed 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, with more pronounced wet conditions over the interior.

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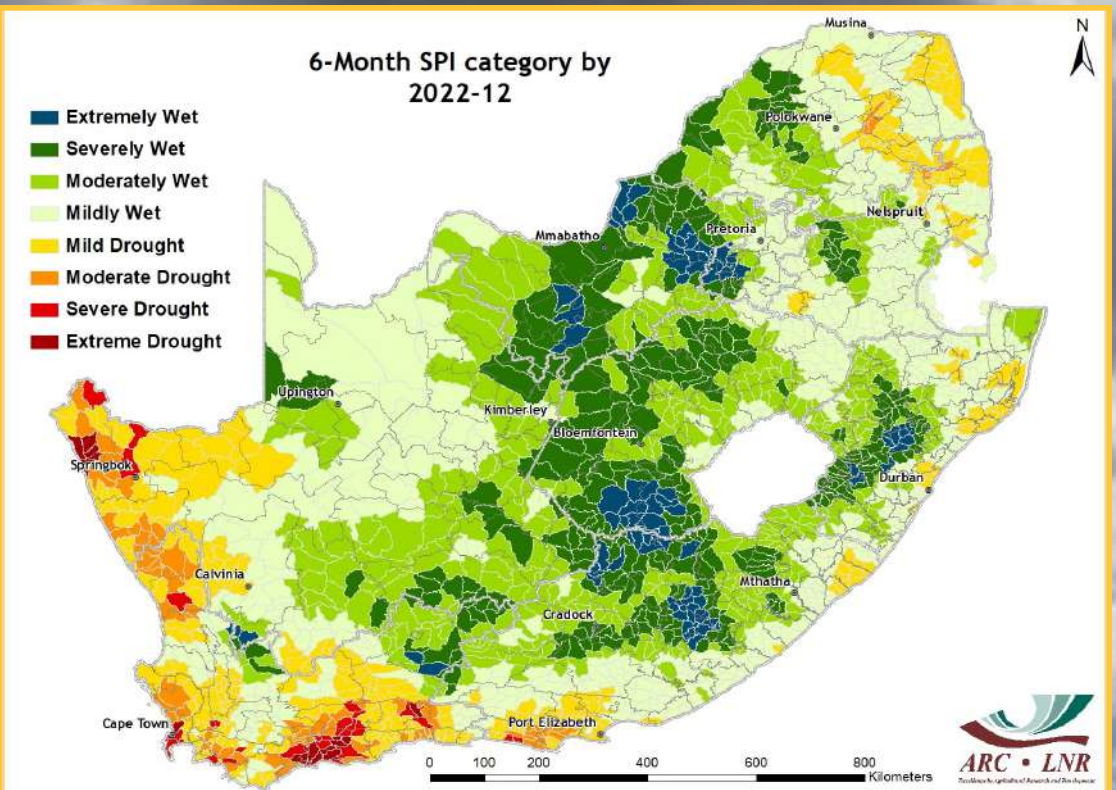


Figure 5

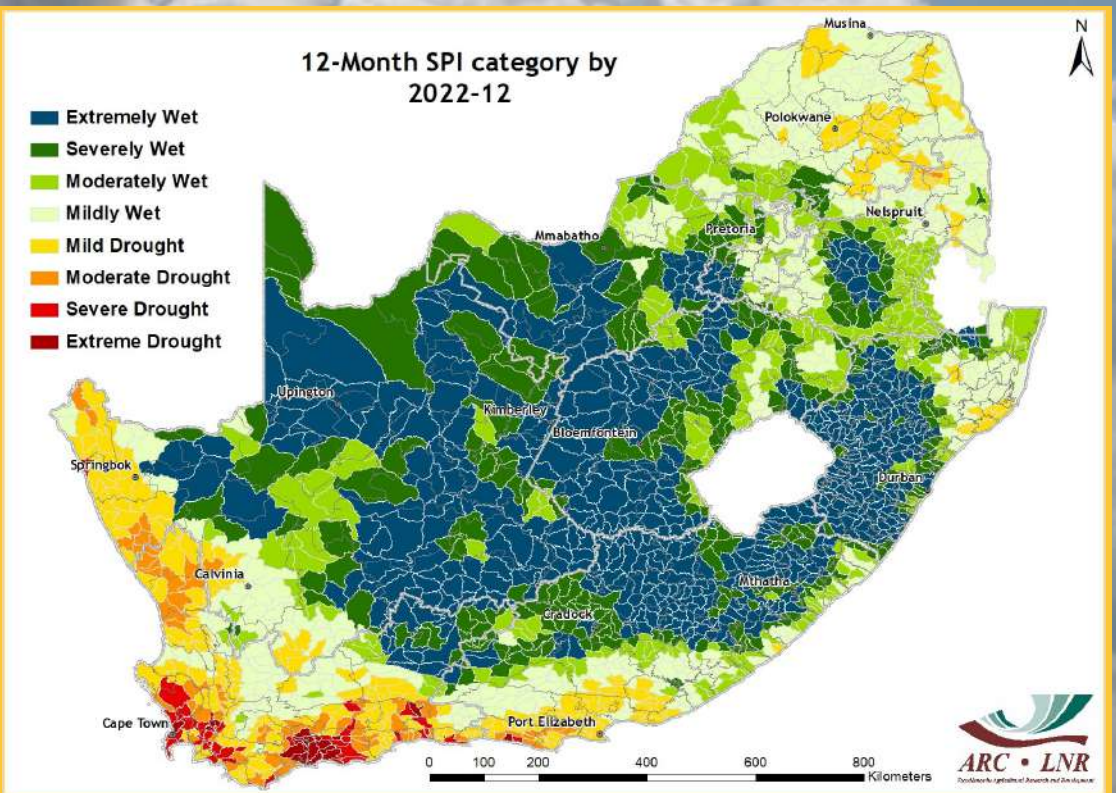


Figure 6

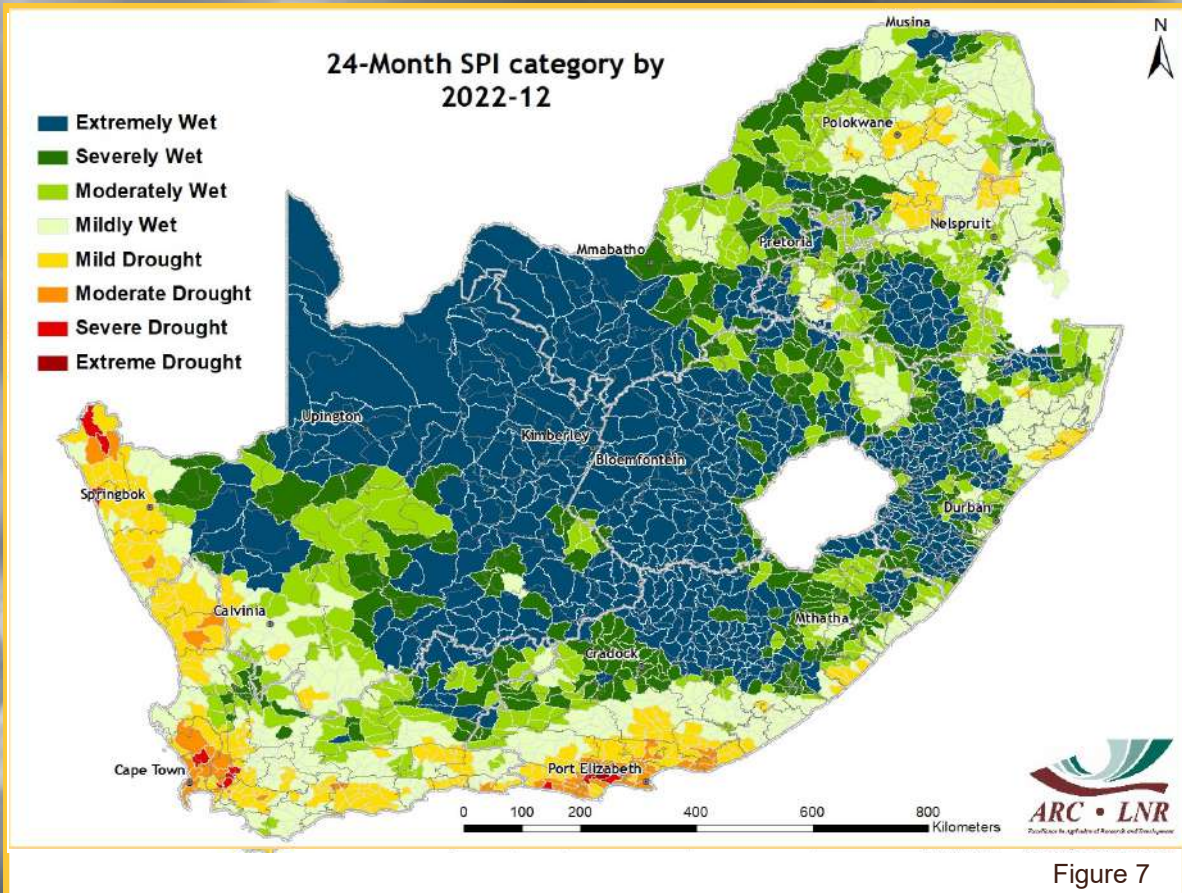


Figure 7

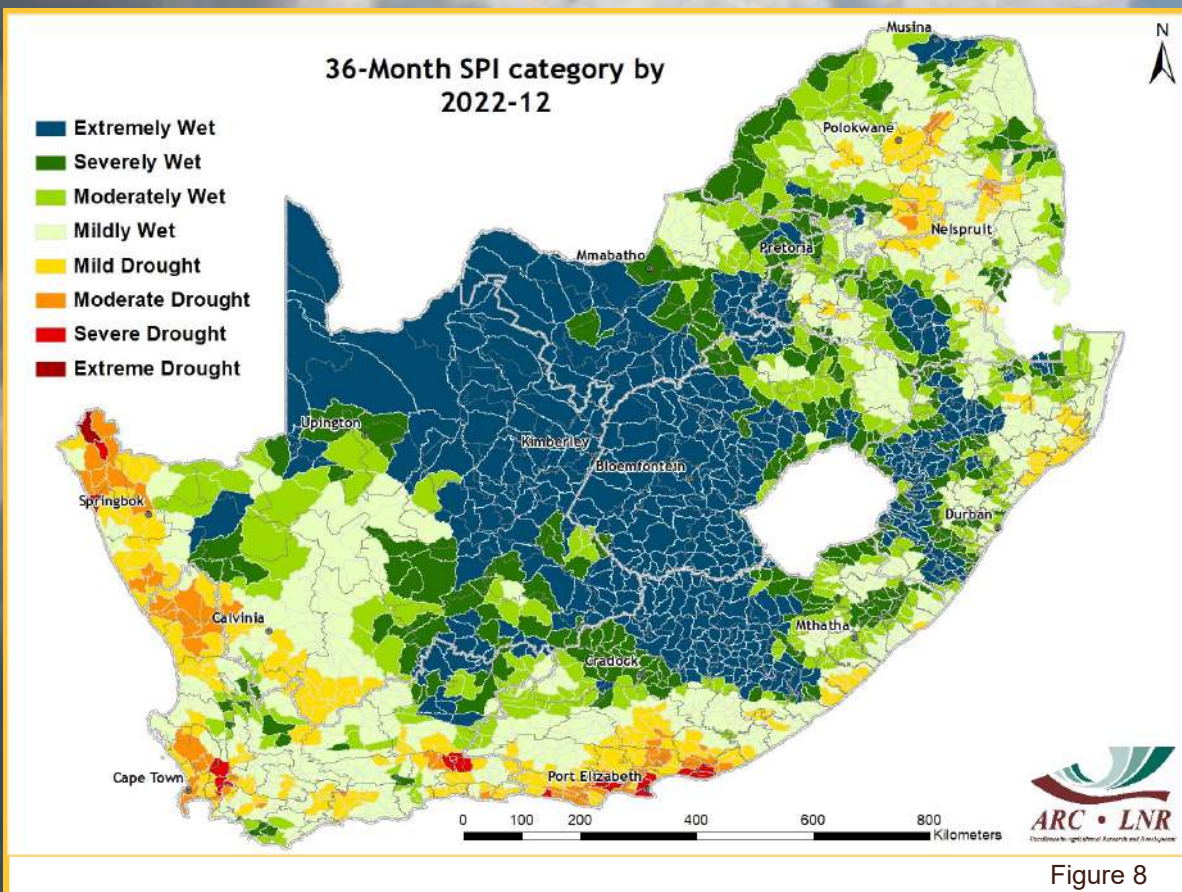


Figure 8

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.

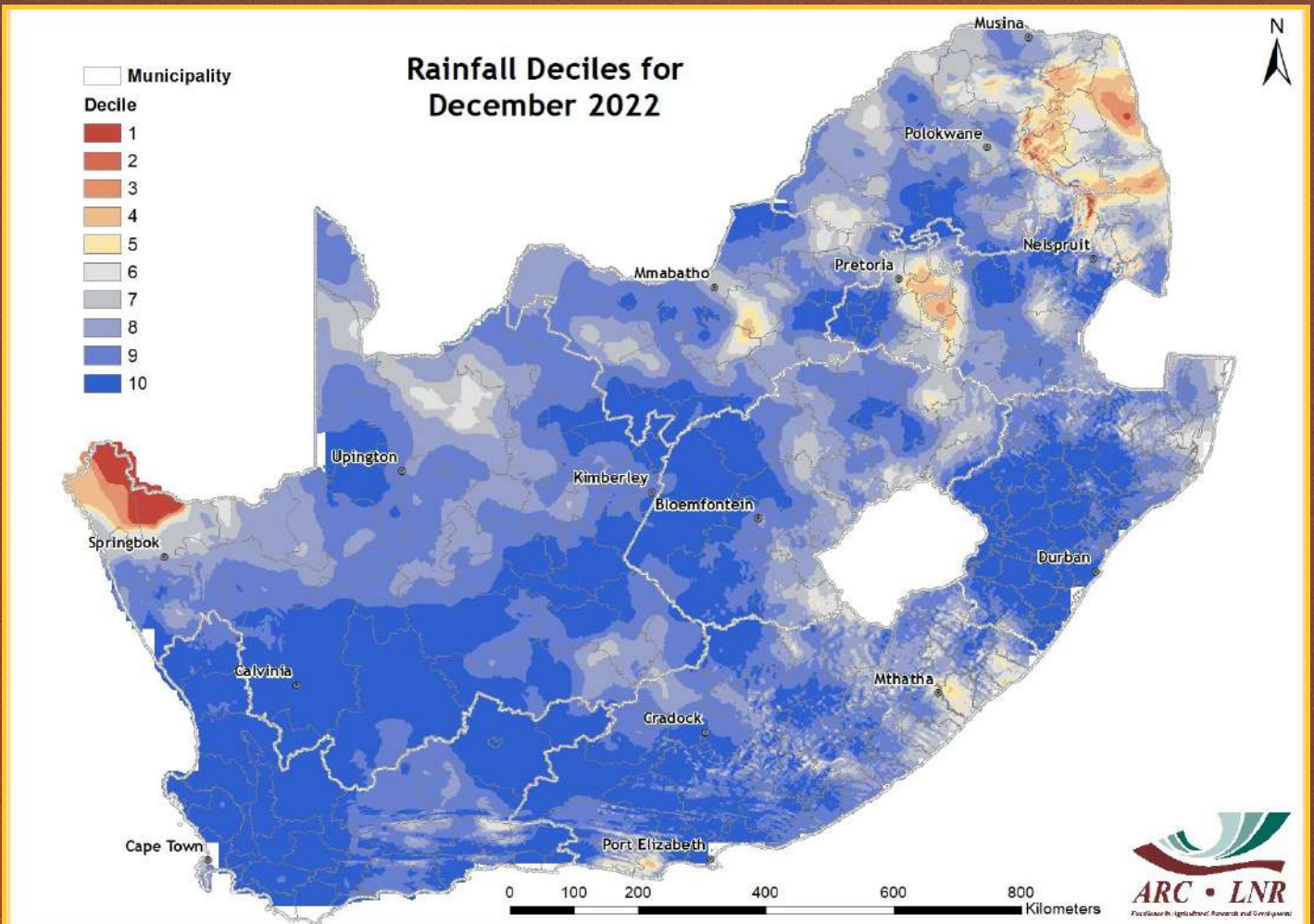


Figure 9

Figure 9: Greater parts of the country compared well with historically wet December months during December 2022.

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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

Standardized Difference Vegetation Index (SDVI) for 11 Dec 2022 - 27 Dec 2022 compared to the long-term (20 years) mean

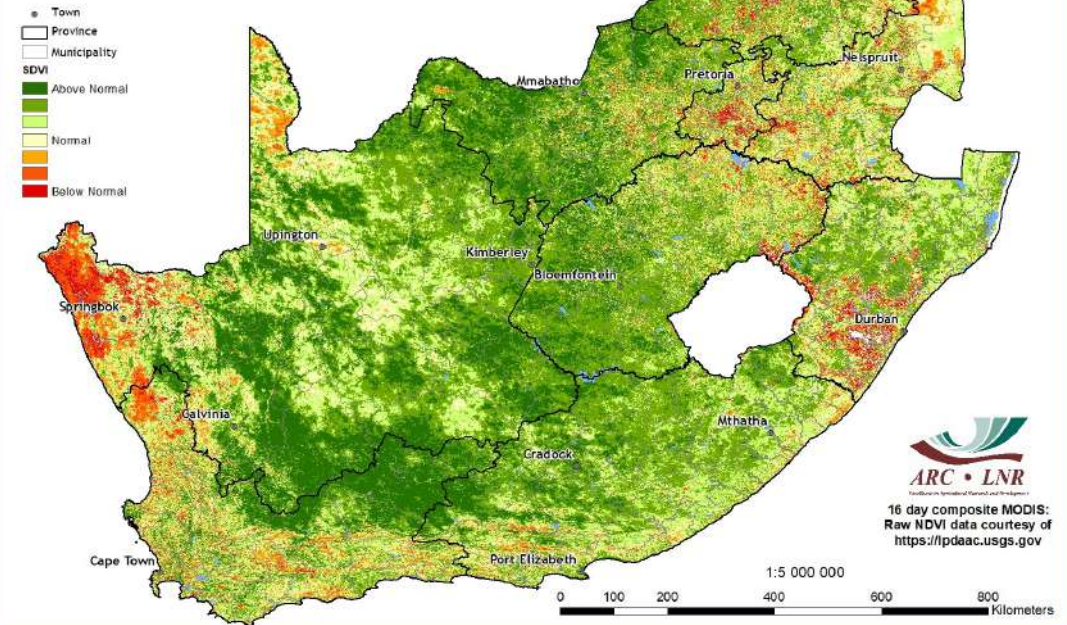


Figure 10

NDVI difference map for 11 Dec 2022 - 27 Dec 2022 compared to 11 Dec 2021 - 27 Dec 2021

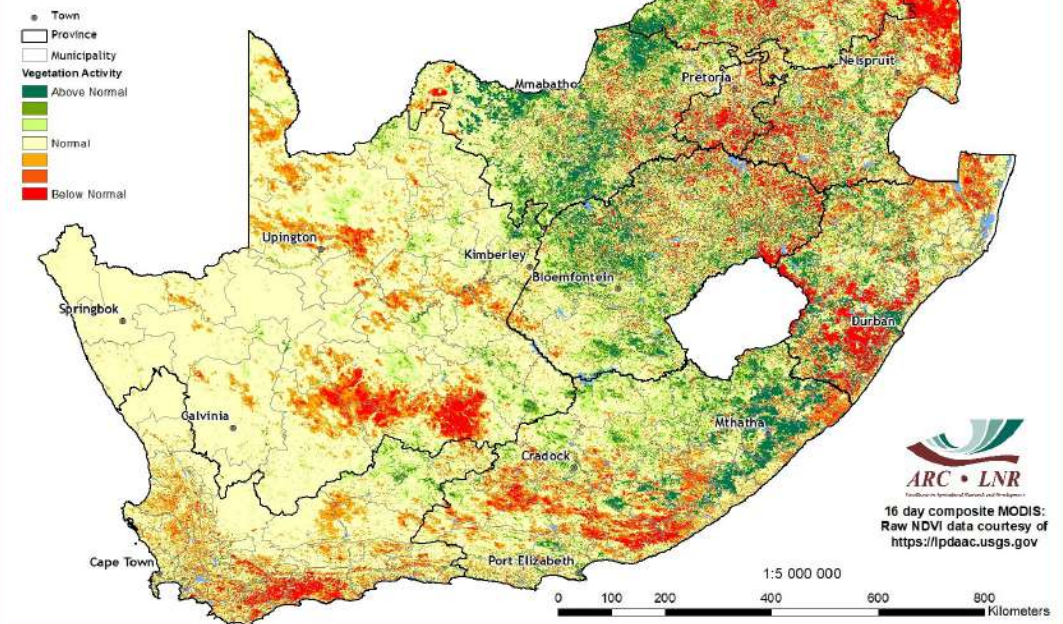


Figure 11

Figure 10:

Compared to the historical averaged vegetation conditions, the 16-day SDVI map for December 2022 shows that areas of poor vegetation activity were restricted to the periphery and the northern parts of the country.

Figure 11:

The 16-day NDVI difference map for December 2022 compared to the preceding 16-day period shows patches of poor vegetation conditions in many areas of the country.

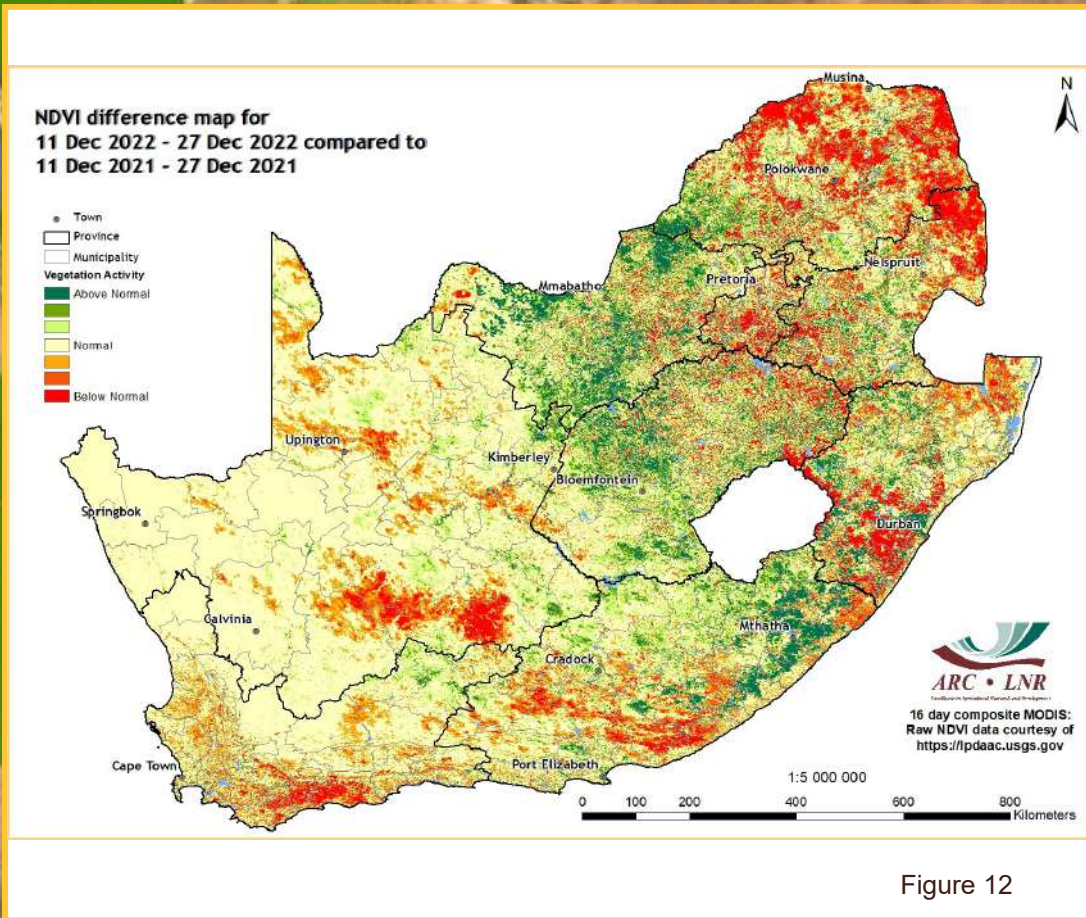


Figure 12

**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

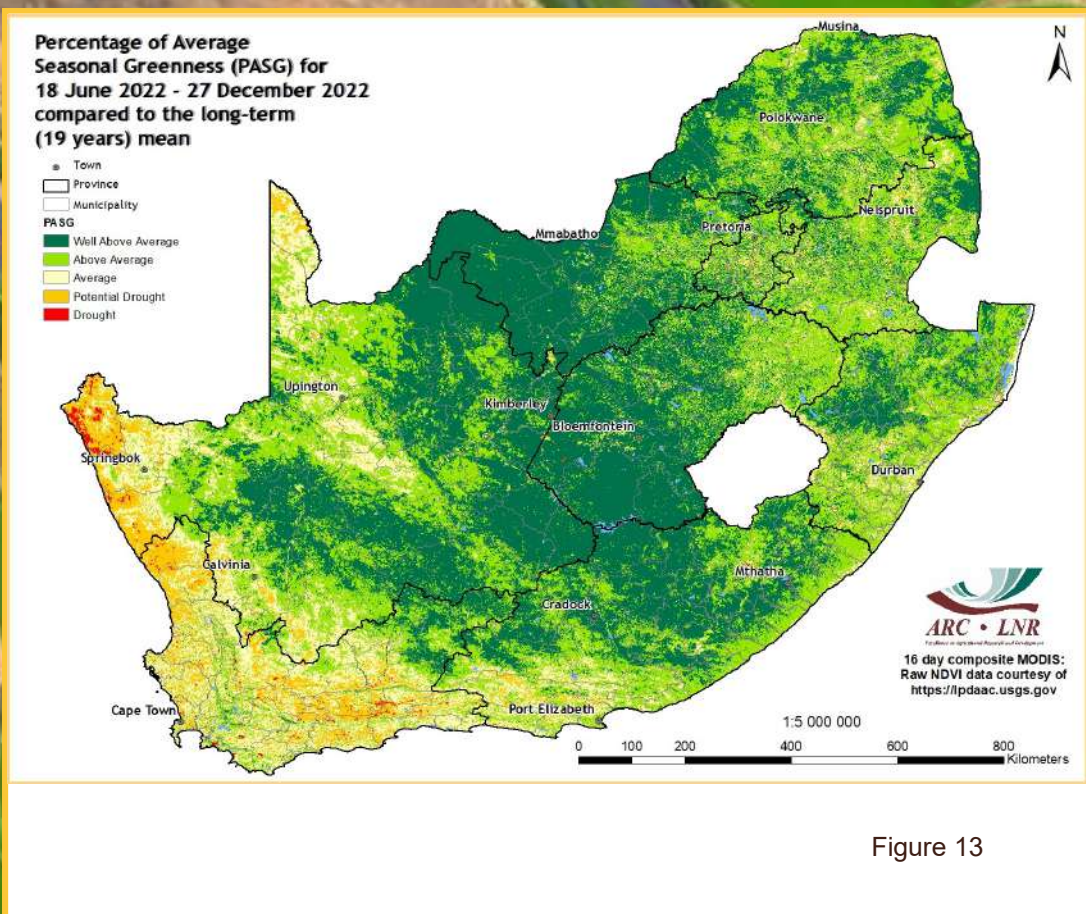


Figure 13

Figure 12:
The 16-day NDVI difference map for December 2022 compared to the same period last year shows a wide range of vegetation conditions across the country with clusters of above-normal vegetation in the interior, patches of below-normal vegetation in the western and far northern parts, and normal conditions more pronounced in the west.

Figure 13:
The Percentage of Average Seasonal Greenness (PASG) map for the past 6 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 11 Dec 2022 - 27 Dec 2022 compared to the long-term (20 years) mean

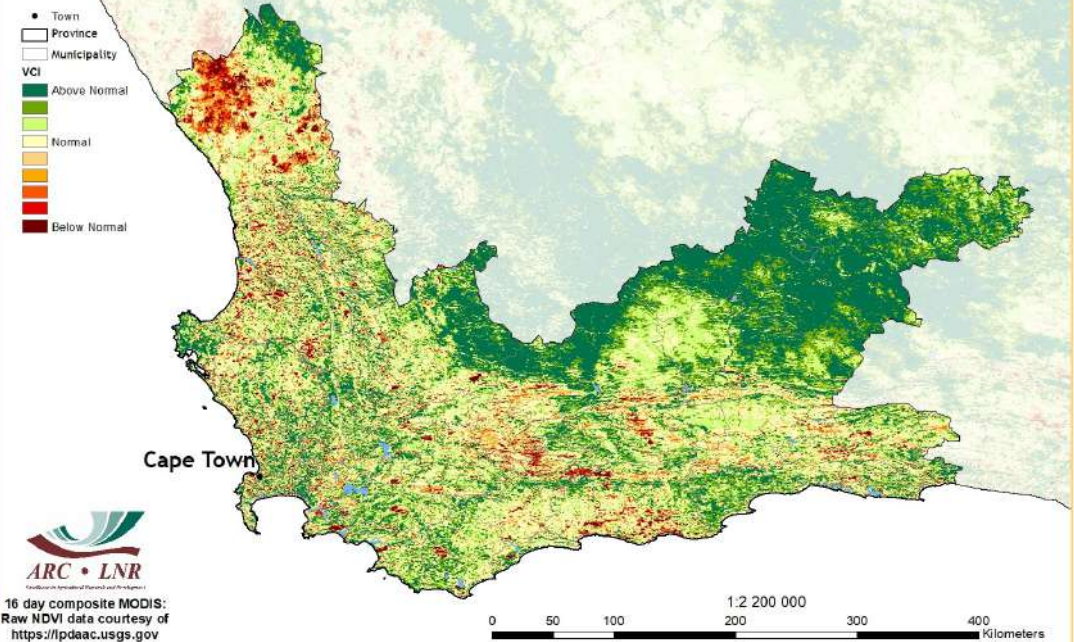


Figure 14

Figure 14:

The 16-day VCI map for December 2022 indicates that 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 December 2022 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 11 Dec 2022 - 27 Dec 2022 compared to the long-term (20 years) mean

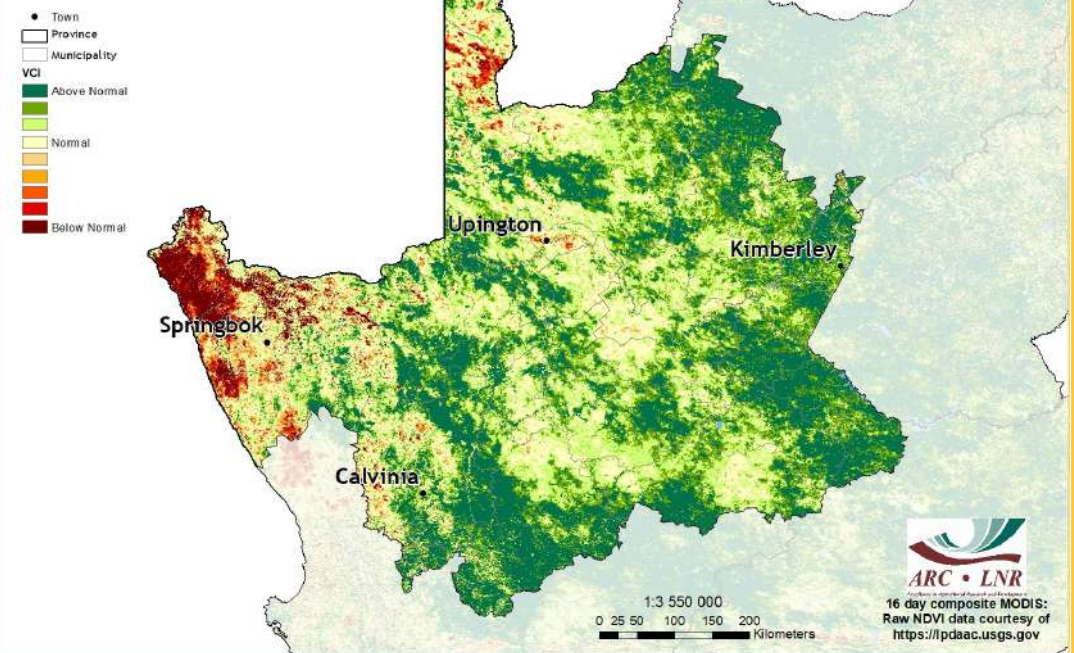


Figure 15

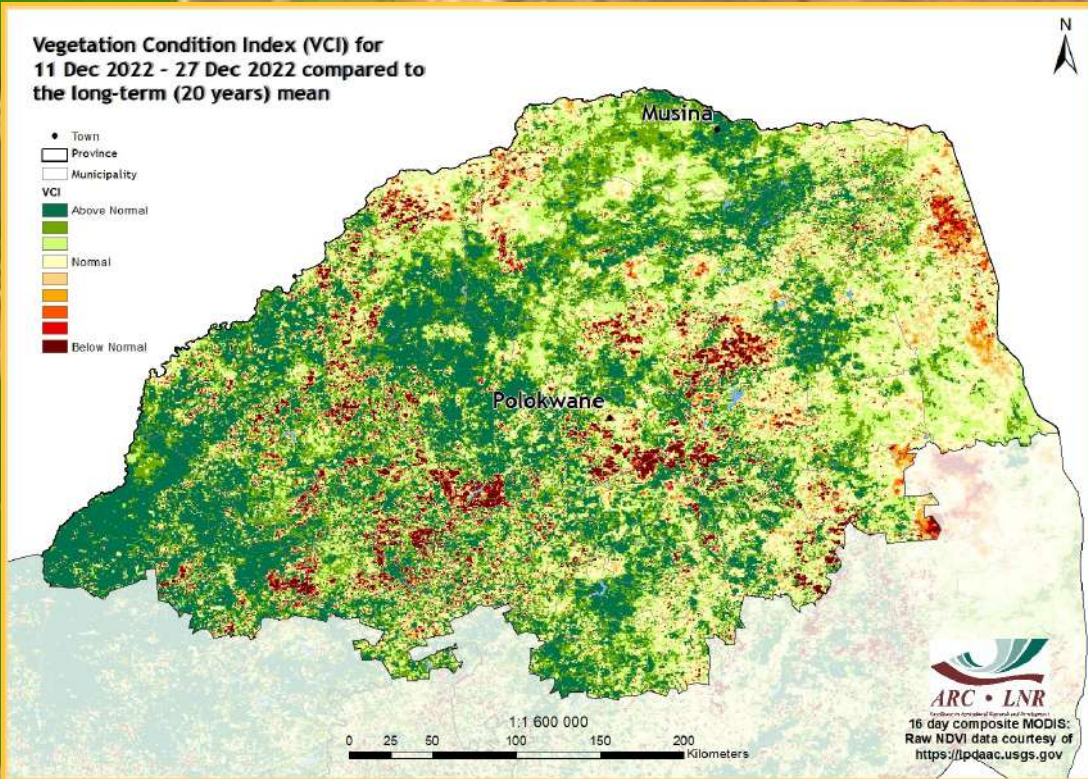


Figure 16

Figure 16:

The 16-day VCI map for December 2022 indicates that above-normal vegetation conditions are prevalent throughout Limpopo with patches of below-normal activity in some areas.

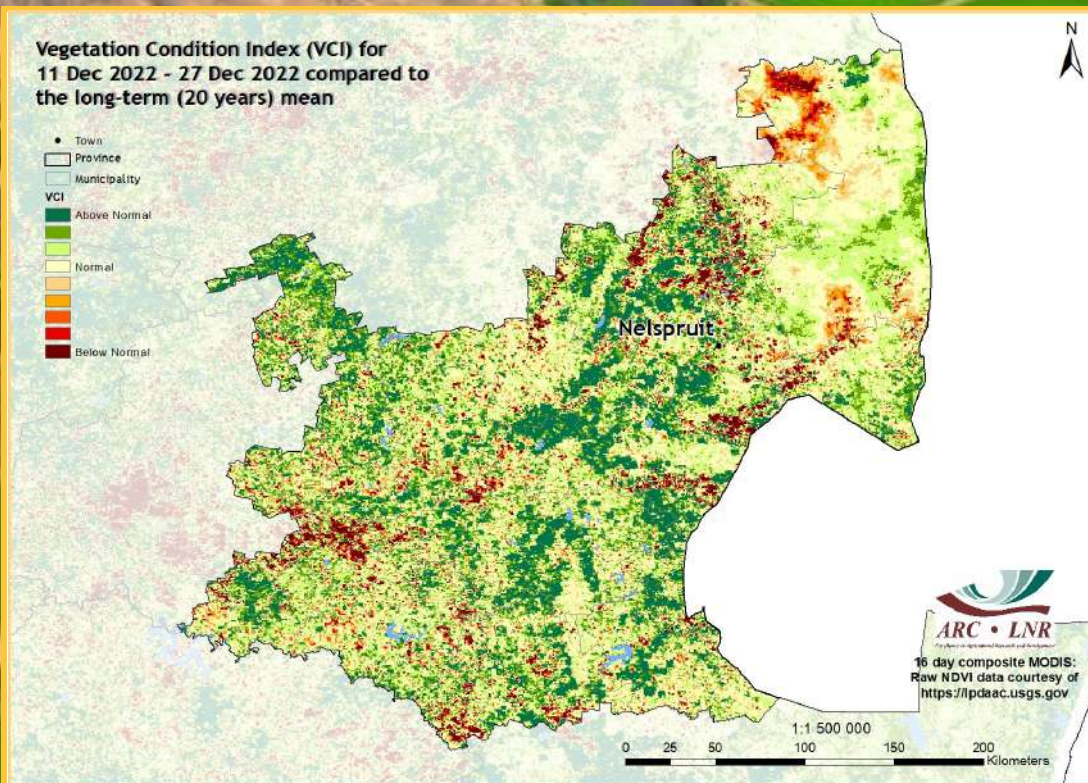


Figure 17

Figure 17:

The 16-day VCI map for December 2022 indicates that above-normal vegetation conditions remain prevalent throughout Mpumalanga, with patches of below-normal activity in some areas.

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6. Vegetation Conditions & Rainfall

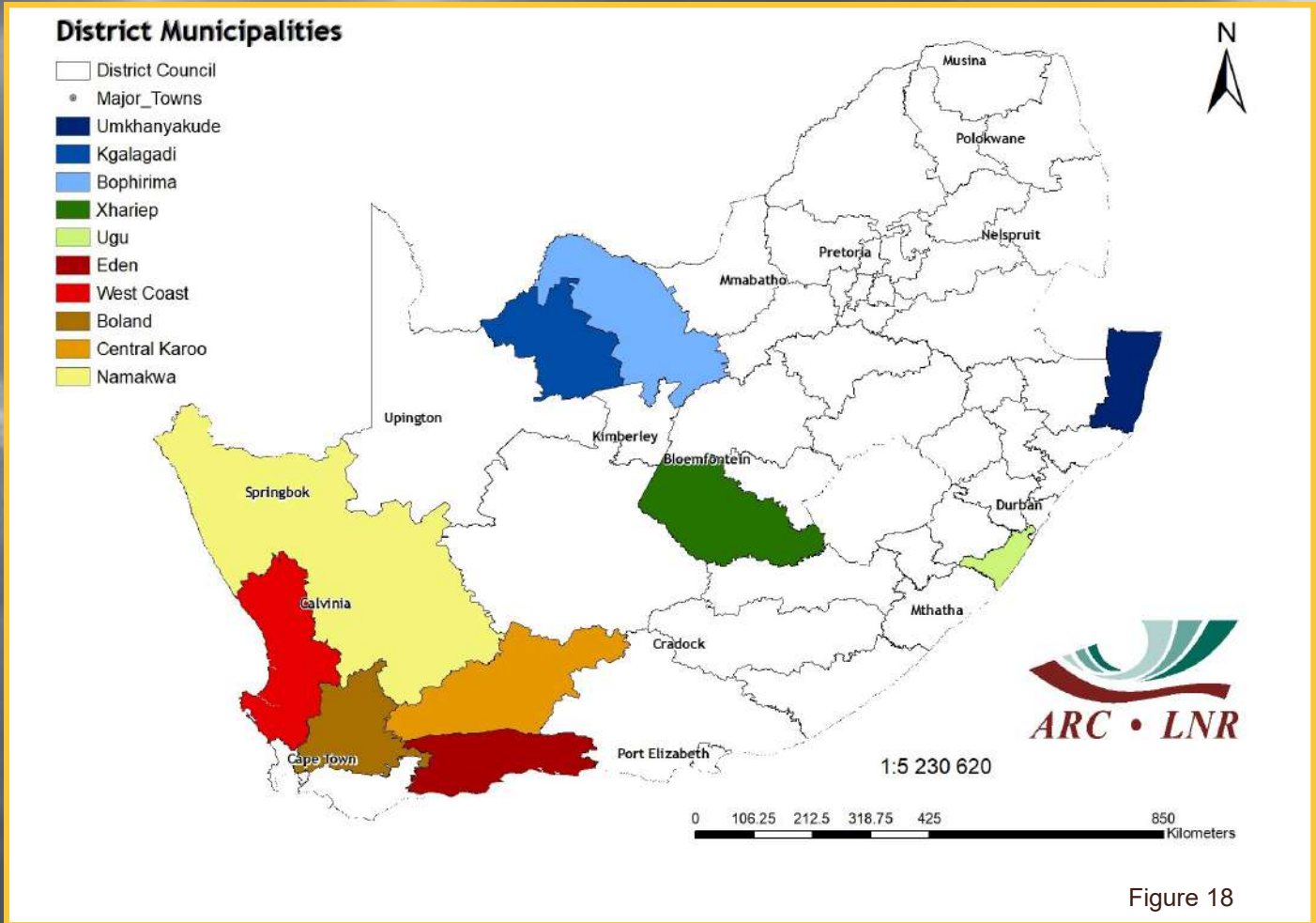


Figure 18

Rainfall and NDVI Graphs

Figure 18: Orientation map showing the areas of interest for December 2022. 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.

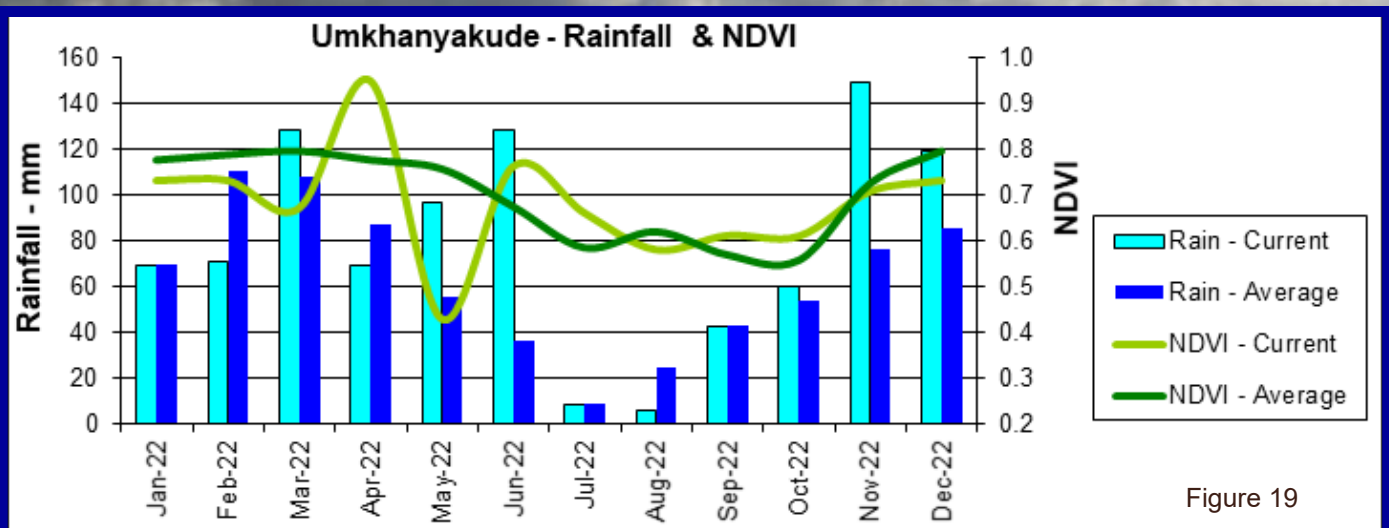
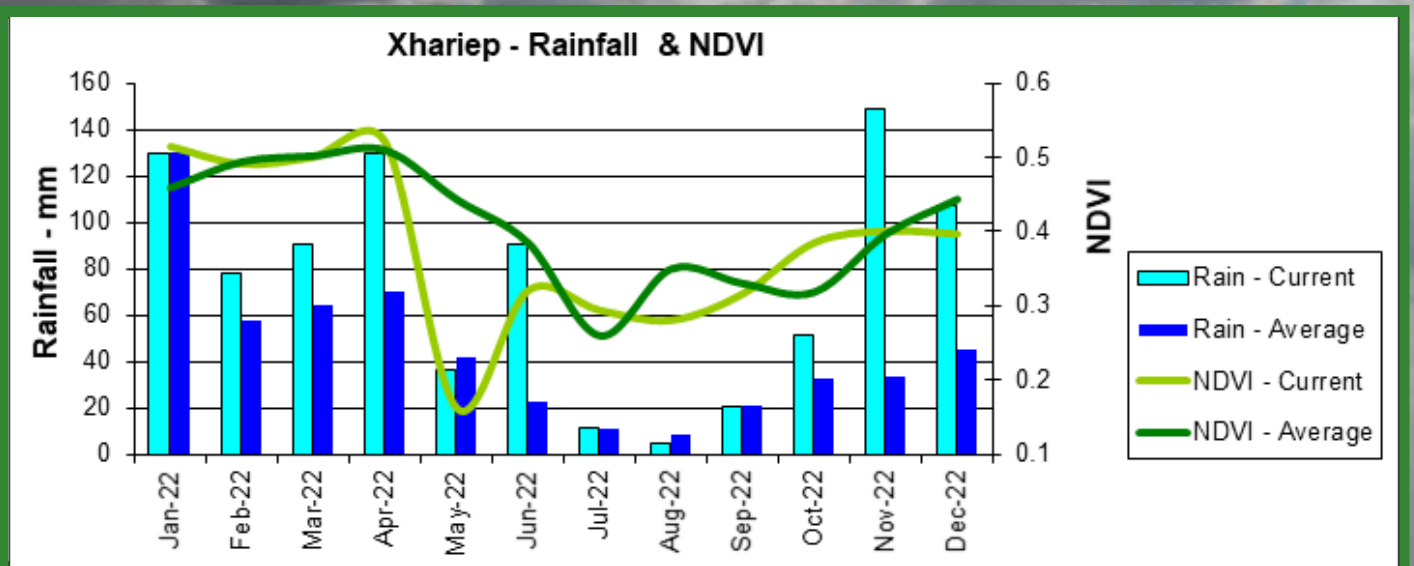
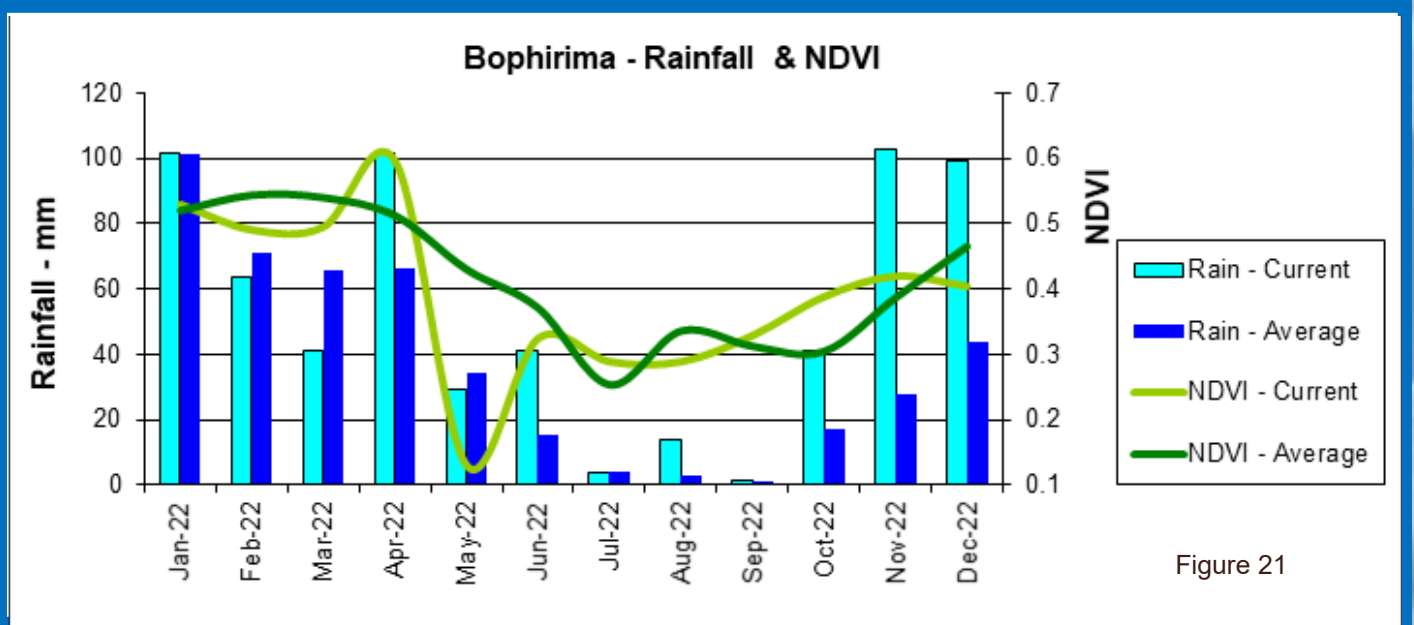
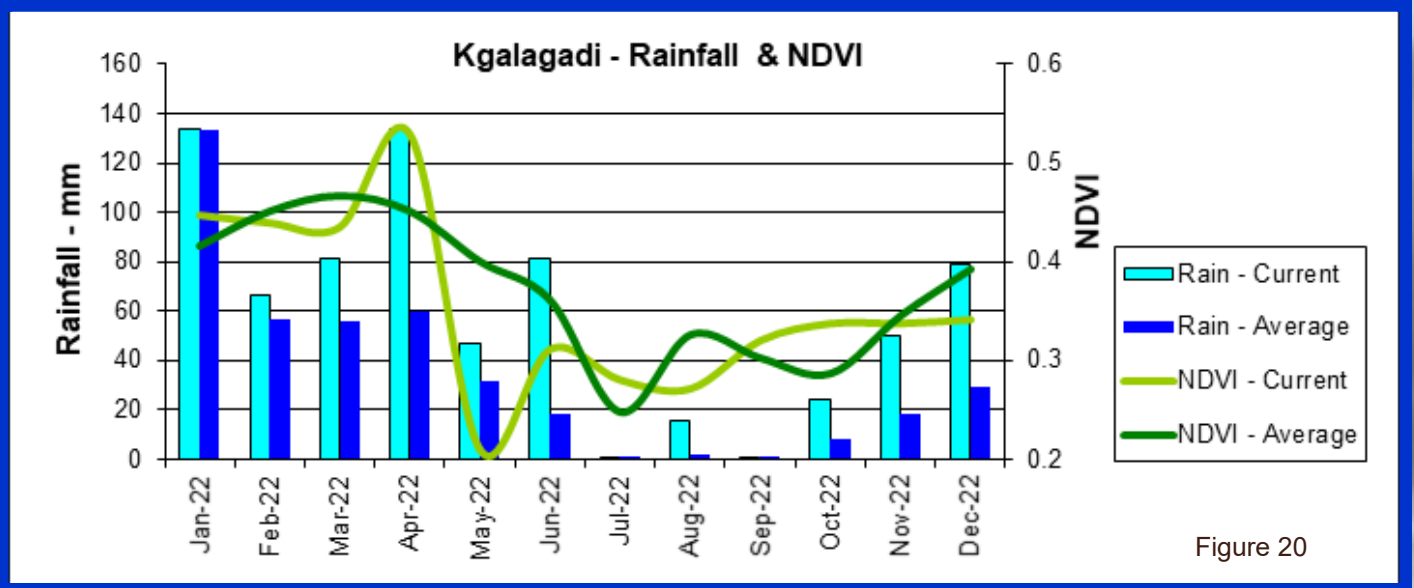
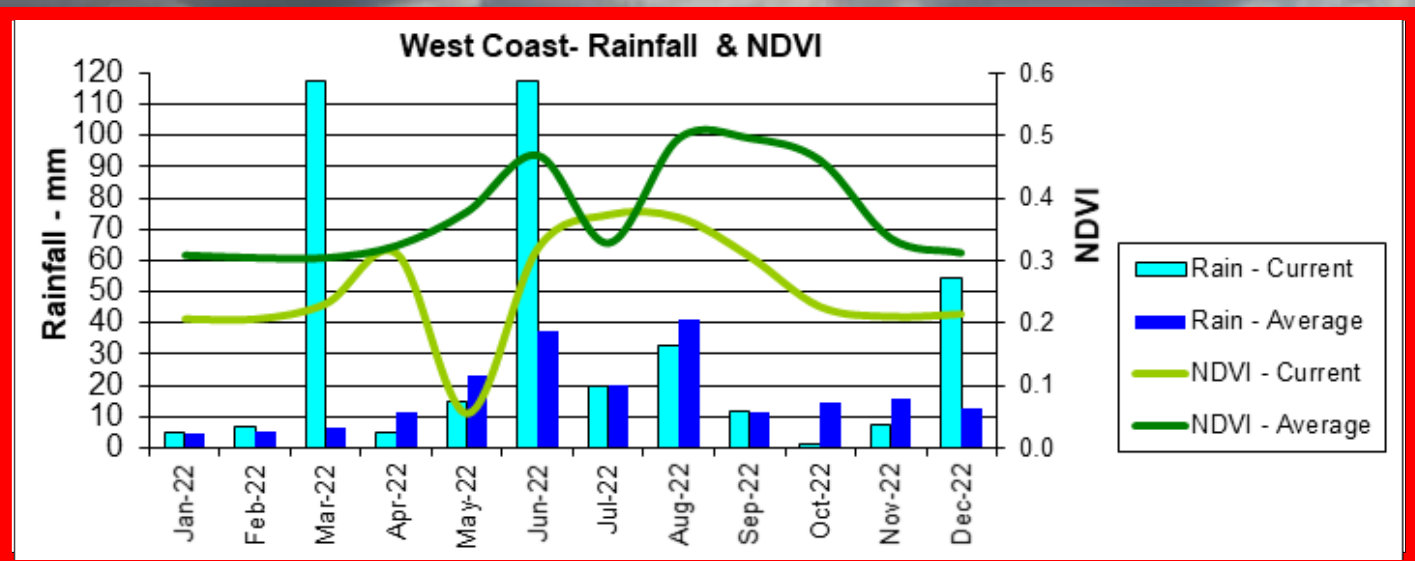
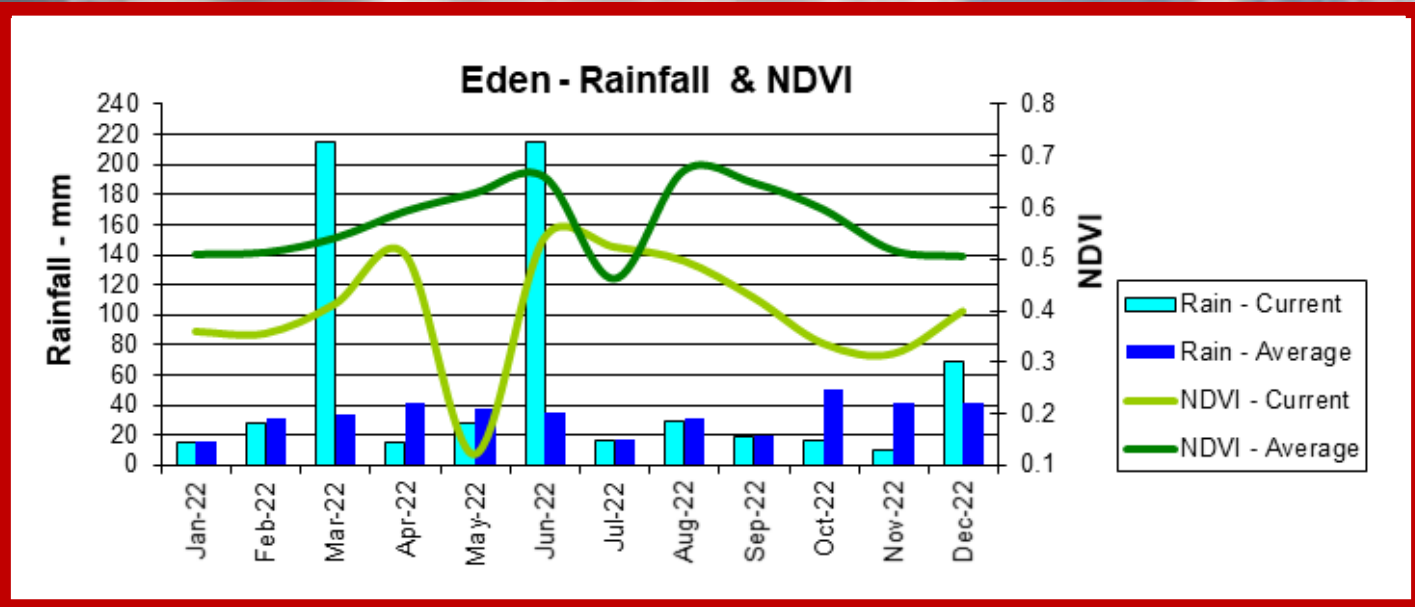
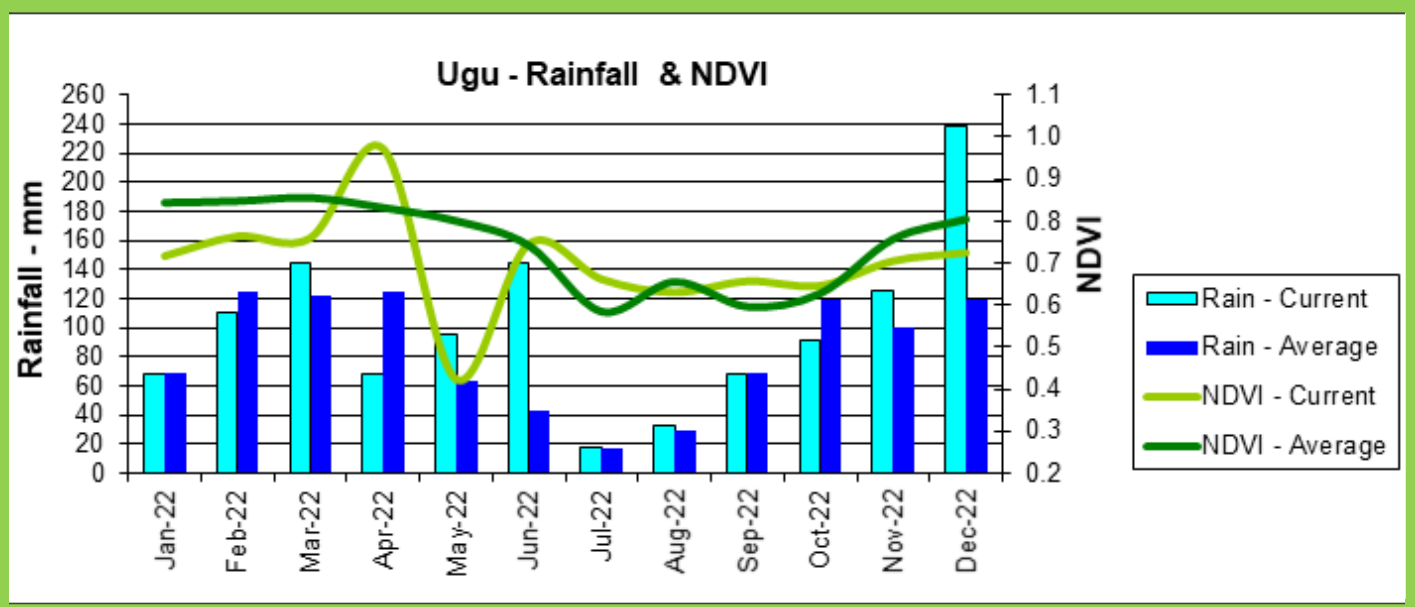


Figure 19





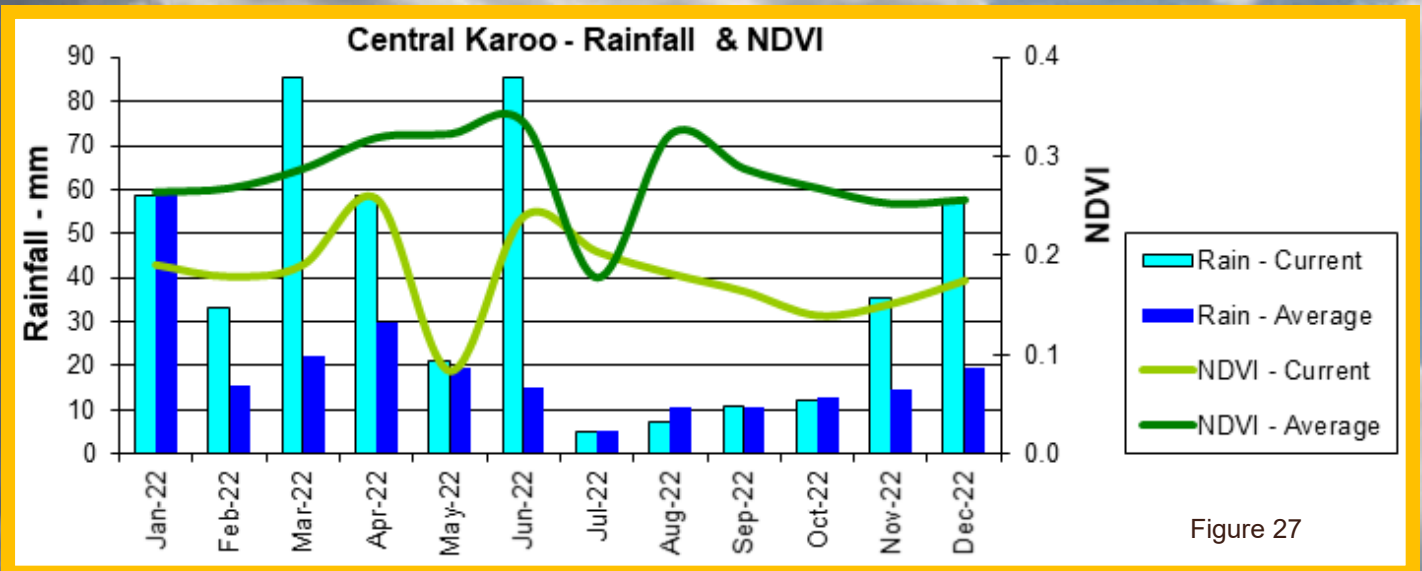
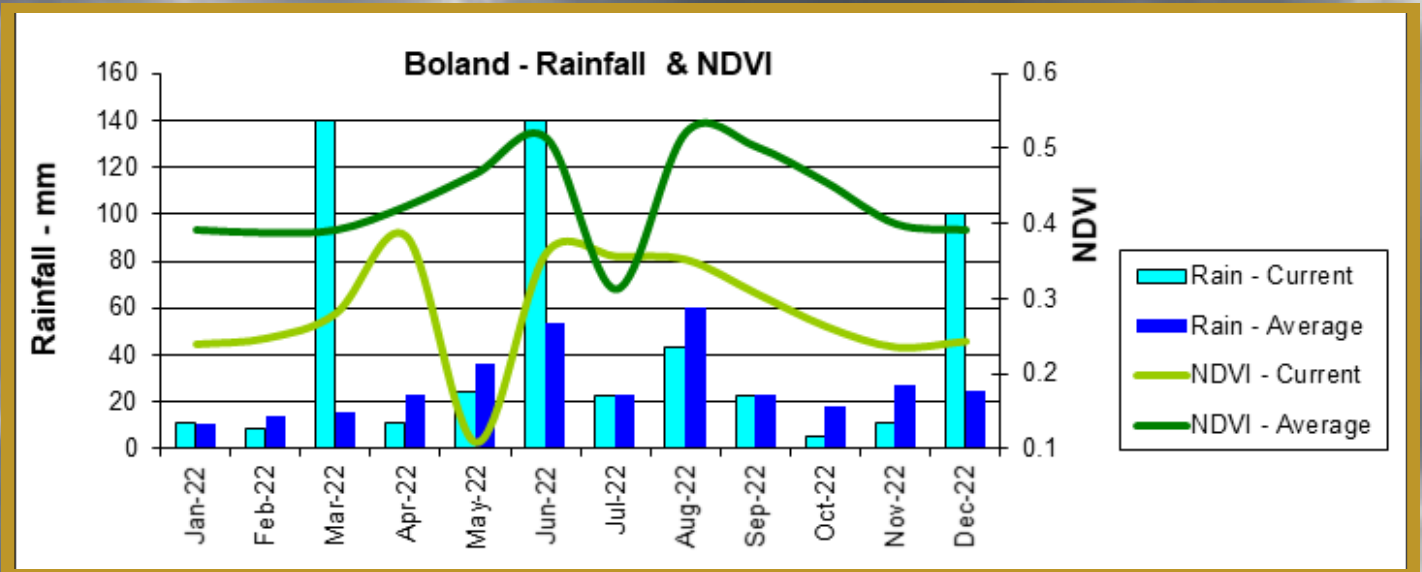


Figure 27

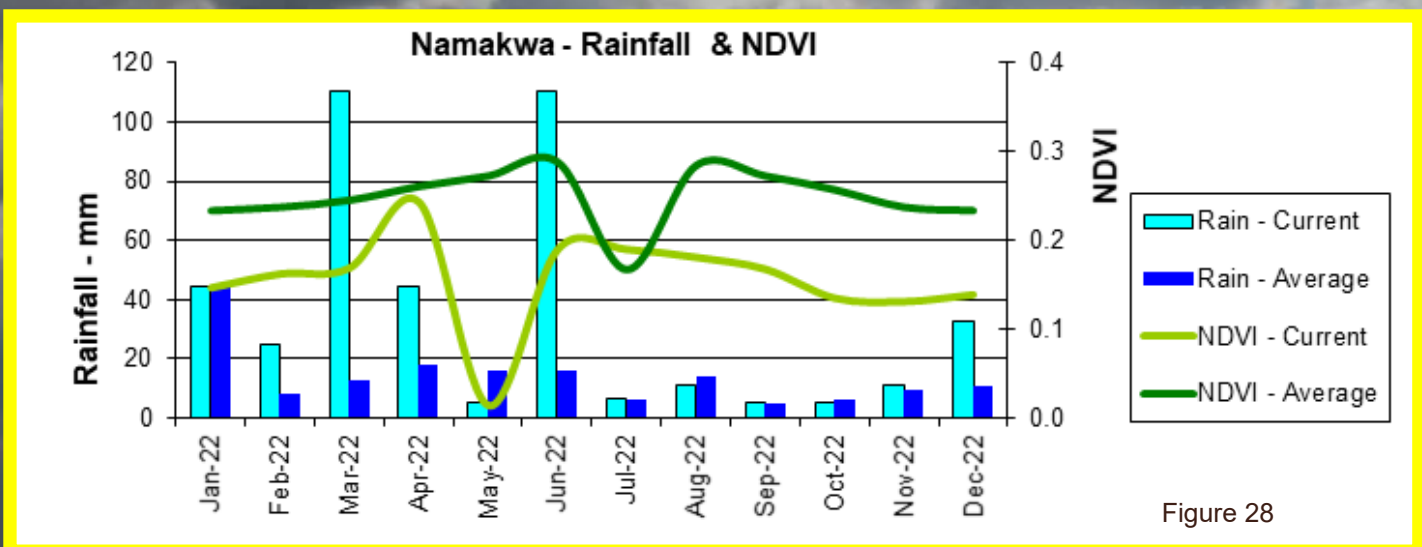


Figure 28

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 2022 to 1 January 2023 per province. Fire activity was higher in North West compared to the long-term average.

Active fire pixels detected from 3 Dec 2022 - 1 Jan 2023

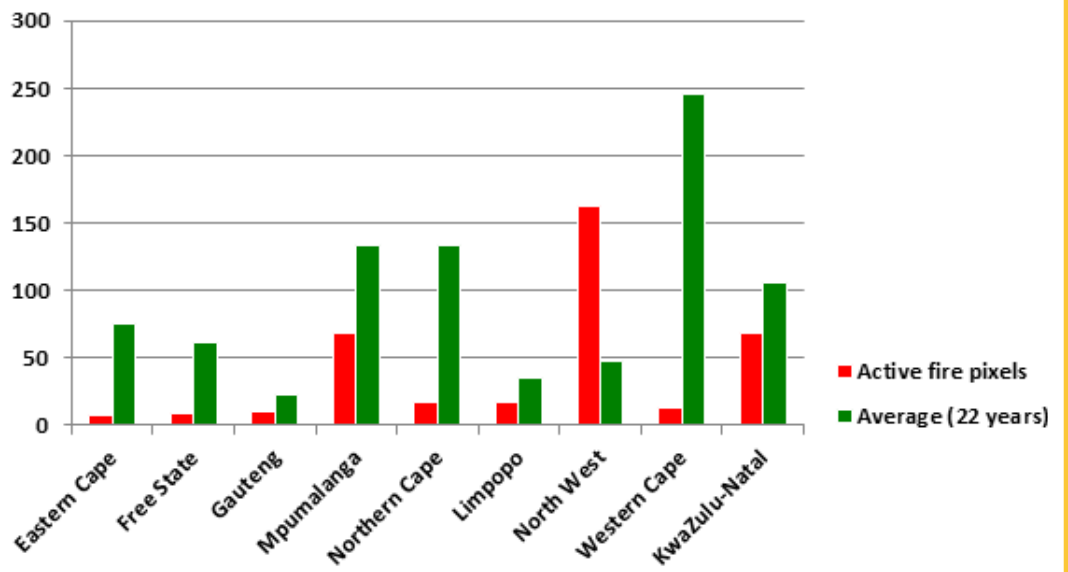


Figure 29

Active fires detected between 3 December 2022 - 1 January 2023

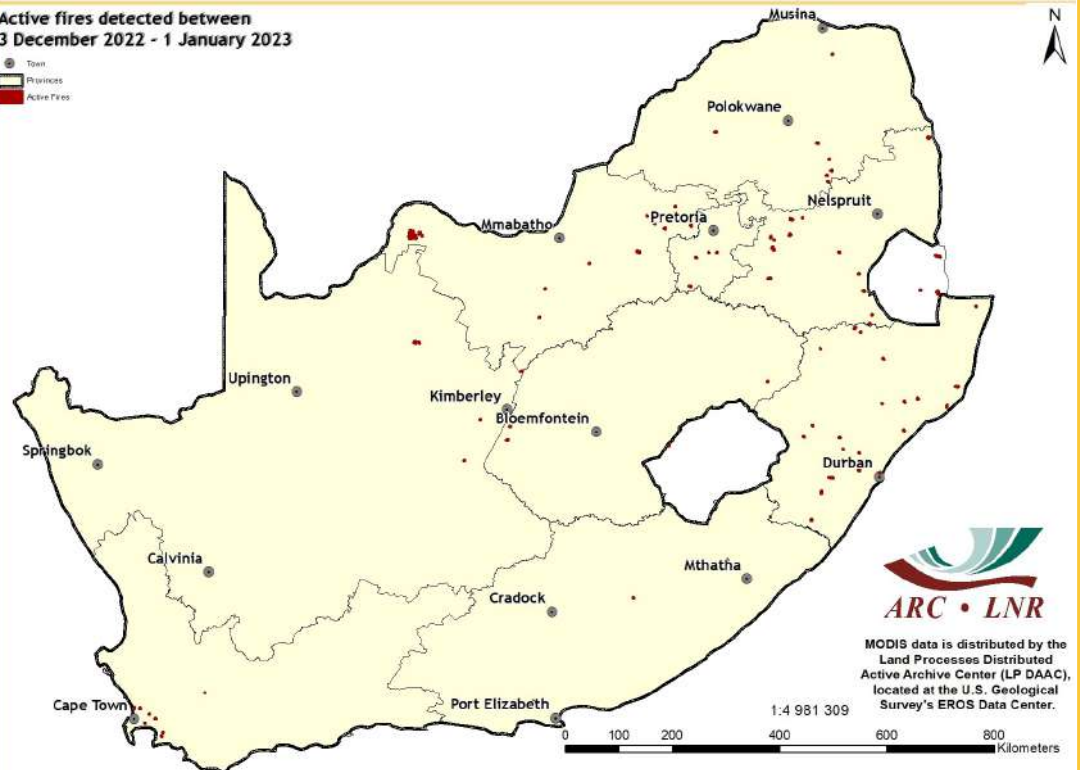


Figure 30

Figure 30:

The map shows the location of active fires detected between 3 December 2022 and 1 January 2023.

Figure 31:
The graph shows the total number of active fires detected from 1 January 2022 to 1 January 2023 per province. Cumulative fire activity remains higher in the Northern Cape and North West, compared to the long-term average.

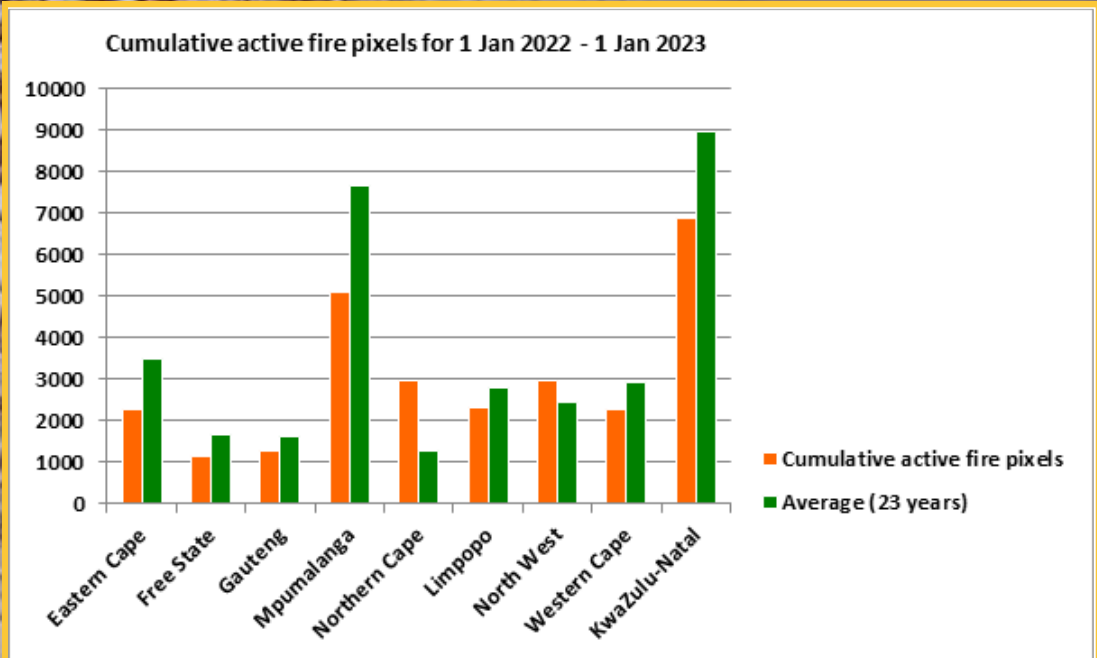


Figure 31

Figure 32:
The map shows the location of active fires detected between 1 January 2022 and 1 January 2023.

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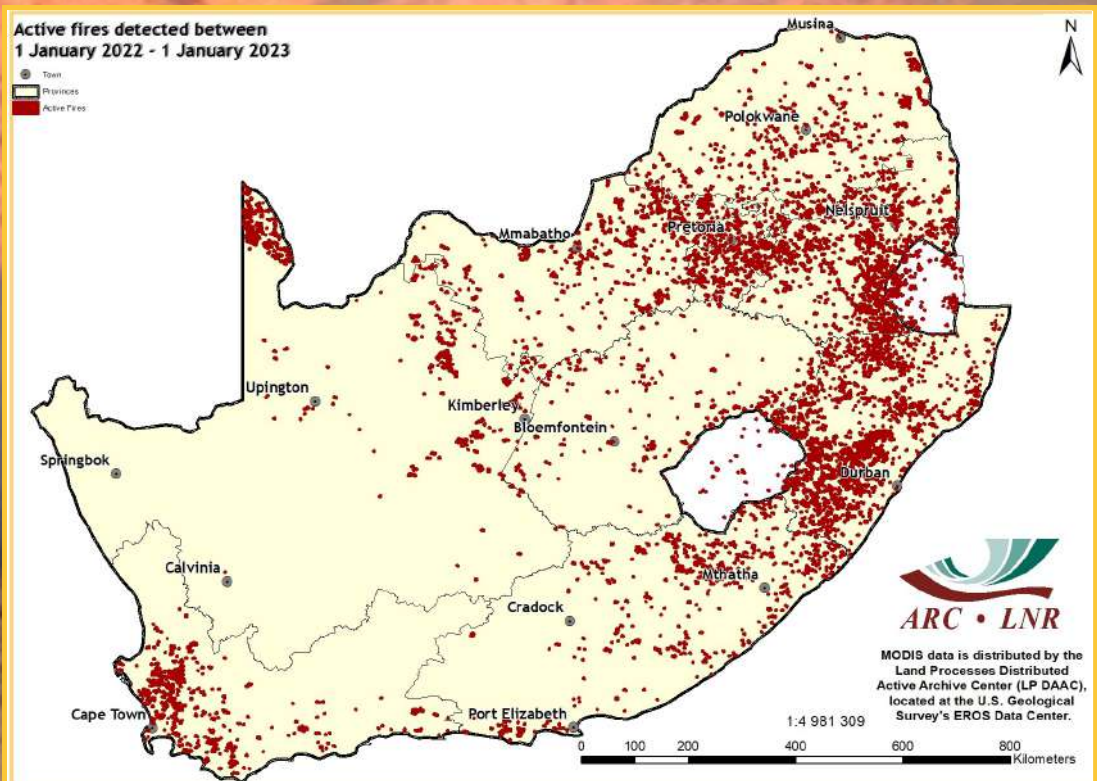


Figure 32

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 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 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 2022 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 December 2022 and December 2021 shows that many catchments across the whole of the interior are showing a similar pattern to the previous month, although there are both localized increases and decreases, with key decreases in some Eastern Cape inland catchments.

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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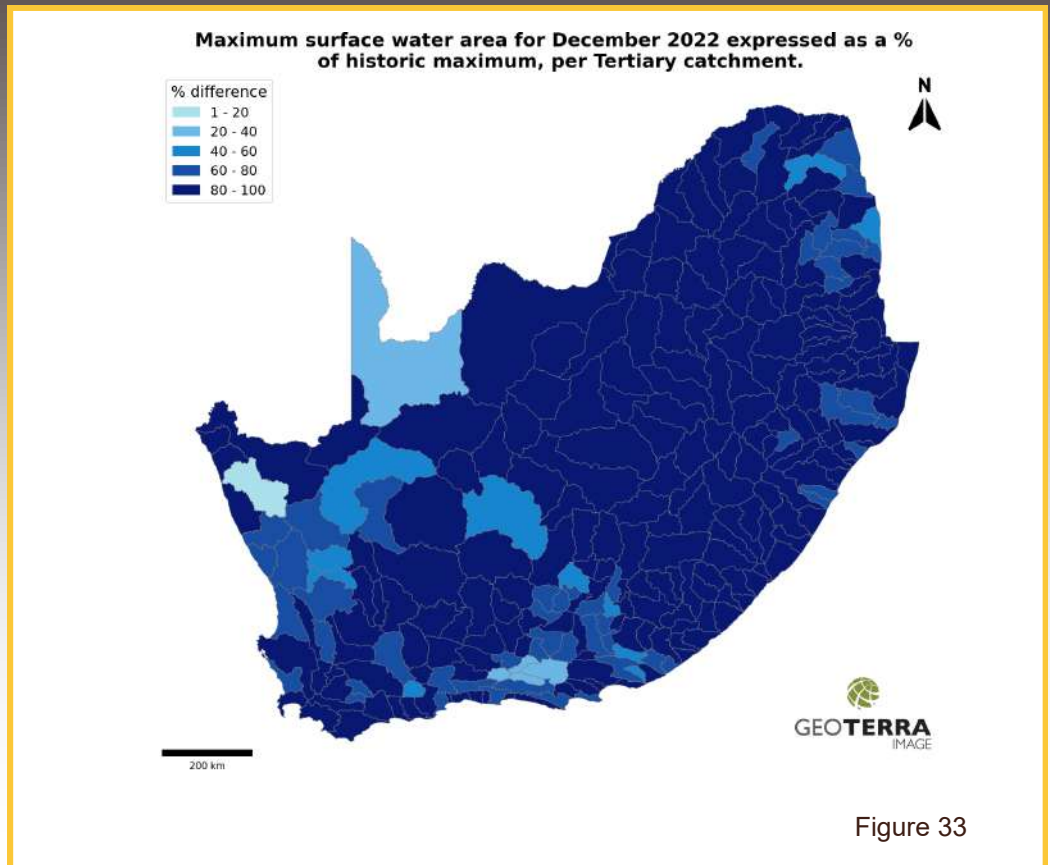


Figure 33

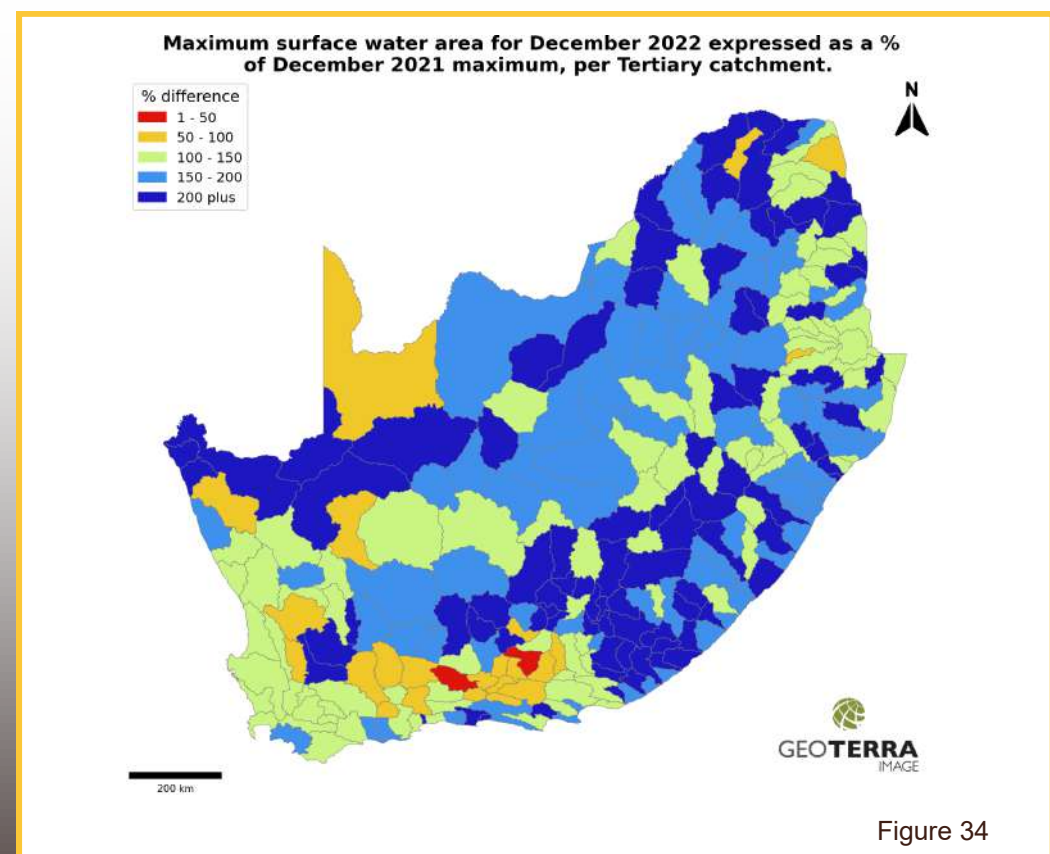


Figure 34



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.

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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

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 m² to 1 km²) 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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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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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.