UNITED NATIONS-AUSTRIA SYMPOSIUM ON INTEGRATED SPACE TECHNOLOGY APPLICATIONS FOR CLIMATE CHANGE 12-14 SEPTEMBER 2016

CHARACTERIZING ECOSYSTEM RESPONSE TO CLIMATE CHANGE IN SOUTH AFRICA USING EARTH OBSERVATION TECHNOLOGY

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WATER RESEARCH COMMISSION

UNIVERSITY OF LIMPOPO

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Outline

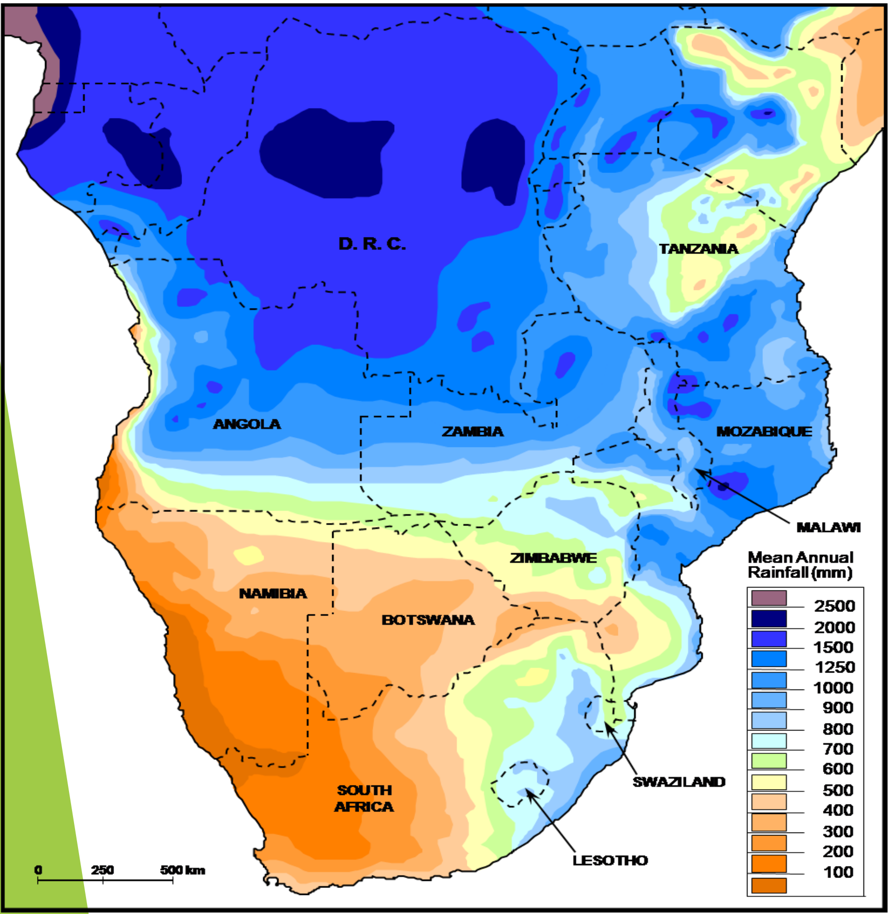
- Introduction and Climate Overview
- Earth Observation Applications (Natural Vegetation and Agro-ecosystems)
- Adaptive Options and Interventions
- Concluding Remarks

Introduction

- Water is critical for development, economic growth and better life.
- Climate plays a significant role to the country's economic development.
- Natural and anthropogenic activities drives the change in climate by altering the Earth's energy budget.
- The IPCC recognizes a clear cause and effect relationship between the enormous growth in the emissions of GHGs, escalating global average temperatures and extreme weather events.
- This therefore calls for positioning and reorientating various sectors in order to realign development with the changing climate (structural and economic reforms).
- Applications of remote sensing are expected to contribute to guidance, advice and direction for reorientation and developmental response in light of the changing climate.

Average annual rainfall & water resource situation

South Africa is characterized by a skewed distribution of **rainfall,** high **solar radiation** and high **evaporation** rate



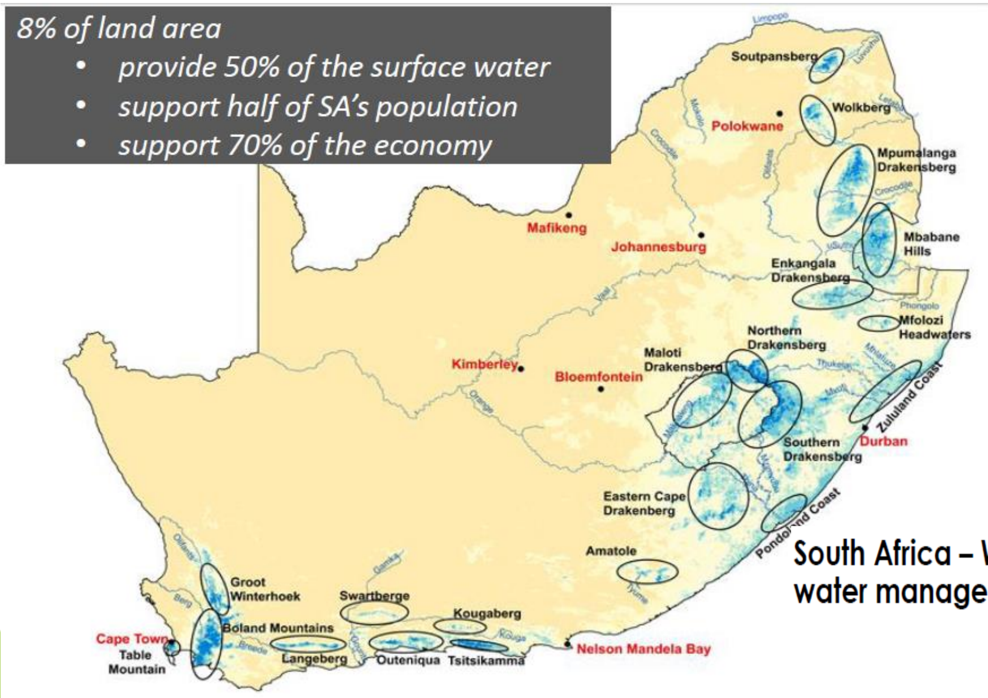
WRC-UNEP, 2006

- Rainfall high: 1500mm N & E; reduces towards S & W: 100mm;
- Water availability is accordingly skewed in terms of distribution (estimated at 650 billion m^3)
- Evaporation rates far exceeds precipitation (relatively higher in areas where it rains less)
- Water is not always fit for use, even under natural conditions
- This translates into water scarcity (even before taking climate change or human induced impacts into account)
- Increased occurrence of extreme climate events.

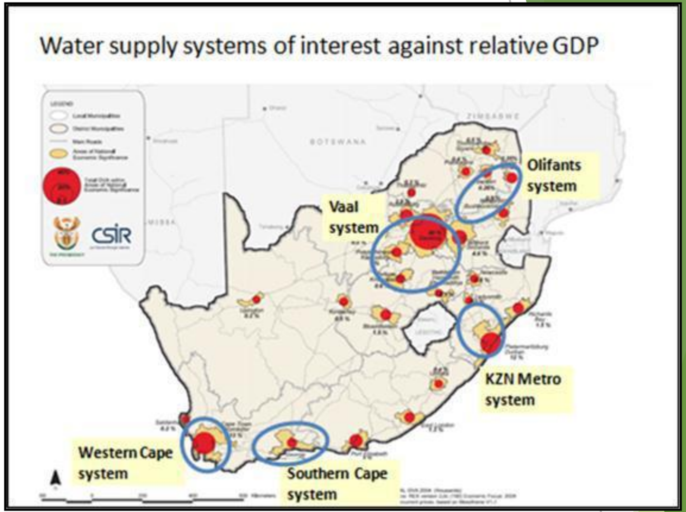
Water and SA's economic hubs

8% of land area

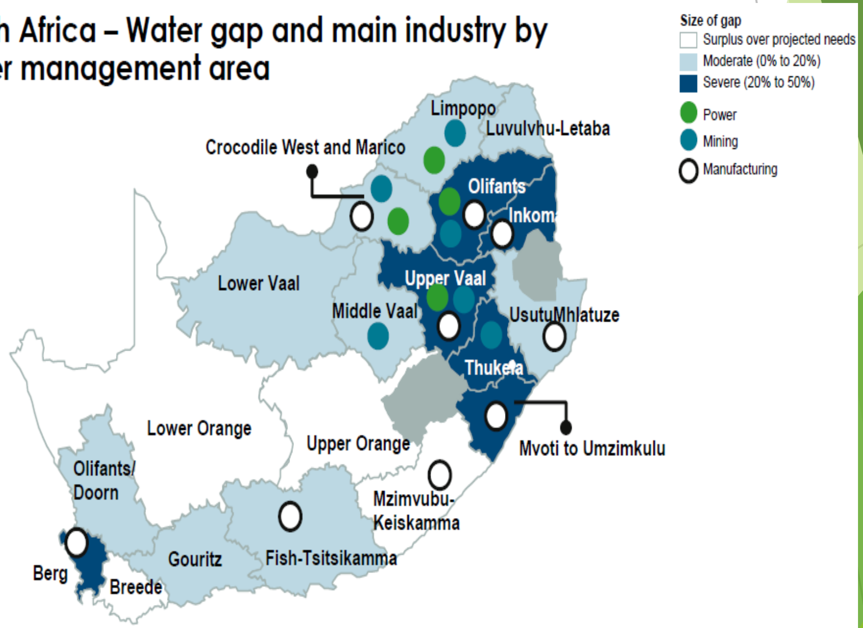
- *provide 50% of the surface water*
- *support half of SA's population*
- *support 70% of the economy*



Strategic Water Resource Areas



South Africa – Water gap and main industry by water management area

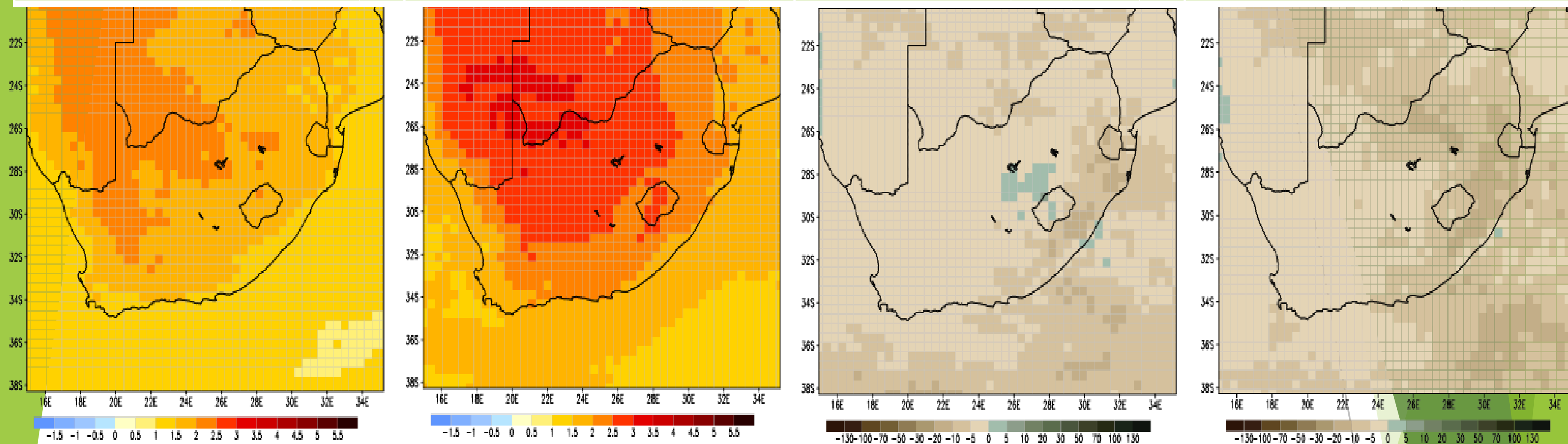


SOURCE: National Water Resource Strategy; DWAF; 2030 Water Resources Group

Projected change

RCP 4.5: Annual temperature change (ºC) relative to 1985-2005 **RCP 4.5: Annual rainfall change (mm/month)** relative to 1985-2005

2046 - 2065 (+50 years)	2076 - 2095 (+80 years)	2046 - 2065 (+50 years)	2076 - 2095 (+80 years)



RCP 8.5: Annual temperature change (ºC) relative to 1985-2005 **RCP 8.5: Annual rainfall change (mm/month)**

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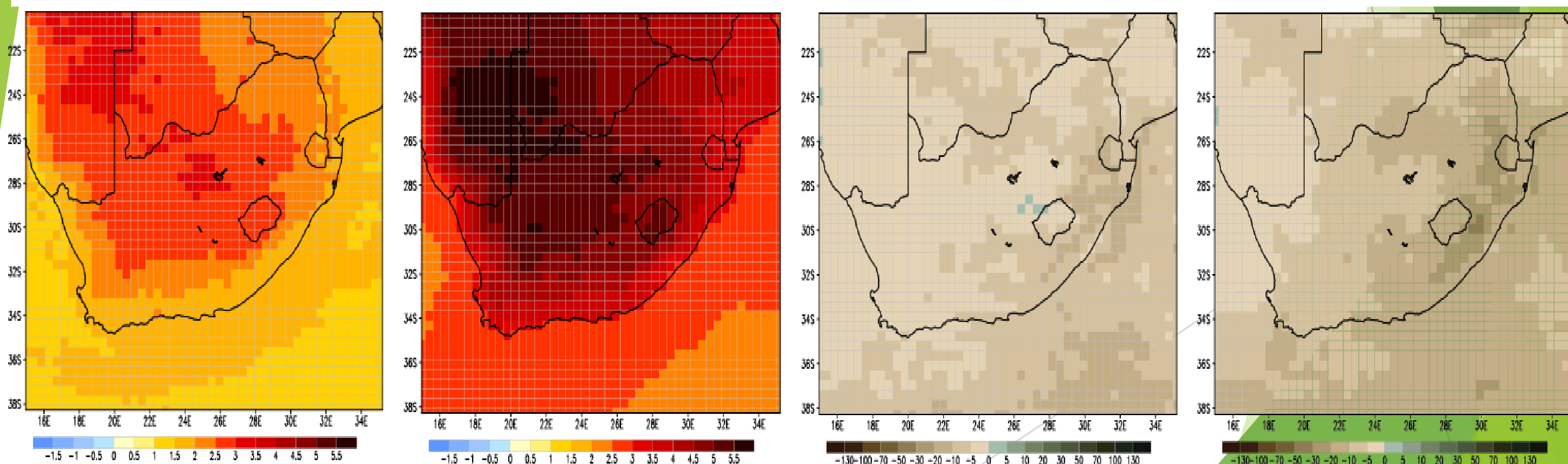
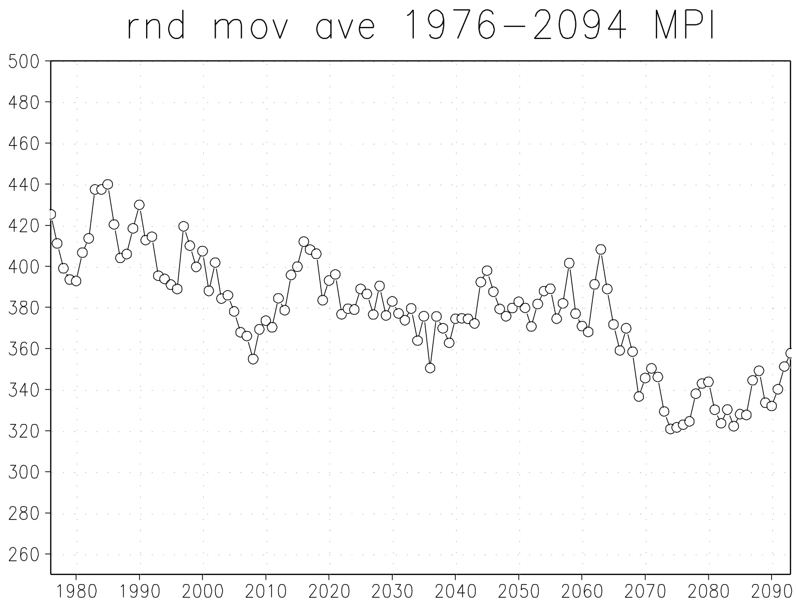
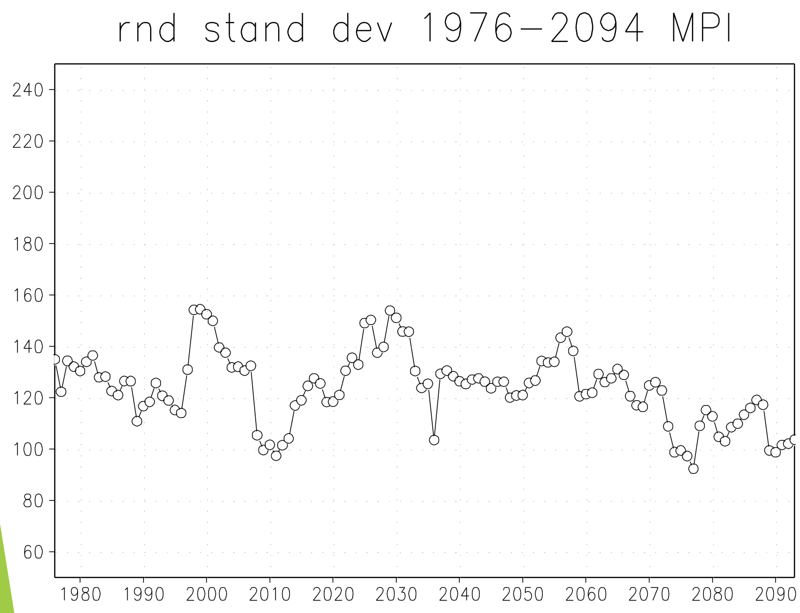


SAWS WRC project 2247





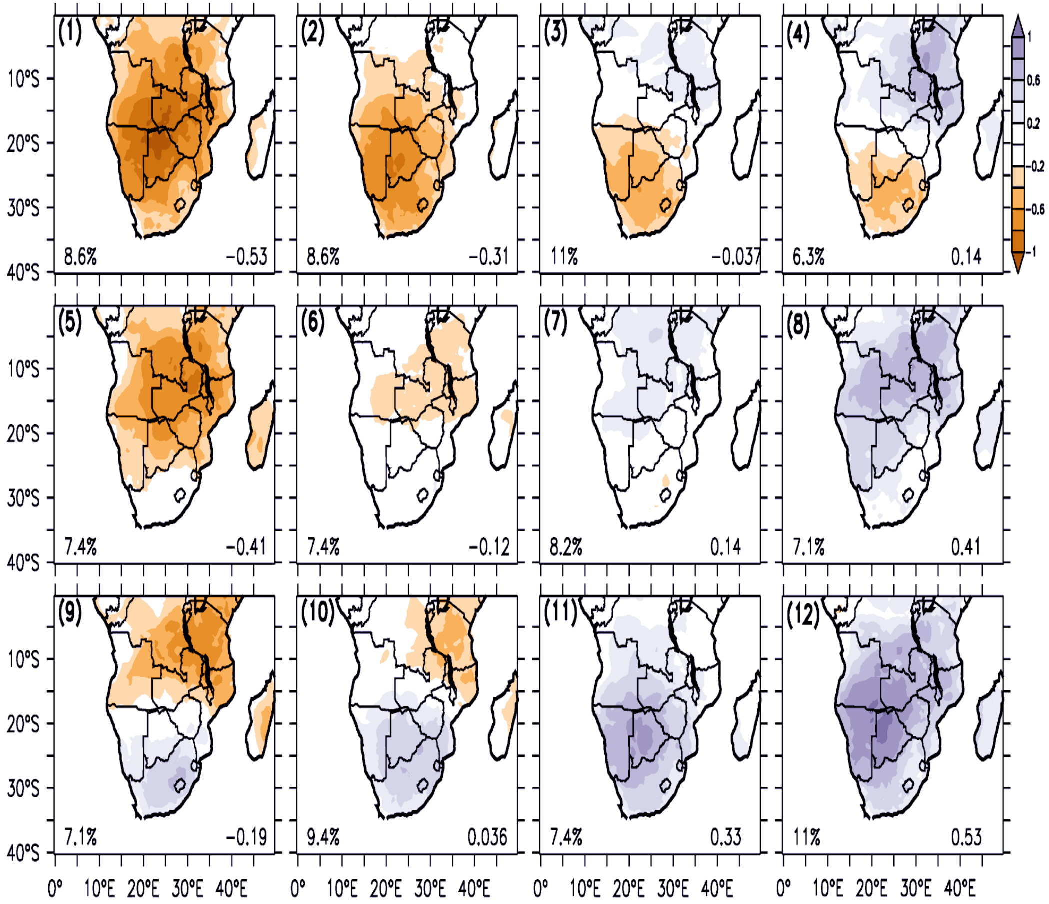
Predictability of hydroclimatic variability over eastern South Africa under climate Change

WRC Project K5/2457

Projected changes in the 11-year moving average of summer rainfall (top) and the variability of rainfall (bottom) over the mega-dam area of South Africa under low mitigation, for a single downscaling. WRC K5/2457 considers the largest ensembles of projections generated for this region to date.

CSIR-CSIRO-CHPC-WRC

Drought patterns over Southern Africa



These are the 12 major types (or patterns) of regionally extensive droughts in southern Africa.
The colours show the values of a drought index (Standardized Evapotranspiration Index). The index is calculated from surface water balance (rainfall minus potential evapotranspiration). Hence, it account for the influence of global warming. A negative value indicates a dry condition (drought), while a positive indicates a wet condition.

The four drought patterns at the edges show the extremes cases of drought patterns:
Top-left => The entire region is experiencing drought
Bottom-right => The entire region is experiencing a wet condition
Top-right => The northern half is experiencing a wet condition, while the southern half is experiencing drought.
Bottom-left => The northern half is experiencing drought, while the southern half is experiencing a wet condition.

SA's vulnerability to climate change



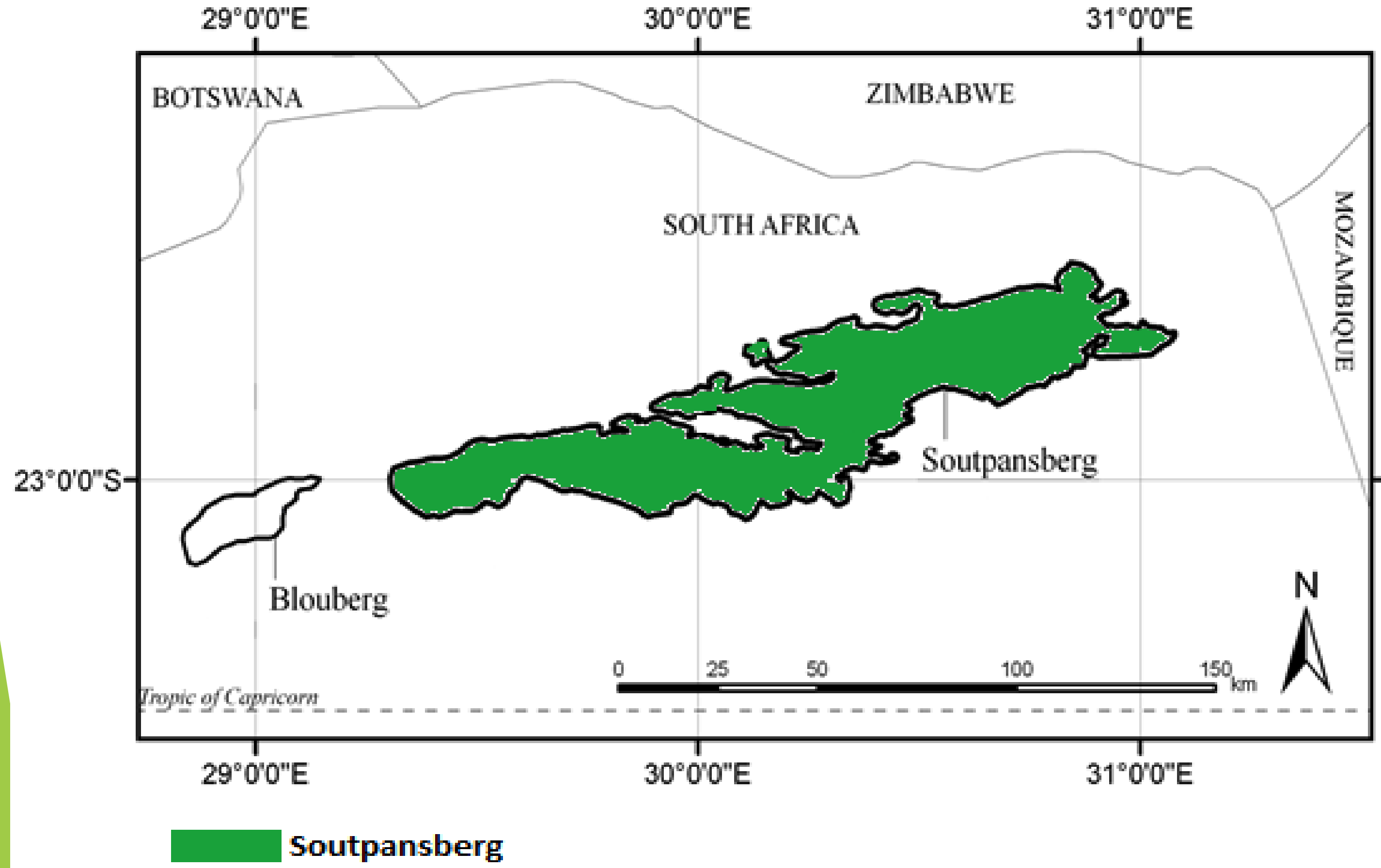



System/ Conditions	Changes
Water	already fully allocated; reductions in availability, increased frequency of extremes
Agriculture	Food security, most scenarios suggest adverse impacts in the agricultural and forestry sectors, with emphasis to small-scale farmers,
Human health	strong interactions with environmental quality and current disease burden
Extreme events	weather-related impacts are already exacerbated by poor land management
Natural resources	degradation trends likely worsen without addressing sustainable management issues; opportunities for increasing resilience of rural and urban communities
Human settlements and livelihoods	emerging understanding suggests significant and adverse impacts

Source: DEA

Earth Observation Applications

CLIMATE CHANGE AND NATURAL FOREST DECLINE



Kephe, Petja and Kabanda, 2015

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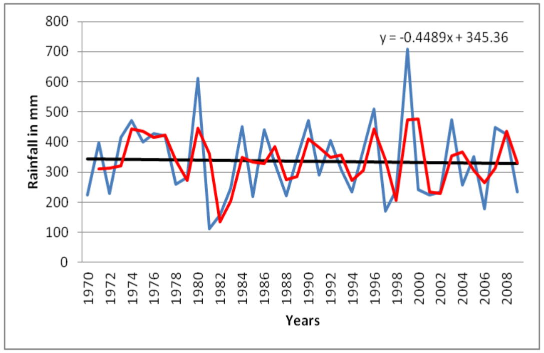
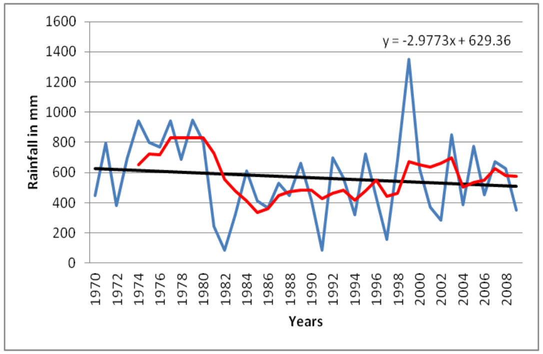
Climatic trends

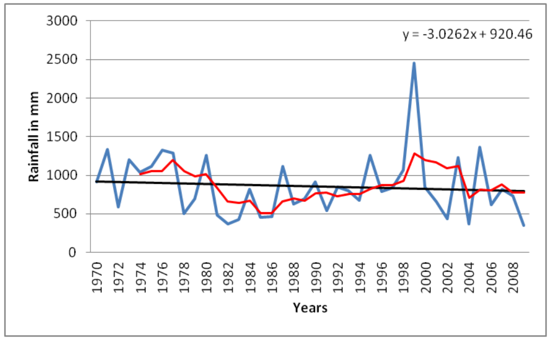
NW



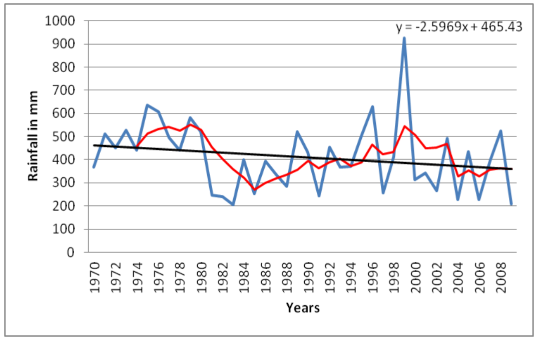
NE



SW

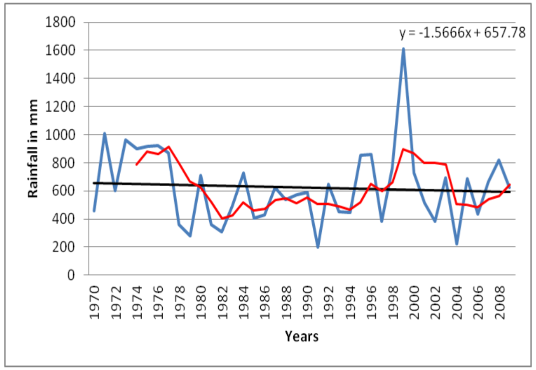


SE



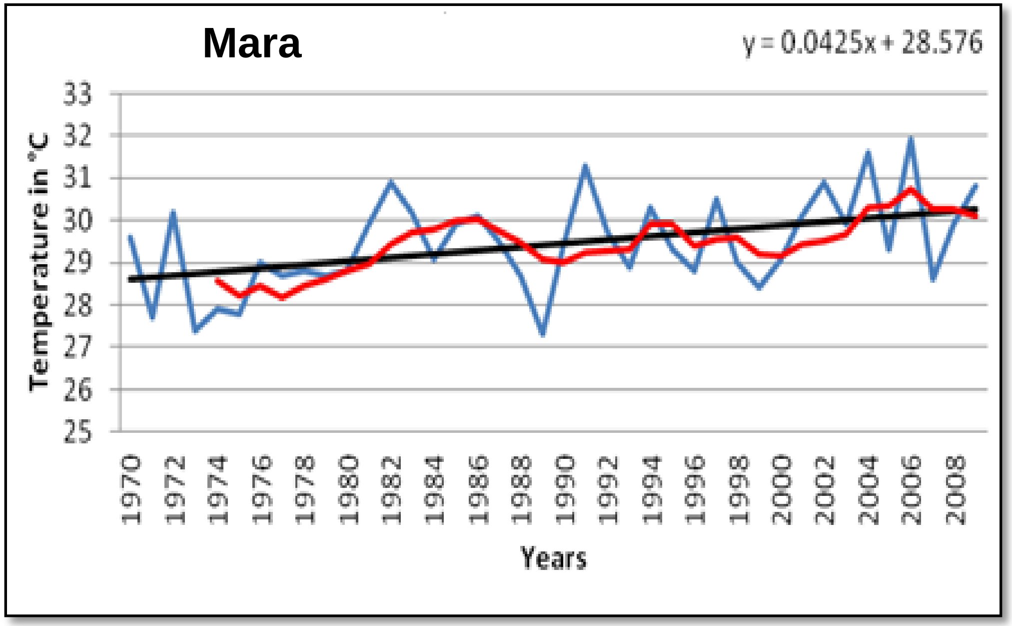
CE

Rainfall

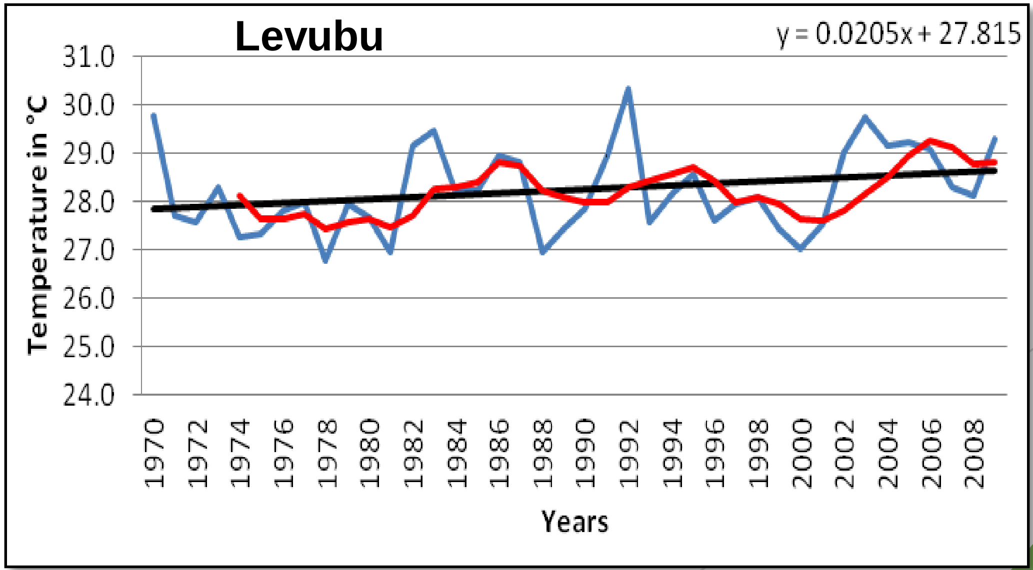


Actual rainfall; 5- year moving average; Trend

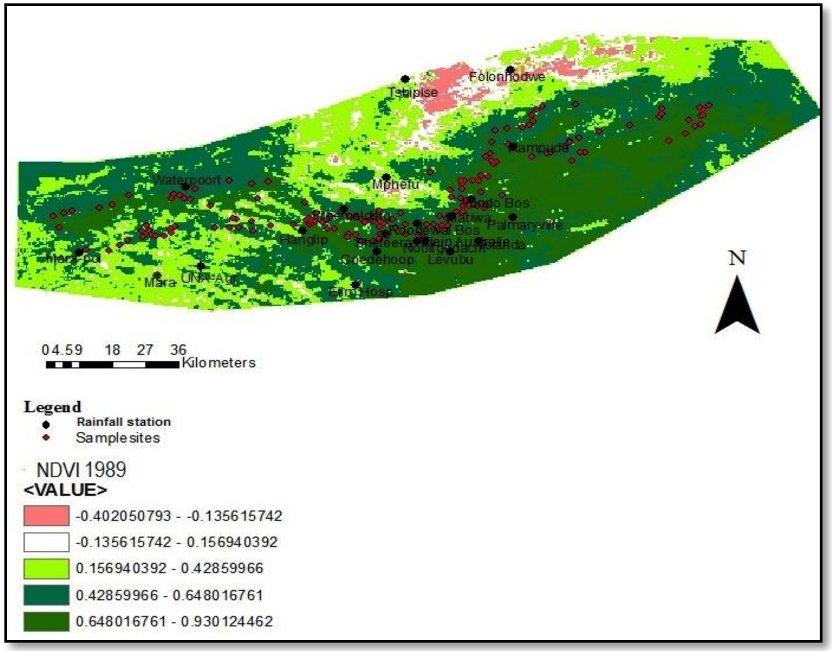
Climatic trends…

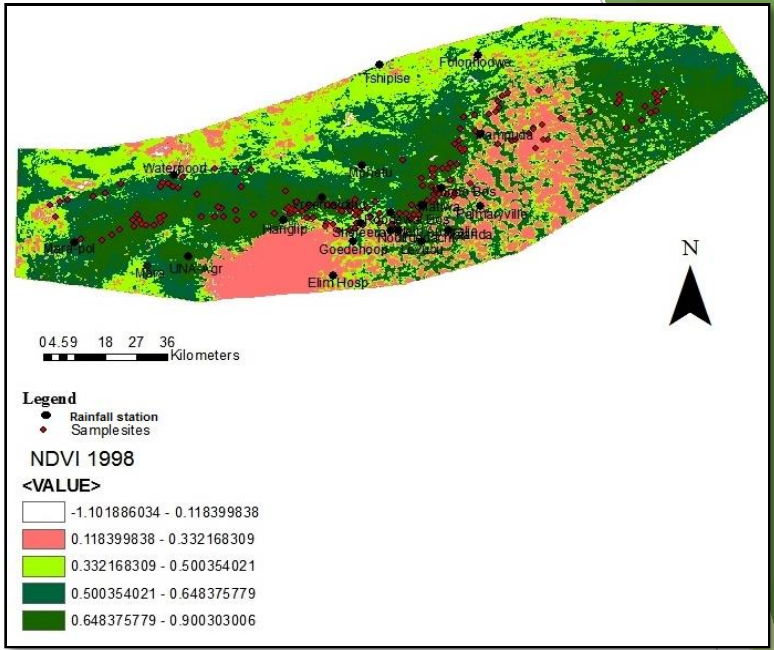


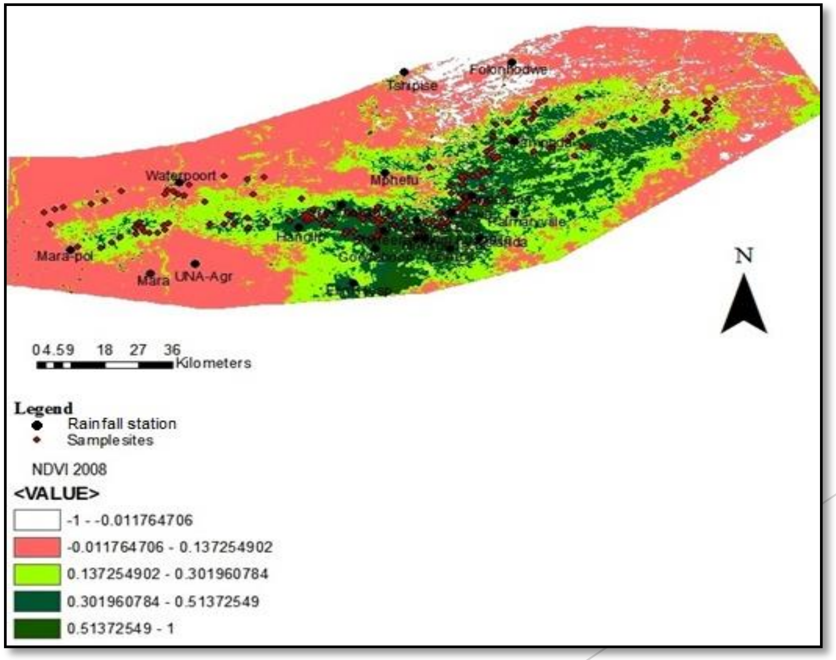
Temperature



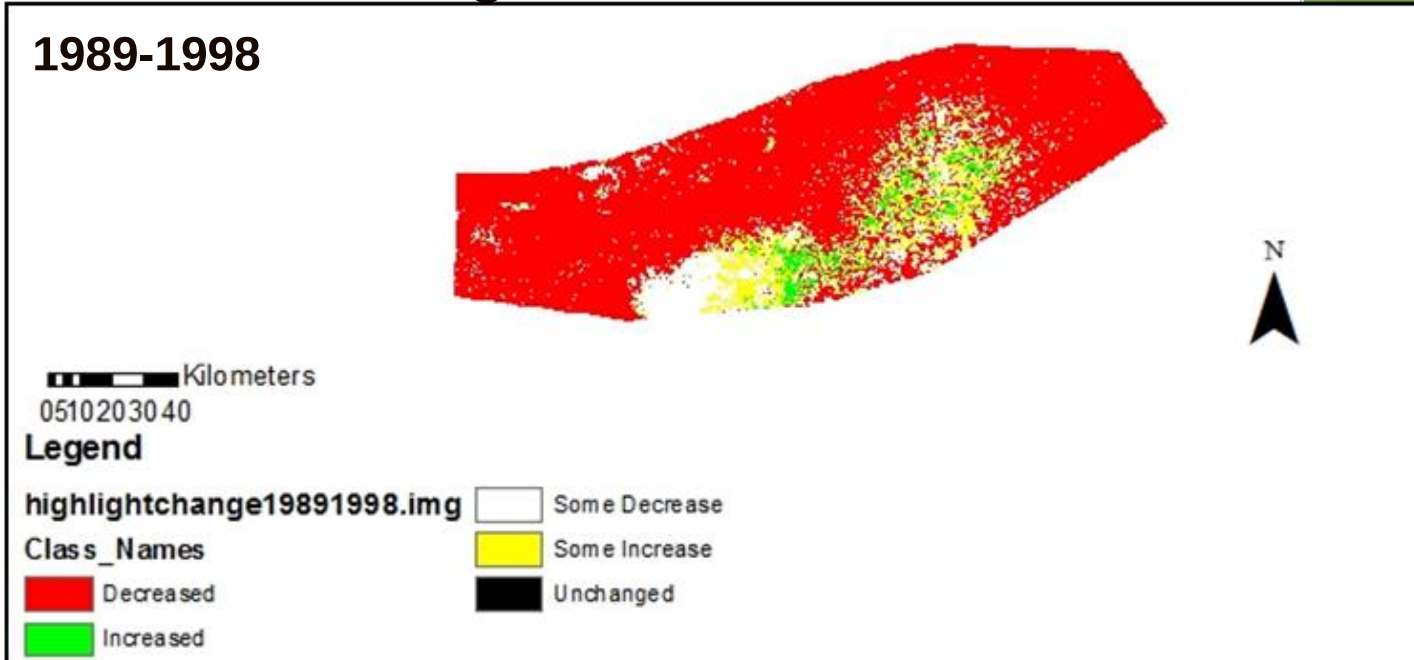
Ecosystem Response (VI)

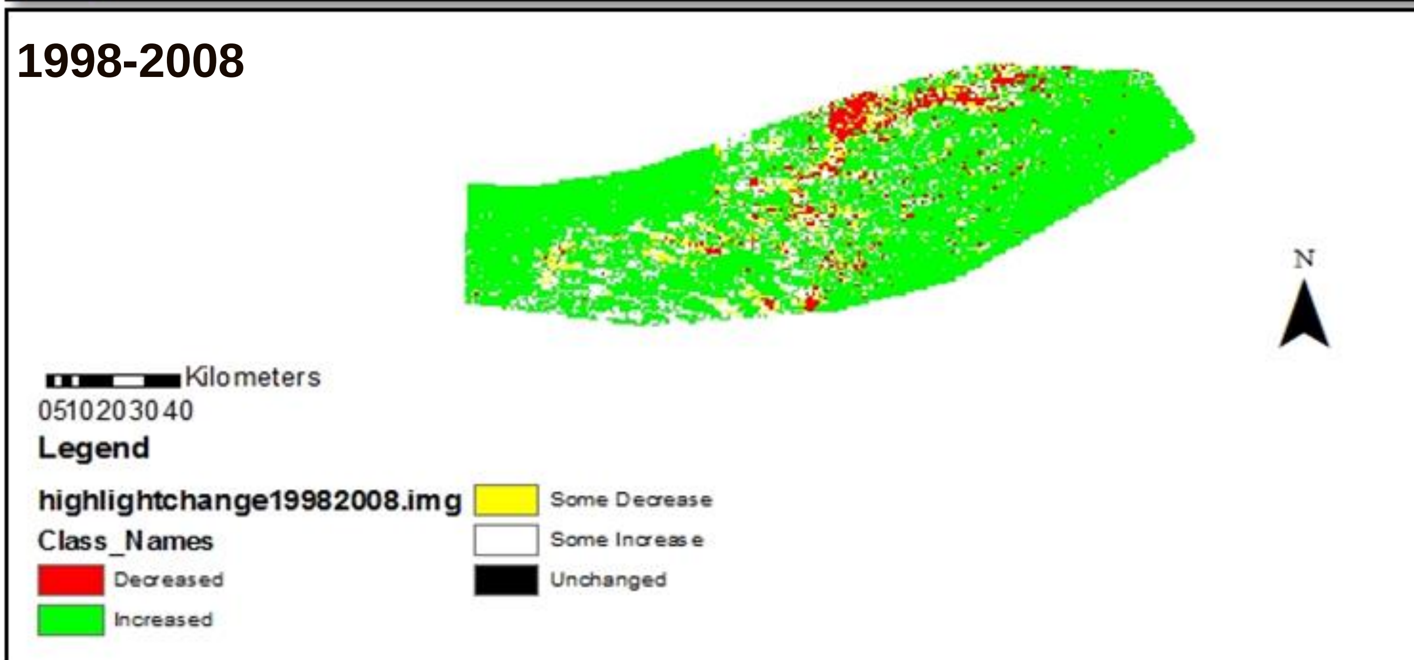






Change detection

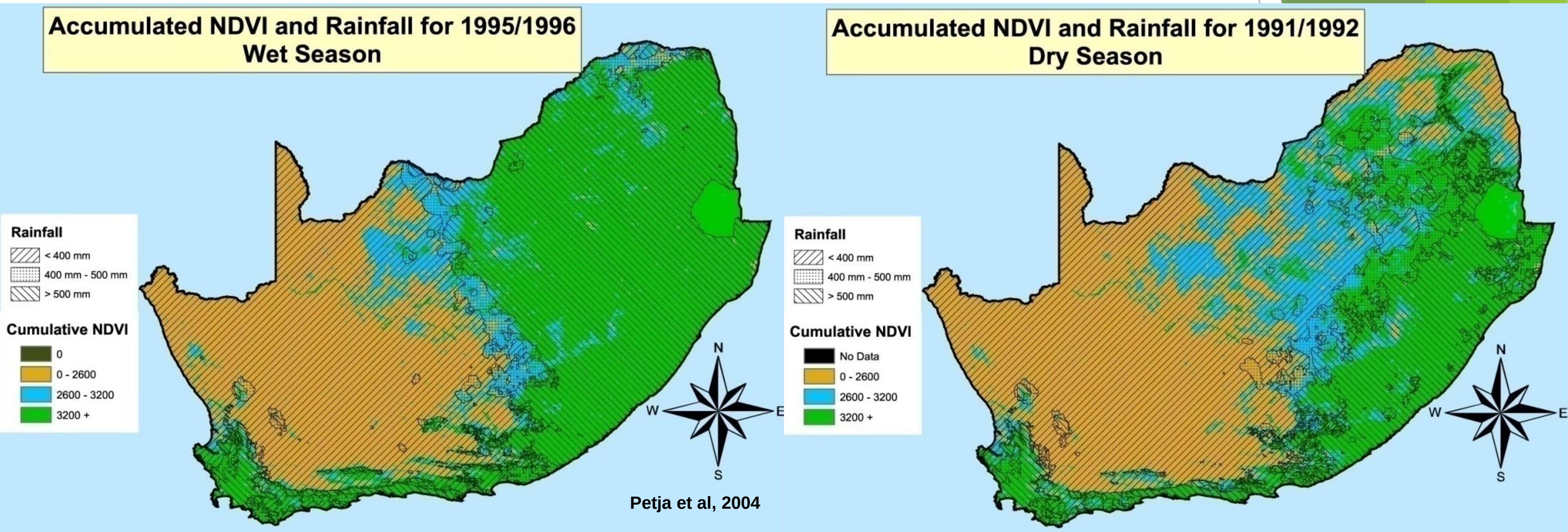




CAUSAL FACTORS: Anthropogenic Activities in the Soutpansberg

Observing and Monitoring Changing Climate

Inter-annual shifts in rainfall distribution

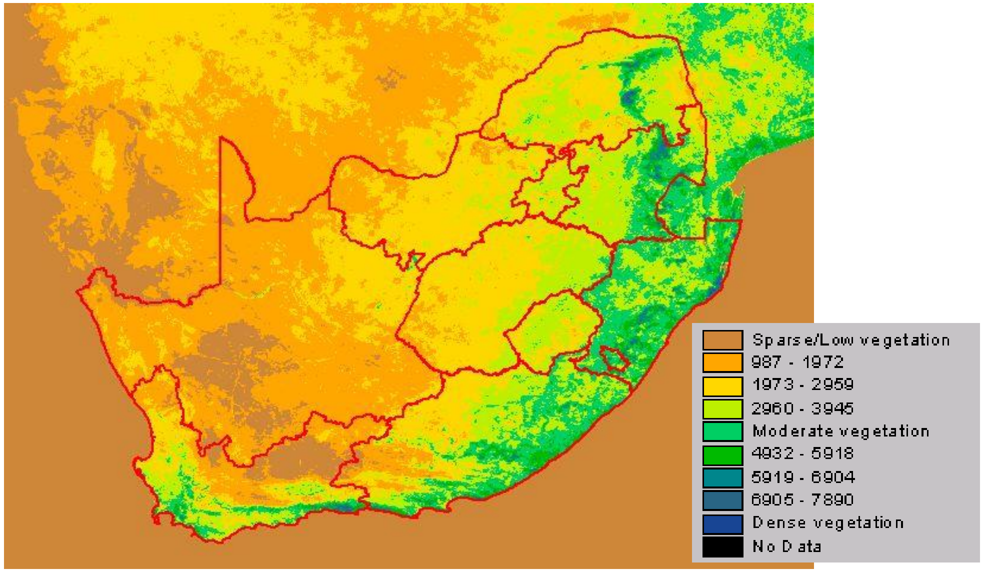


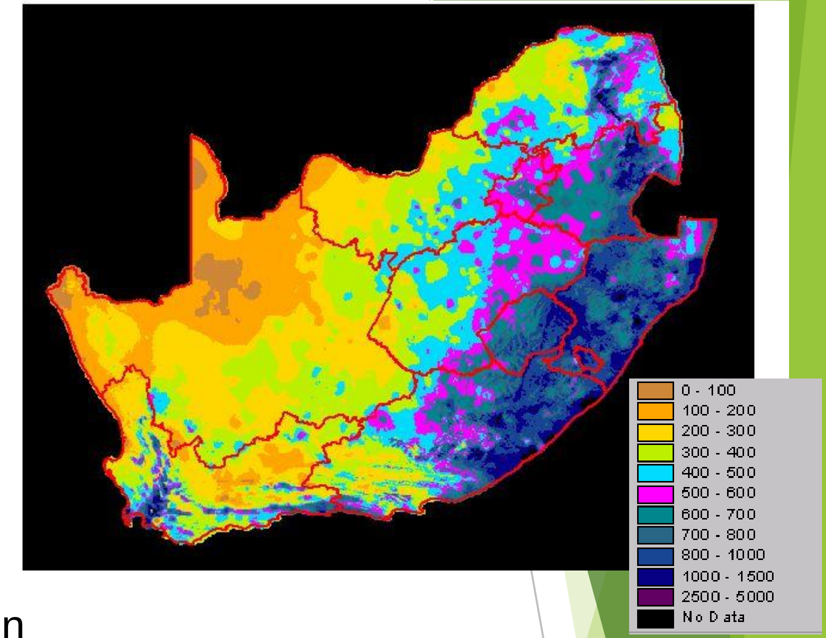
Petja et al, 2004

Cumulative NDVI

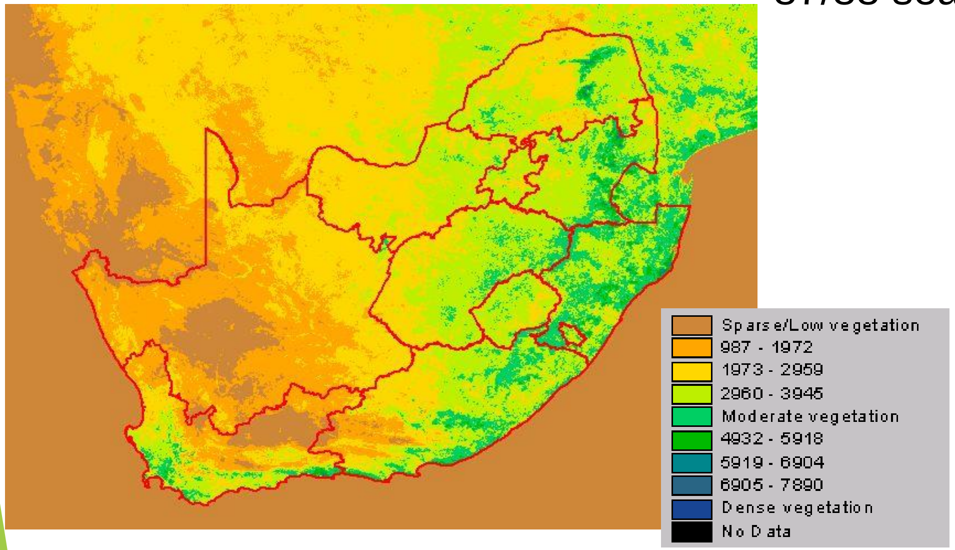
85/86 season

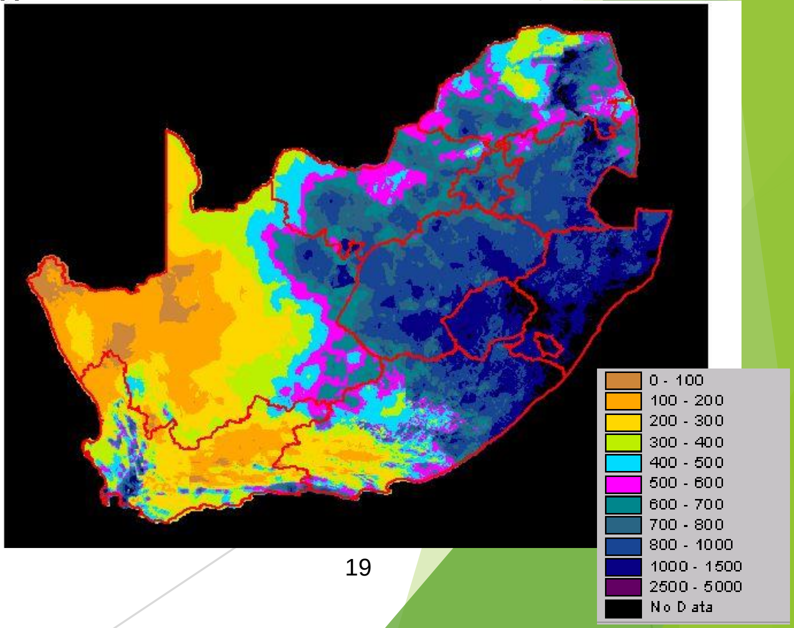
Rainfall





87/88 season

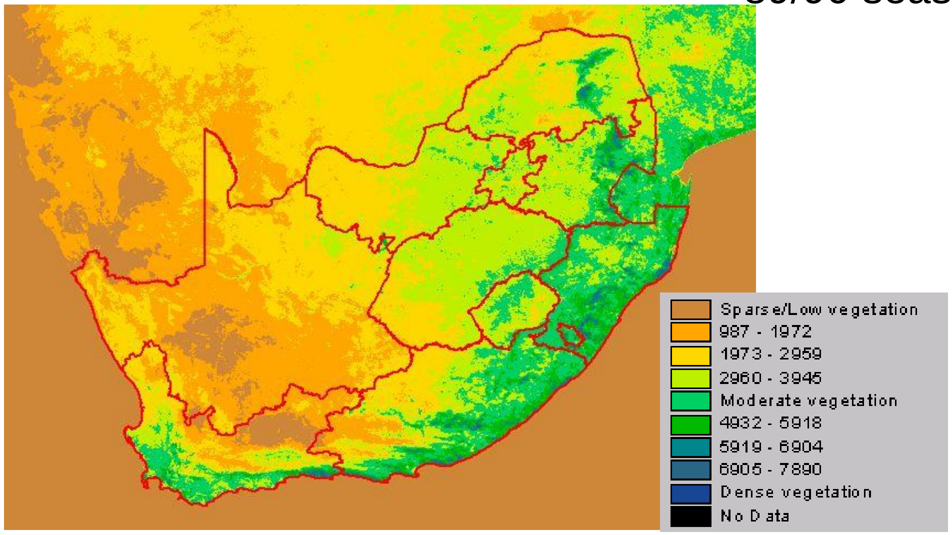


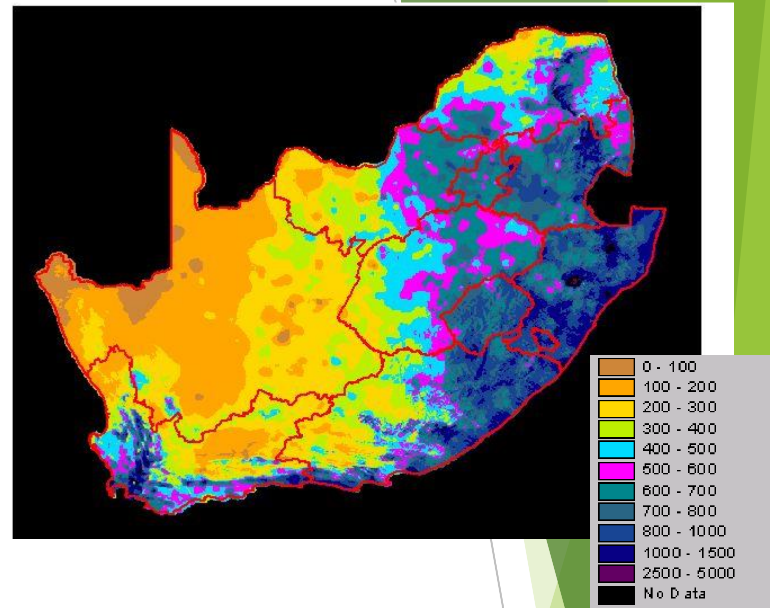


Cumulative NDVI

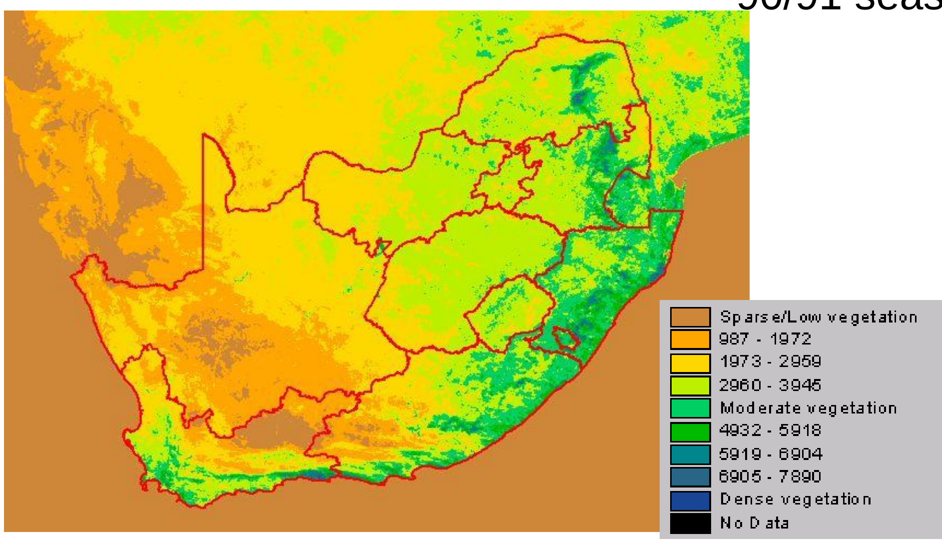
Rainfall

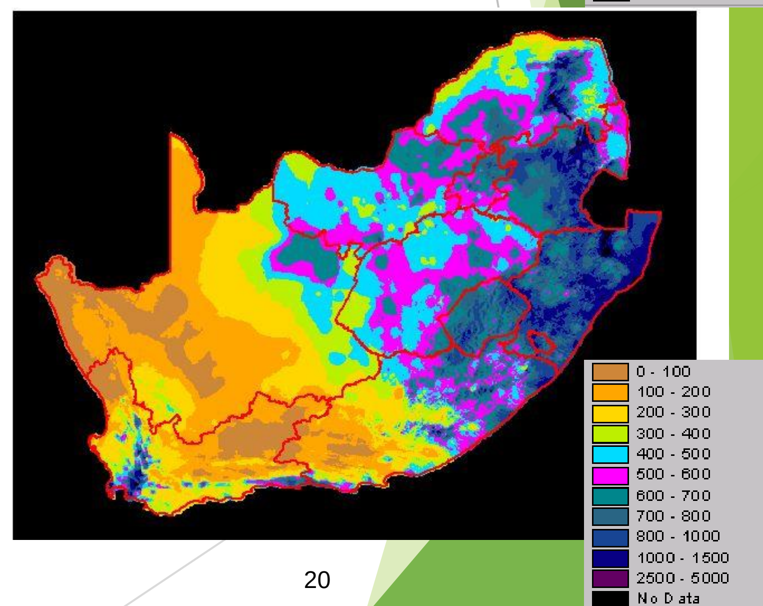
89/90 season





90/91 season

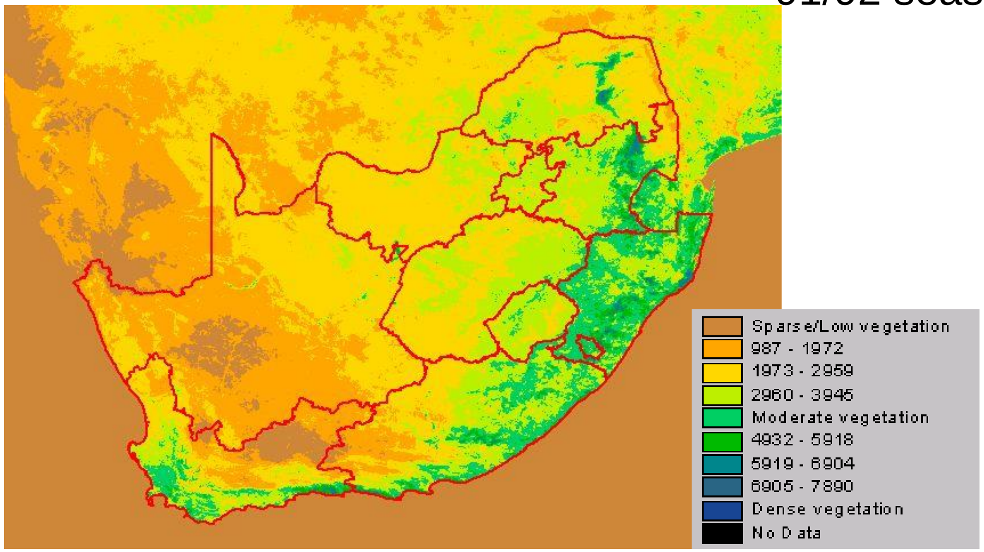


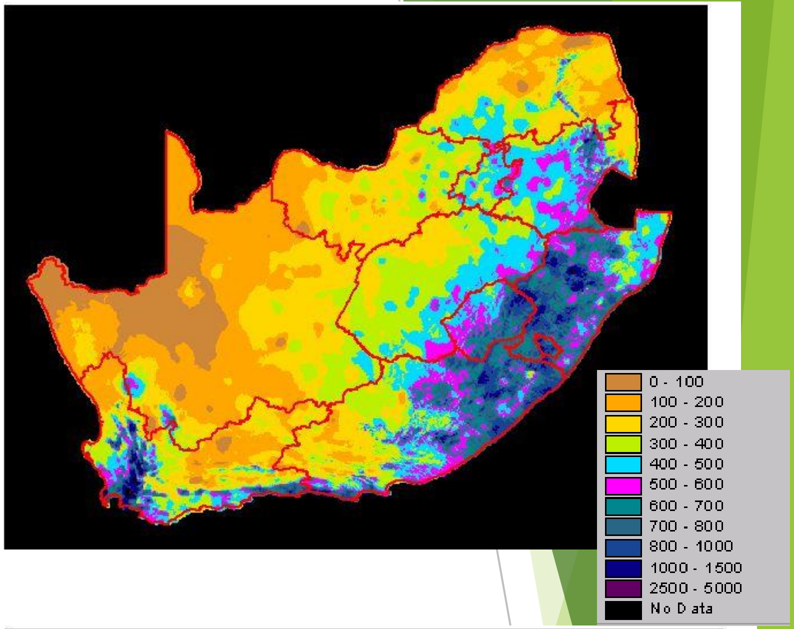


Cumulative NDVI

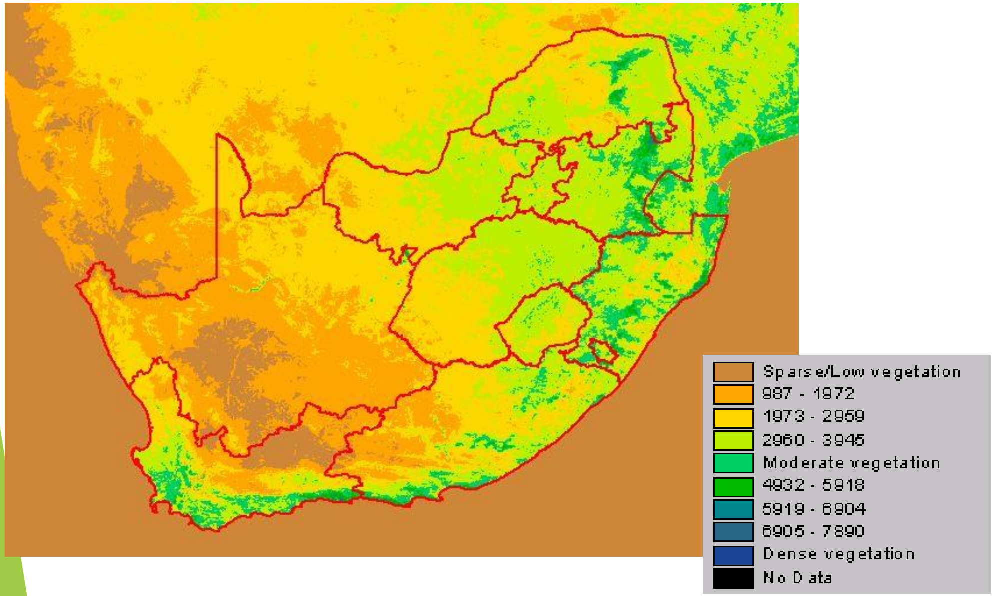
Rainfall

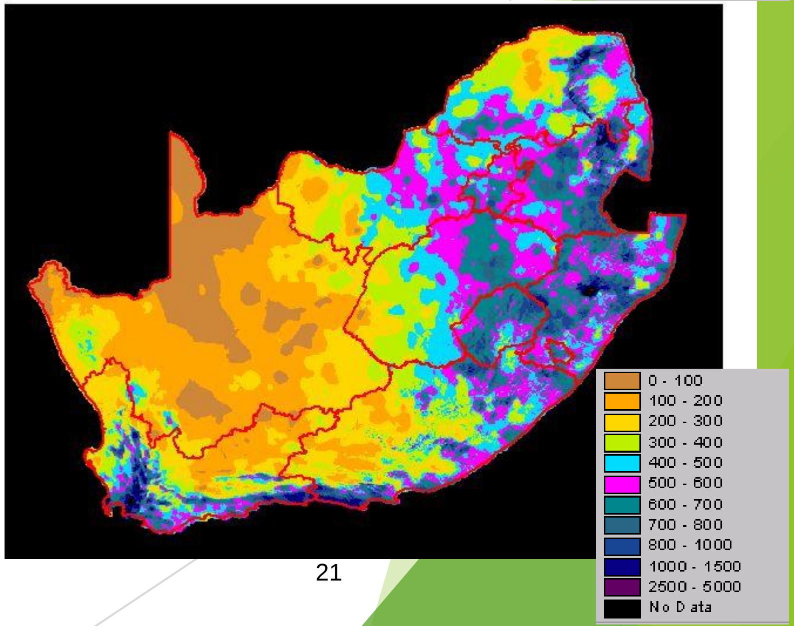
91/92 season





92/93 season

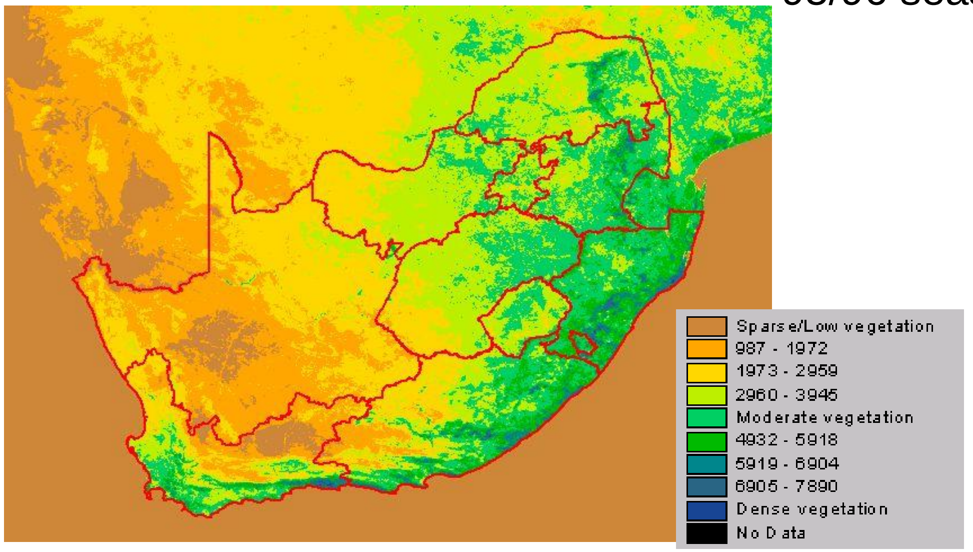


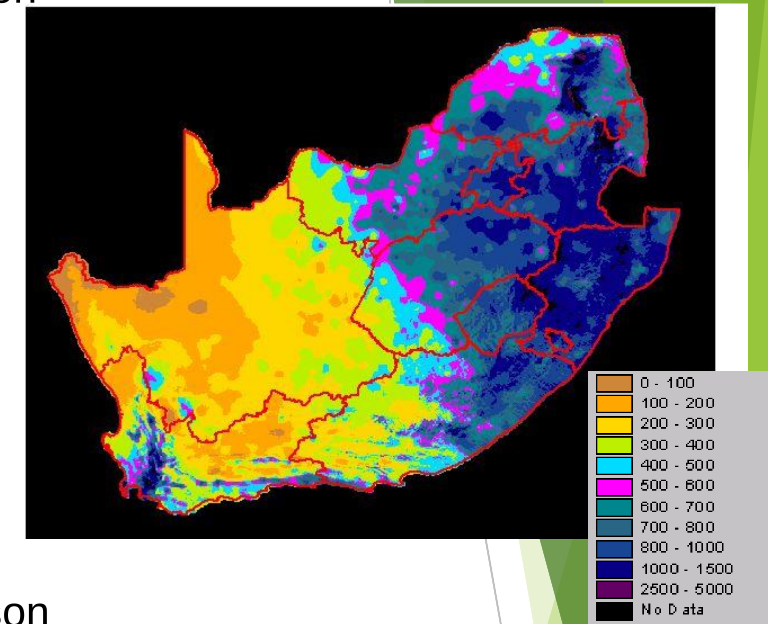


Cumulative NDVI

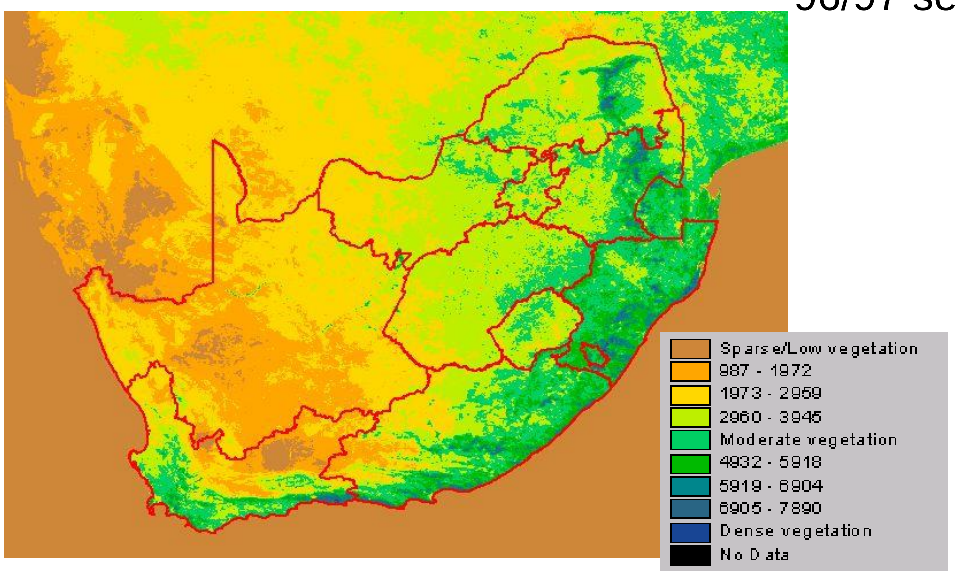
Rainfall

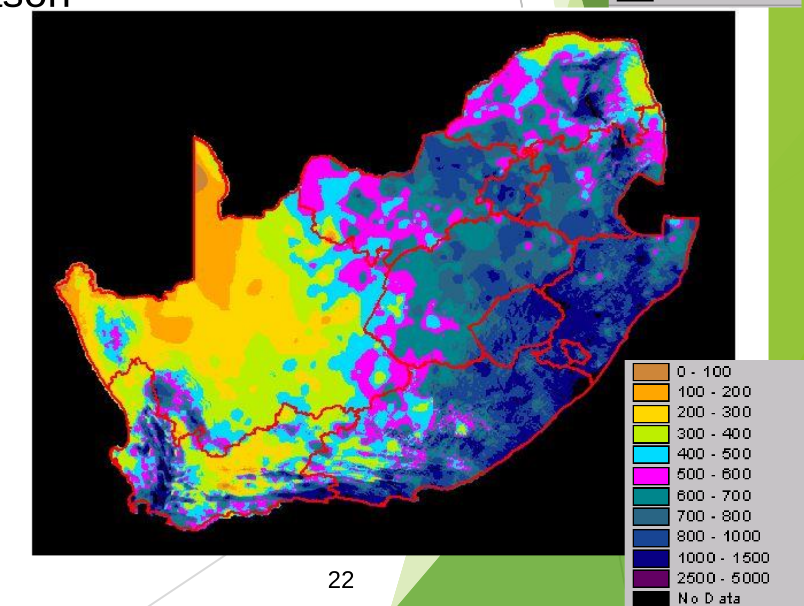
95/96 season



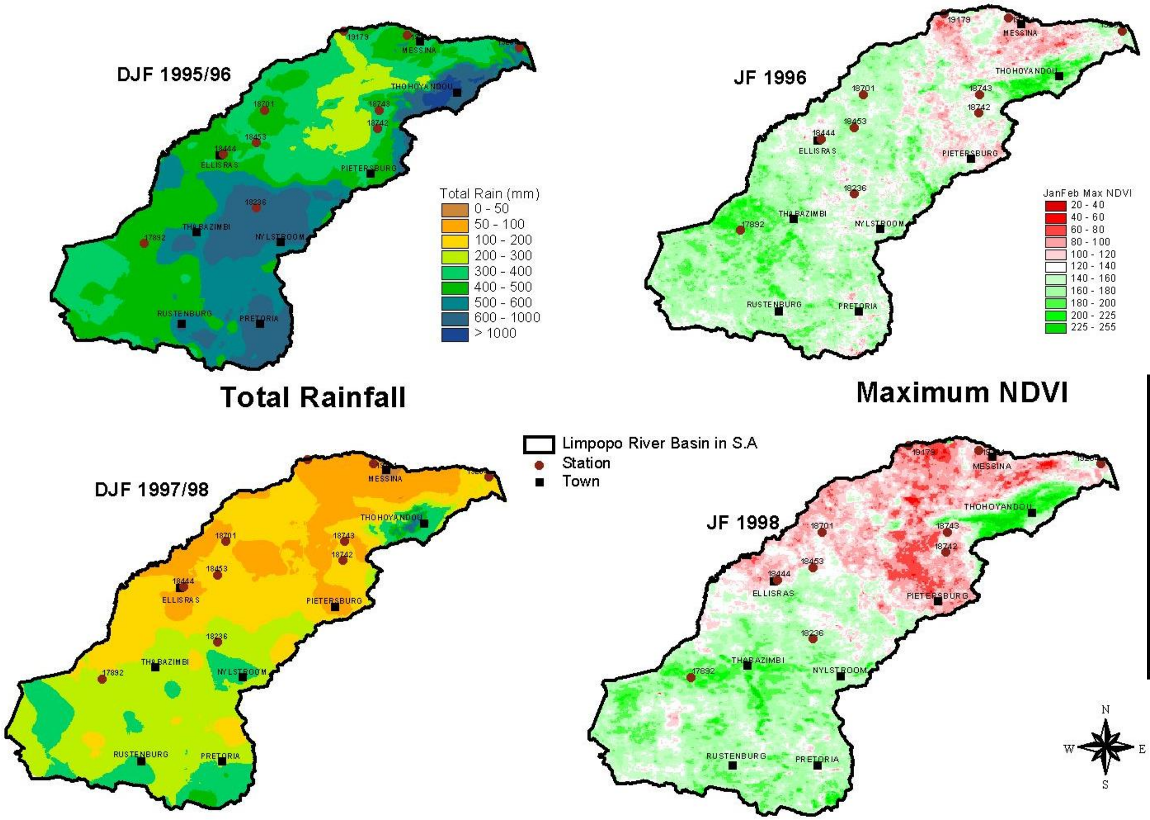


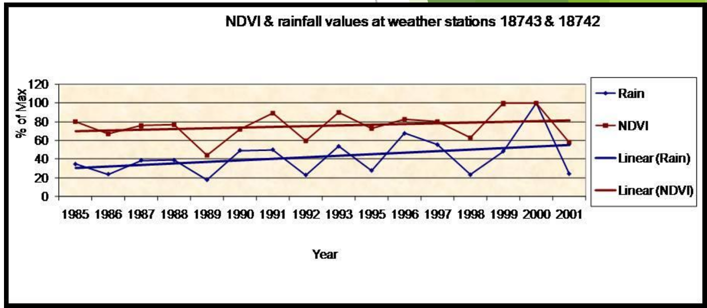
96/97 season





Pasture Productivity under different Climatic Regimes





- Production areas demarcated and managed in line with projected changes.
- Threat to degradation quantified in relation to stocking density.

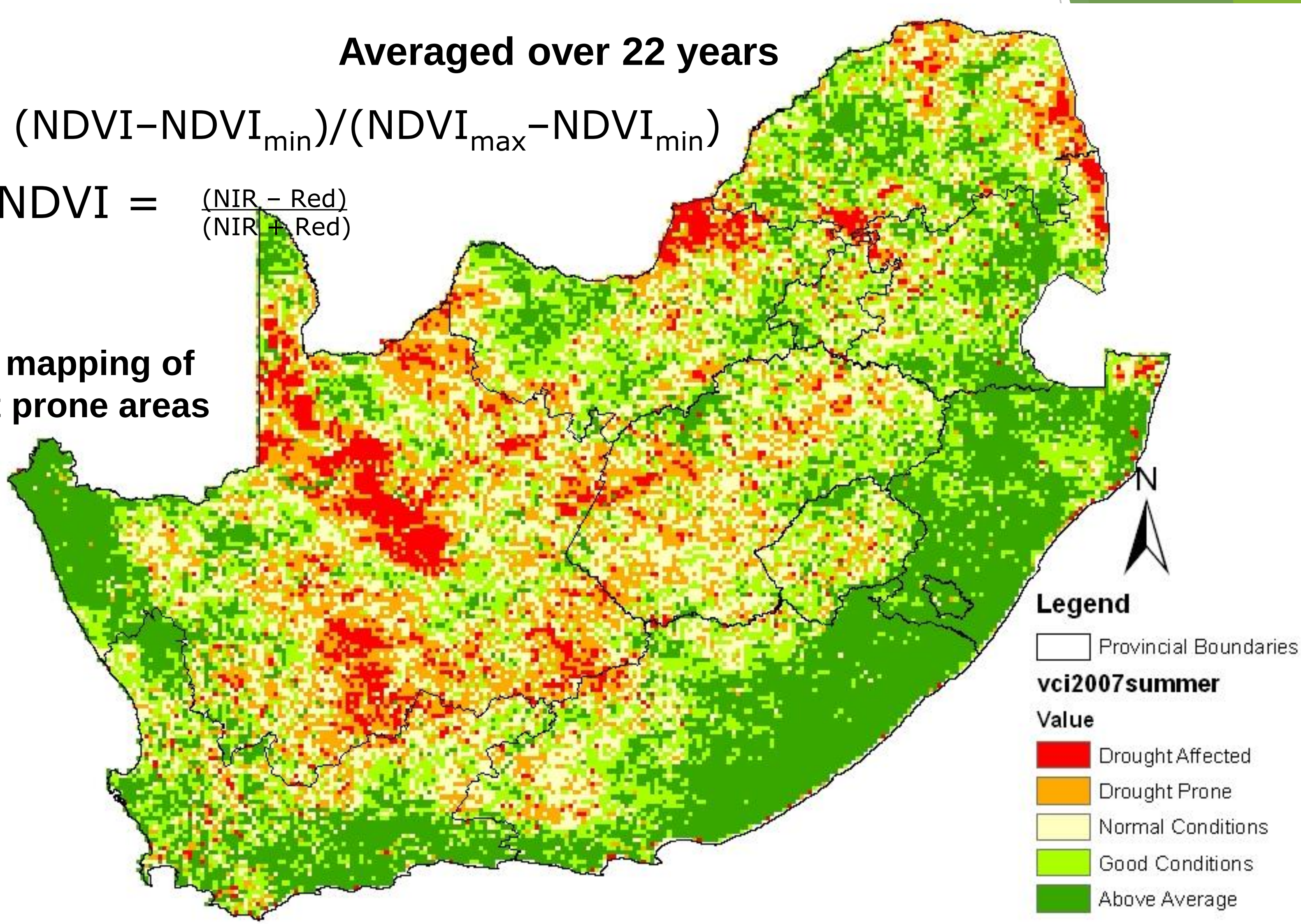
Declining Area for Summer Grain Production

Averaged over 22 years

$$VCI = (NDVI - NDVI_{min})/(NDVI_{max} - NDVI_{min})$$

where $NDVI = \frac{(NIR - Red)}{(NIR + Red)}$

Depicts mapping of drought prone areas

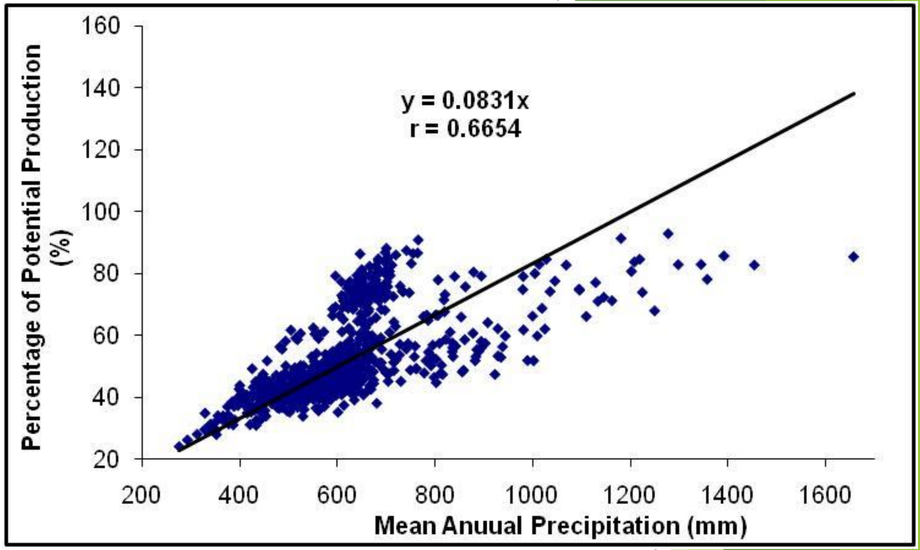


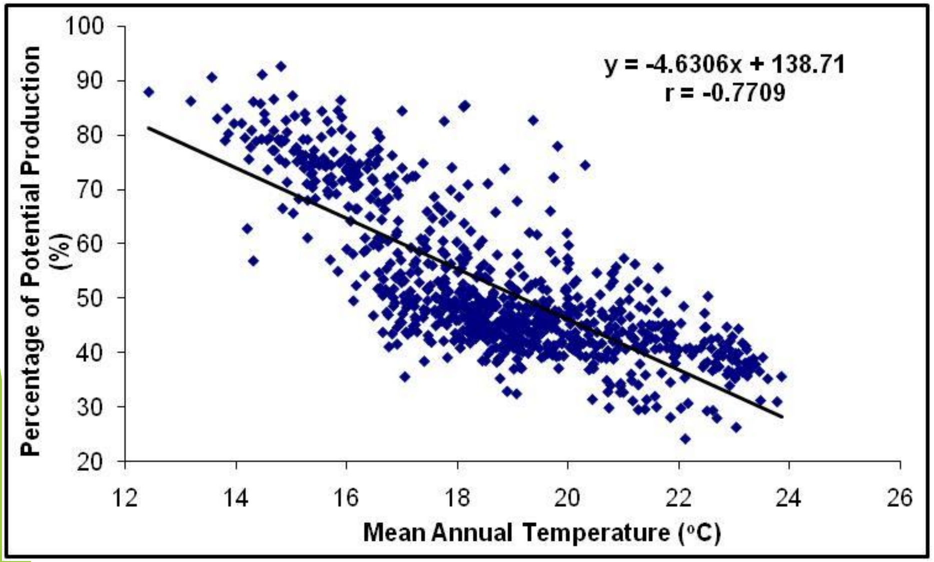
Expanding drought window due to increased variability (processed and calculated using satellite derived drought index over 22 years for summer rainfall areas)

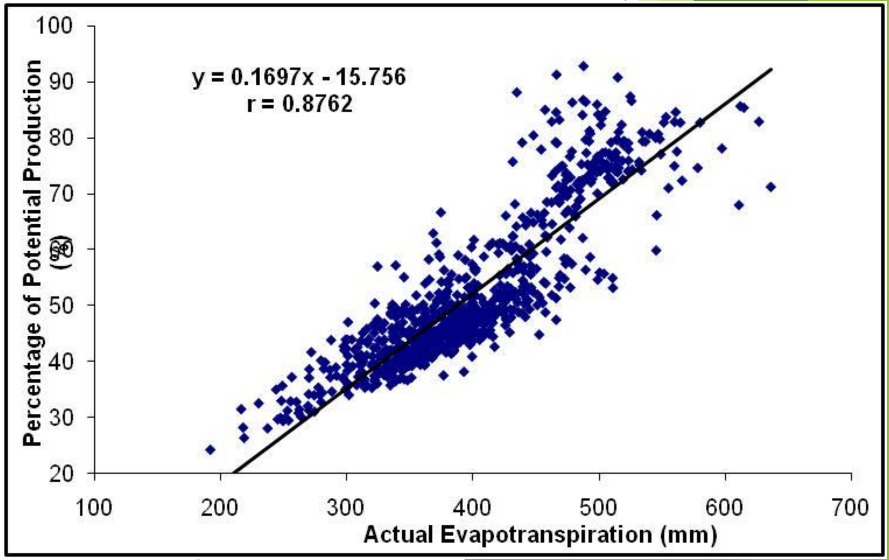
Source; Petja *et al*, 2008

Climate and Agricultural Production

- Positive relationship between climate change drivers and agricultural production.
- A change in climate may affect agricultural production negatively or positively.
- Crop stress, pest and diseases, crop failure etc.

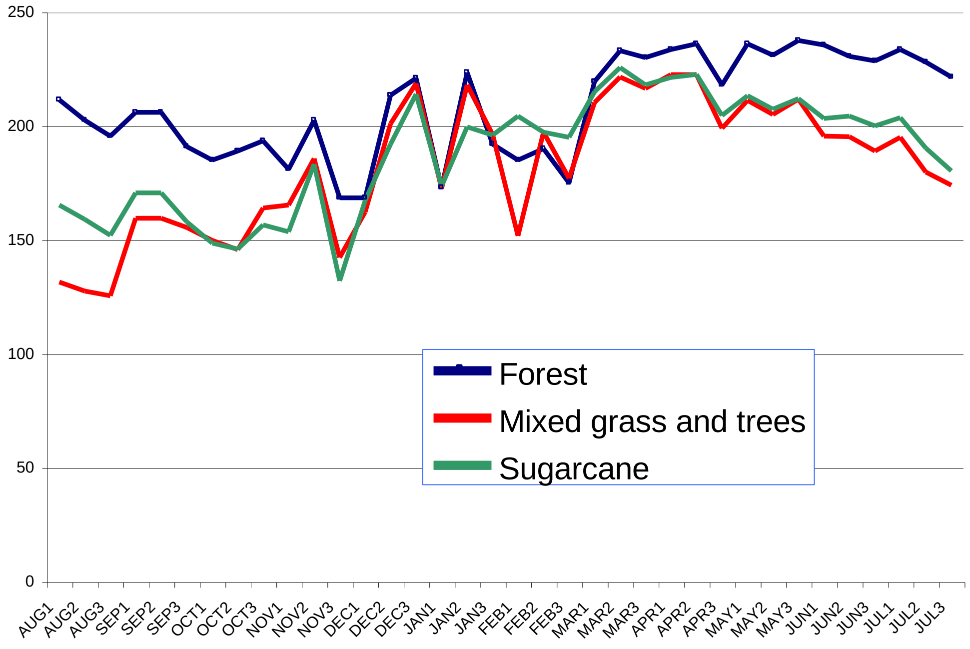






Nesamvuni *et al*, 2009, Lekalakala, 2011

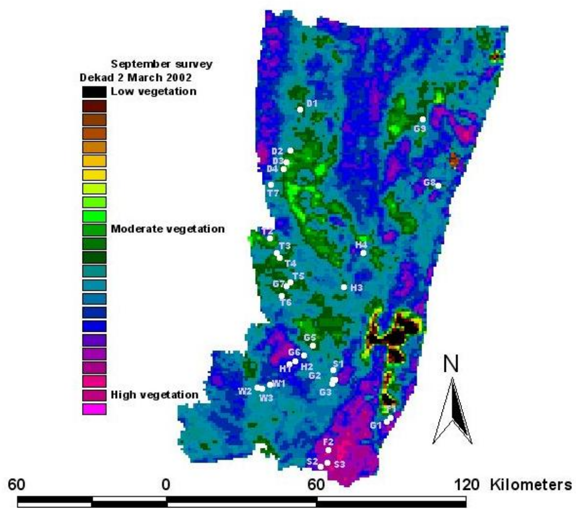
Monitoring crop response



- Vegetative response depicted over a growing season.
- Anomalies detected.

SPOT VEG

NDVI time series

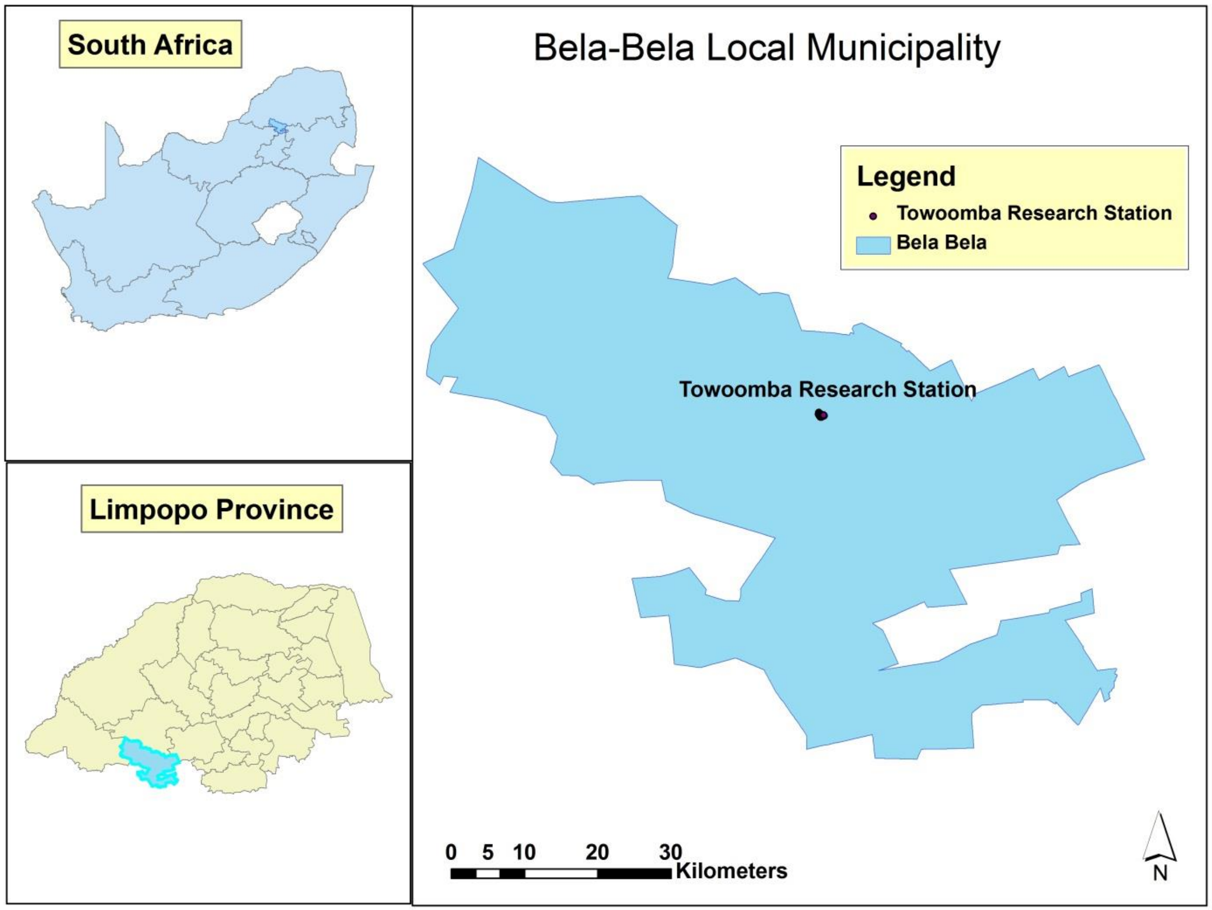


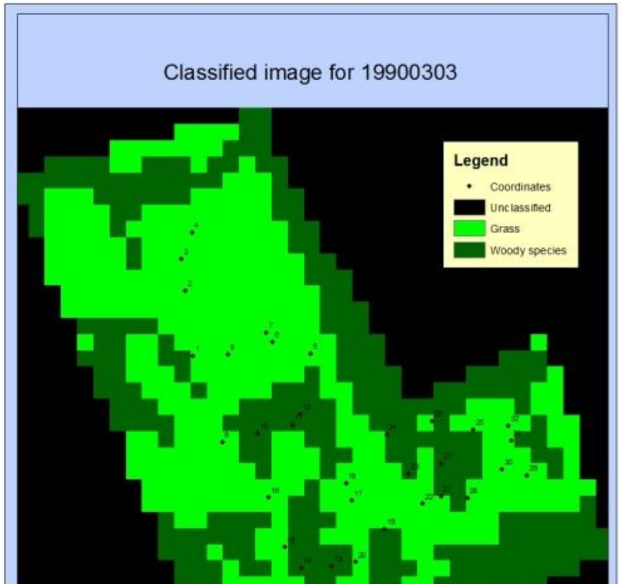
Sugarcane

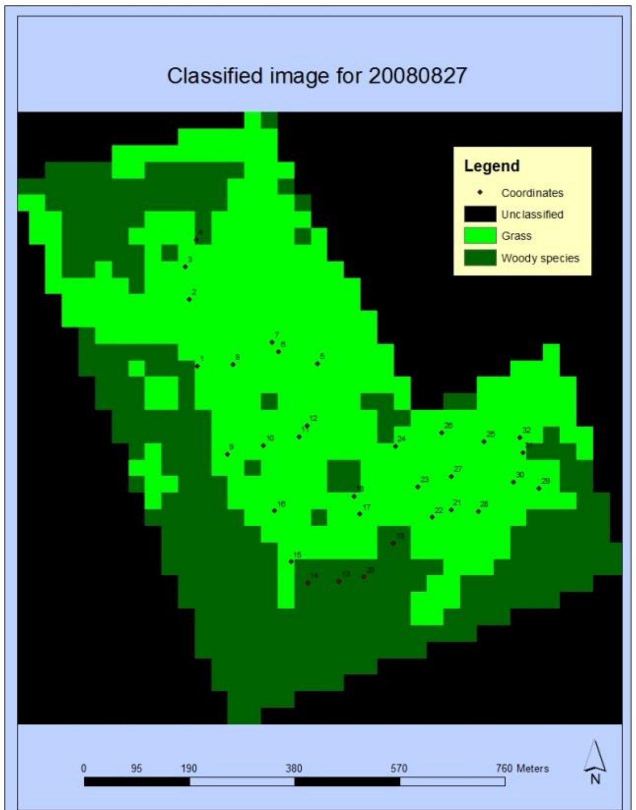
Resultant Impacts on Crops

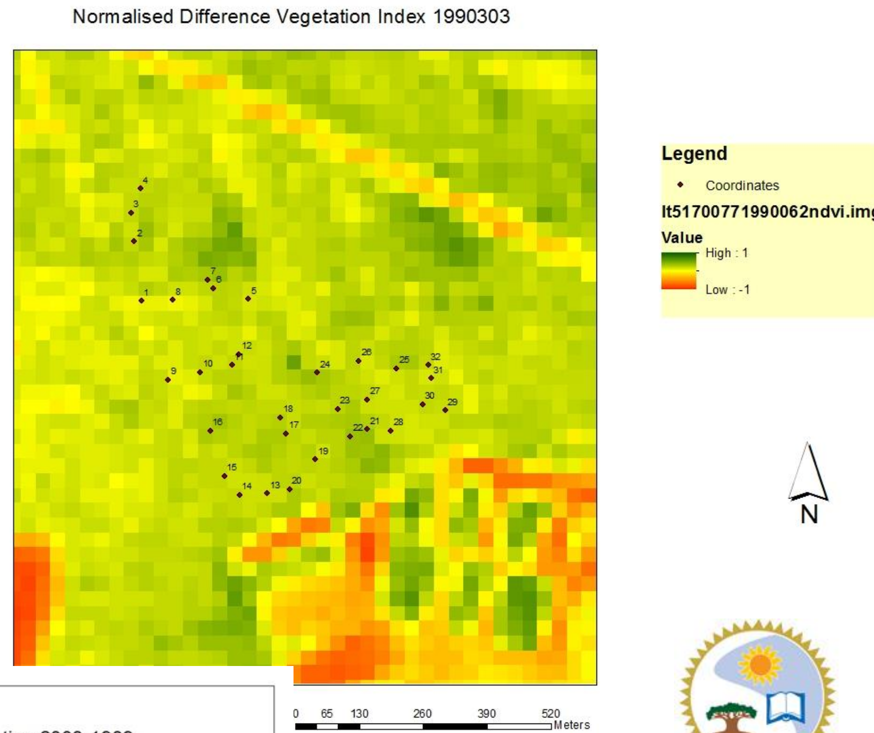
- Crop responses to temperature, precipitation, CO_2.
  - Increased crop vigour (positive response)
  - Crop mortality (extreme temperatures – decreased yields)
  - Flood damage
- Changing water availability for irrigation.
- Changing lengths of growing periods and reliability of rainy season.
- Plant diseases.

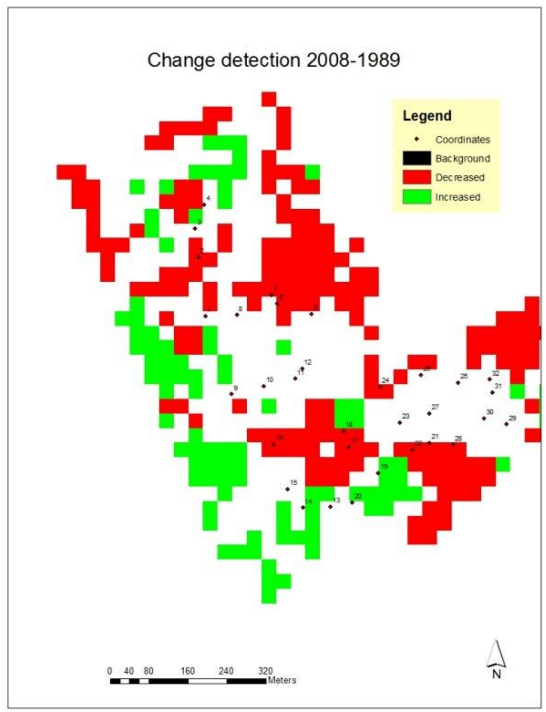
BUSH ENCROACHMENT

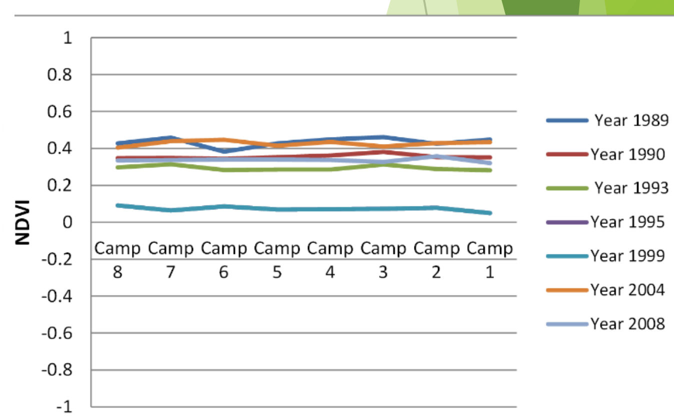



Classified image for 19900303
Legend
Coordinates
Unclassified
Grass
Woody species


Classified image for 20080827
Legend
Coordinates
Unclassified
Grass
Woody species
0 95 190 380 570 760 Meters
N


Normalised Difference Vegetation Index 1990303
Legend
Coordinates
lt51700771990062ndvi.img
Value
High : 1
Low : -1
N
0 65 130 260 390 520 Meters


Change detection 2008-1989
Legend
Coordinates
Background
Decreased
Increased
0 40 80 160 240 320 Meters
N

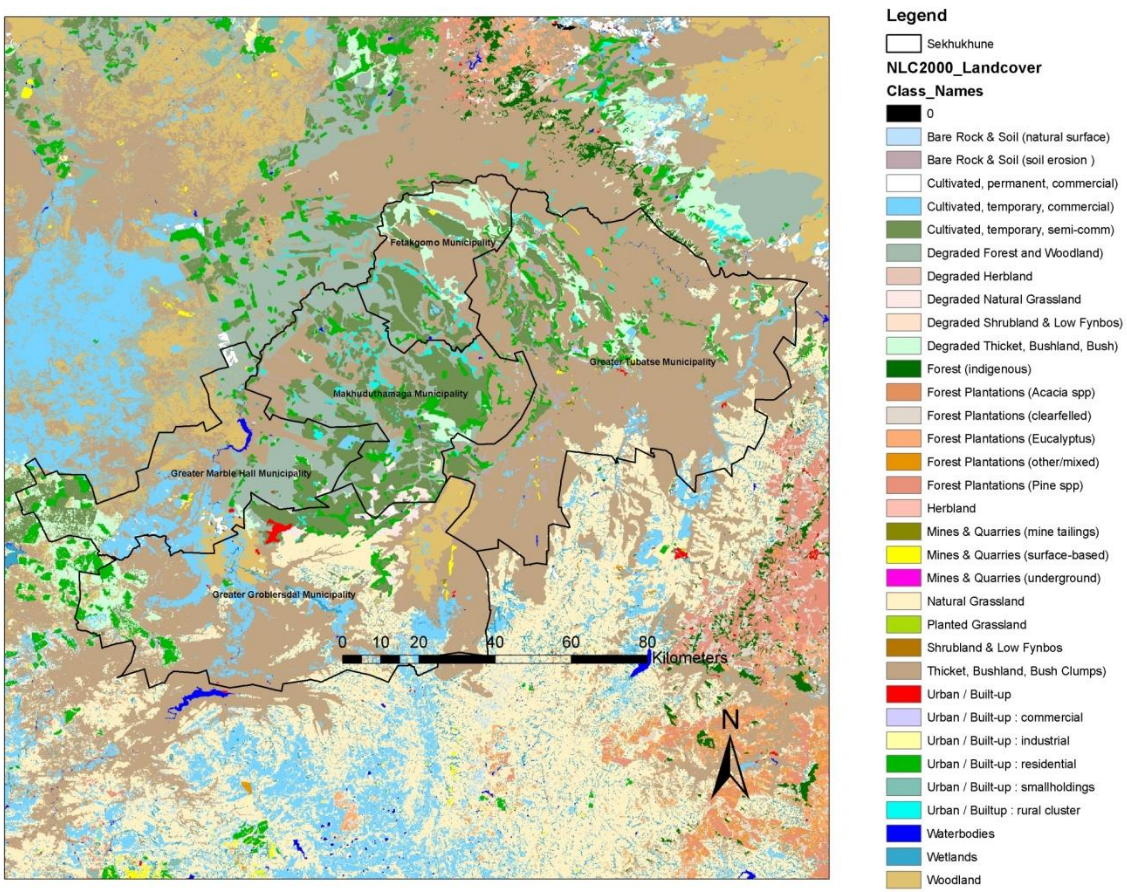

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
NDVI
Camp 8
Camp 7
Camp 6
Camp 5
Camp 4
Camp 3
Camp 2
Camp 1
Year 1989
Year 1990
Year 1993
Year 1995
Year 1999
Year 2004
Year 2008

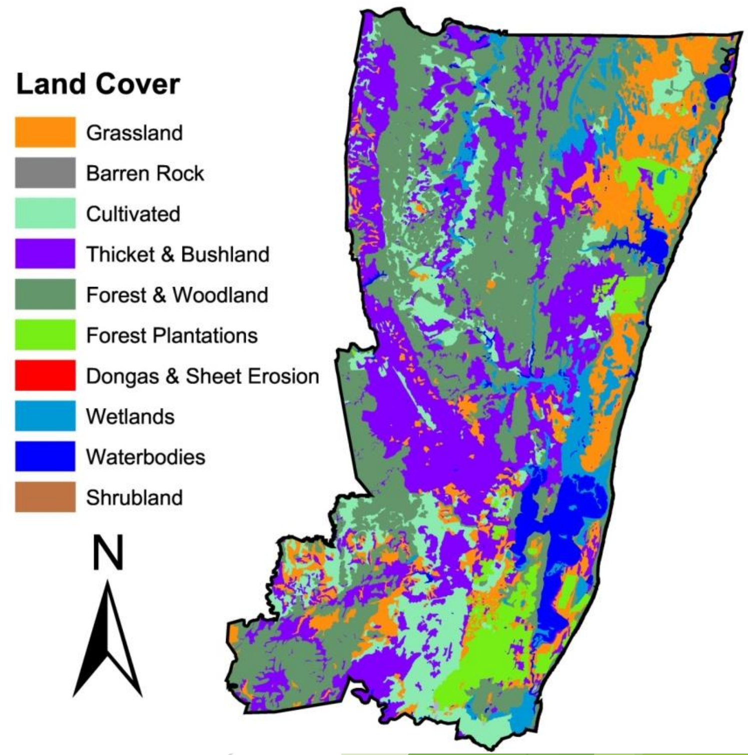
Adaptive Options and Interventions

- Routine applications of EO technology in operational management.
- Integration of climate change adaptation strategies into development and spatial plans.
- Protection of vegetated areas affecting local climate regimes.
- Afforestation and agroforestry projects in deforested areas.
- Land use change.
- Land use policy should address mechanisms for mitigation and adaptation to the challenges brought by changes in the climate.

Adapted Land Use in light of the Changing Climate

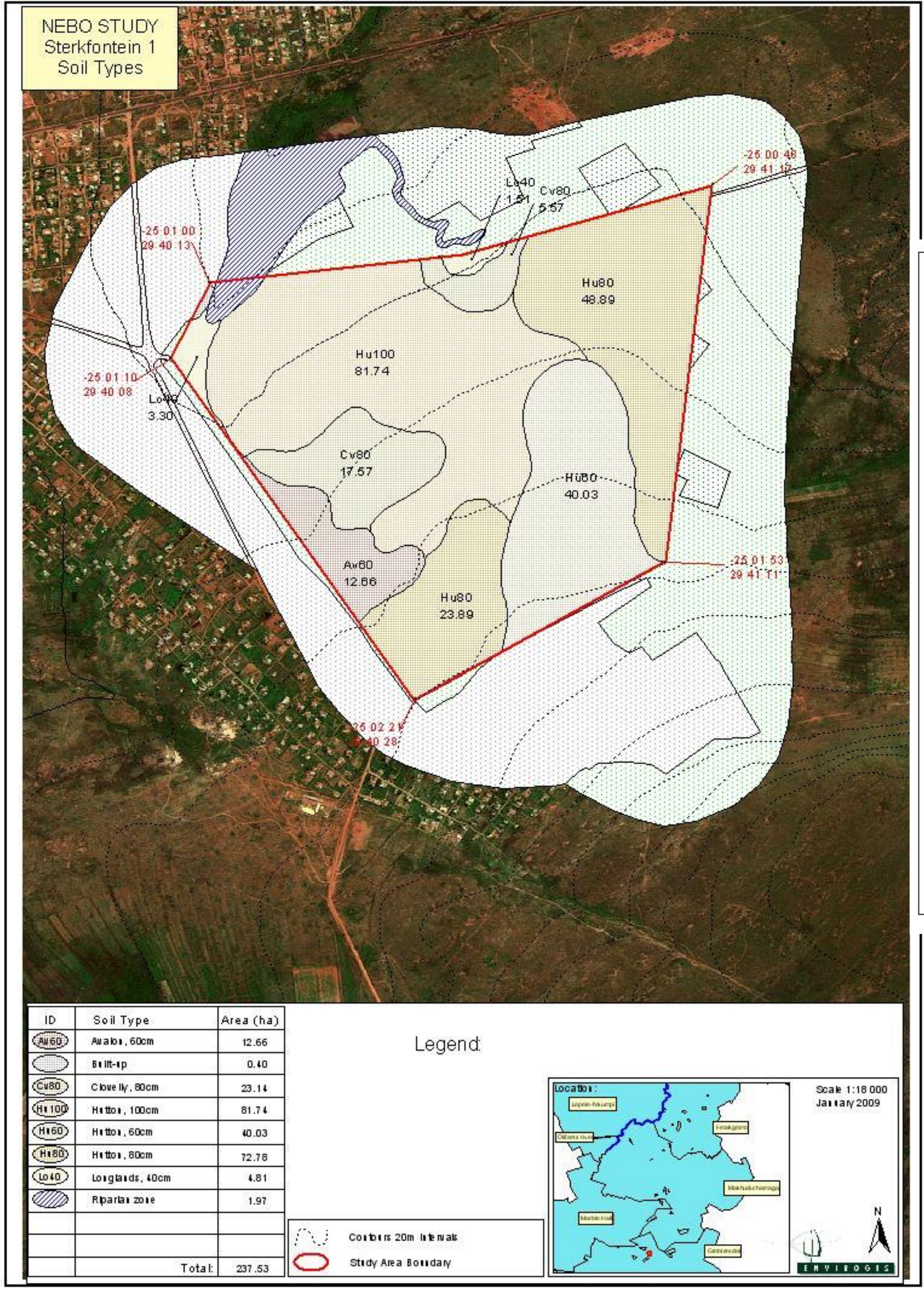
- Differentiated land use.
- Classified biomes
- Sensitive ecosystems

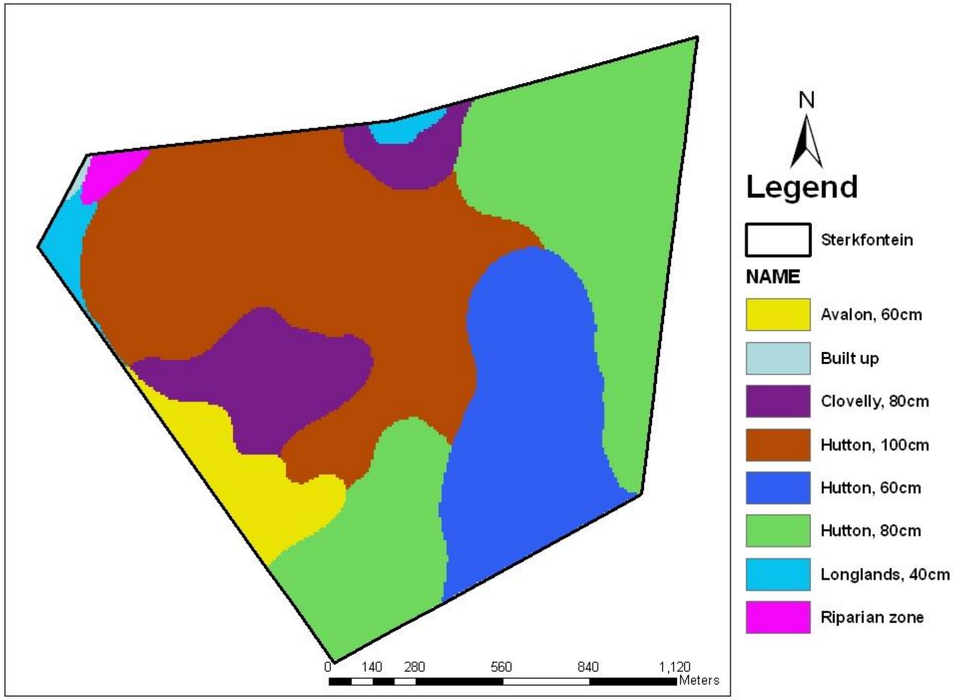




Site-Specific Development Planning

Soils





Soil Form

STERKFONTEIN 1

CLIMATE

Mean Annual Rainfall	Rainfall Coeff Variation	Refer Crop Evaporation	Mean Annual Temp	Mean Growth Season Days	Growth Season Start	Growth Season End
544 - 572	26.5	1419.00	16	166 - 170	Oct 06 - Oct 08	Mar 23 - Mar 25
	Jan	***Feb***	***Mar***	***Apr***	***May***	***Jun***
Avg Montly Rainfall	170.00	115.00	85.00	28.00	25.00	15.00
Avg Min Daily Temp	13.63	13.80	12.80	9.80	6.47	3.85
Avg Max Daily Temp	25.83	25.47	24.83	22.87	20.97	18.30
Avg Mean Daily Temp	20.37	19.73	18.93	16.27	13.93	10.63
	Jul	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
Avg Montly Rainfall	14.00	17.00	25.00	125.00	149.00	152.00
Avg Min Daily Temp	2.67	4.97	8.85	10.80	12.38	13.55
Avg Max Daily Temp	18.83	21.13	24.40	24.57	24.73	26.00
Avg Mean Daily Temp	11.20	12.77	16.27	18.33	19.03	19.77

Heat Units		Average Summer Temp			Average Winter Temp		
Winter	***Summer***	***Min***	***Max***	***Avg***	***Min***	***Max***	***Avg***
516.67	1516.67	13.35	25.51	19.43	4.49	19.81	12.15

CROP SUITABILITY

Soil Unit	Field Nr	Area (Ha)- Effective	Optimal	Suitable-Optimal	Suitable	Marginal-Suitable	Marginal
Av60	St1-1	10.31	Potatoes	Onions; Drybeans	Avo; Tomatoes; Okra; Cassava; Kikuyu	Butternut; Pepper Dew; Maize; Sorghum; Millet; Canola; Panicum; Cenchrus	Spinach; Sunflower; Ground Nuts; Lucerne
Cv80	St1-4; St1-5	20.34	Potatoes	Onions; Spinach; Okra; Drybeans	Tomatoes; Butternut; Pepper Dew; Cassava; Maize; Sorghum; Millet; Ground Nuts; Kikuyu	Canola; Sunflower; Panicum; Cenchrus	Banana; Lucerne
Hu100	St1-2	74.25	Potatoes; Sorghum	Onions; Spinach; Okra; Cassava; Maize; Millet; Drybeans; Kikuyu	Tomatoes; Butternut; Pepper Dew; Canola; Sunflower; Ground Nuts; Panicum; Cenchrus	Lucerne	Banana; Vetch
Hu60	St1-6	34.97	Potatoes	Onions; Drybeans	Tomatoes; Okra; Cassava; Kikuyu	Butternut; Pepper Dew; Maize; Sorghum; Millet; Canola; Panicum; Cenchrus	Spinach; Sunflower; Ground Nuts; Lucerne
Hu80	St1-3; St1-9	69.40	Potatoes	Onions; Spinach; Okra; Drybeans	Tomatoes; Butternut; Pepper Dew; Cassava; Maize; Sorghum; Millet; Ground Nuts; Kikuyu	Canola; Sunflower; Panicum; Cenchrus	Banana; Lucerne
Lo40	St1-7; St1-8	4.12	None	Onions	Cassava; Drybeans	None	Maize; Sorghum; Millet; Kikuyu
	Total:	**213.39**					

Concluding remarks

- Climate plays a significant role to rural and regional development.
- Increased inter-annual and intra-seasonal variability climate threaten most development sectors.
- Changes and shifts in climate => socio-economic, agricultural and environmental spheres
- EO technology presents more opportunities to characterize and observe the frequency of climatic anomalies and variation to aid in mitigation and adaptation strategies.
- More action is required at local scale in terms of adaptive response and mainstreaming.
- United sectoral and inter-sectoral response will defeat the might of climate change.

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