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Agriculture

Preparing agriculture for a changing climate: lessons from the Western Cape's SmartAgri programme

Prof Stephanie Midgley

Zoom Workshop: the African Bavarian Alliance for Applied Life Sciences
14 October 2022

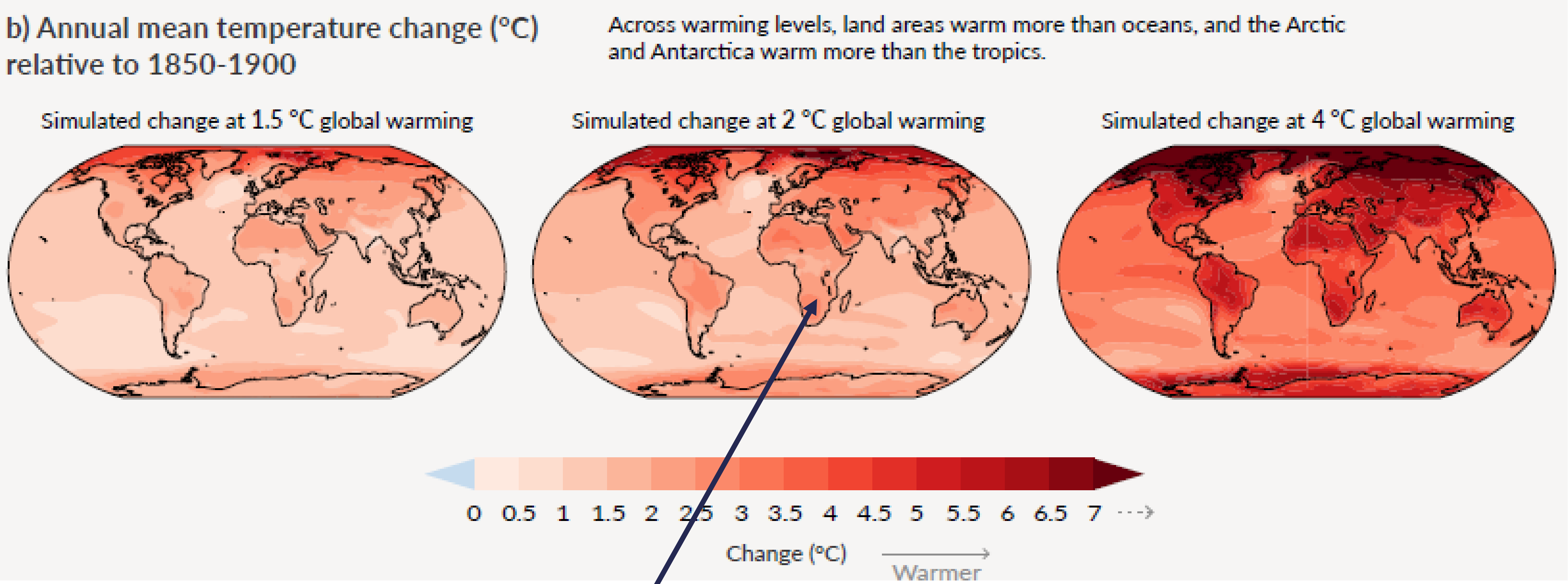
Outline

1. The nature and scale of the climate change challenge in South Africa, specifically the Western Cape Province

2. Climate change sectoral response planning and implementation

3. Applied research for climate adaptation in agriculture

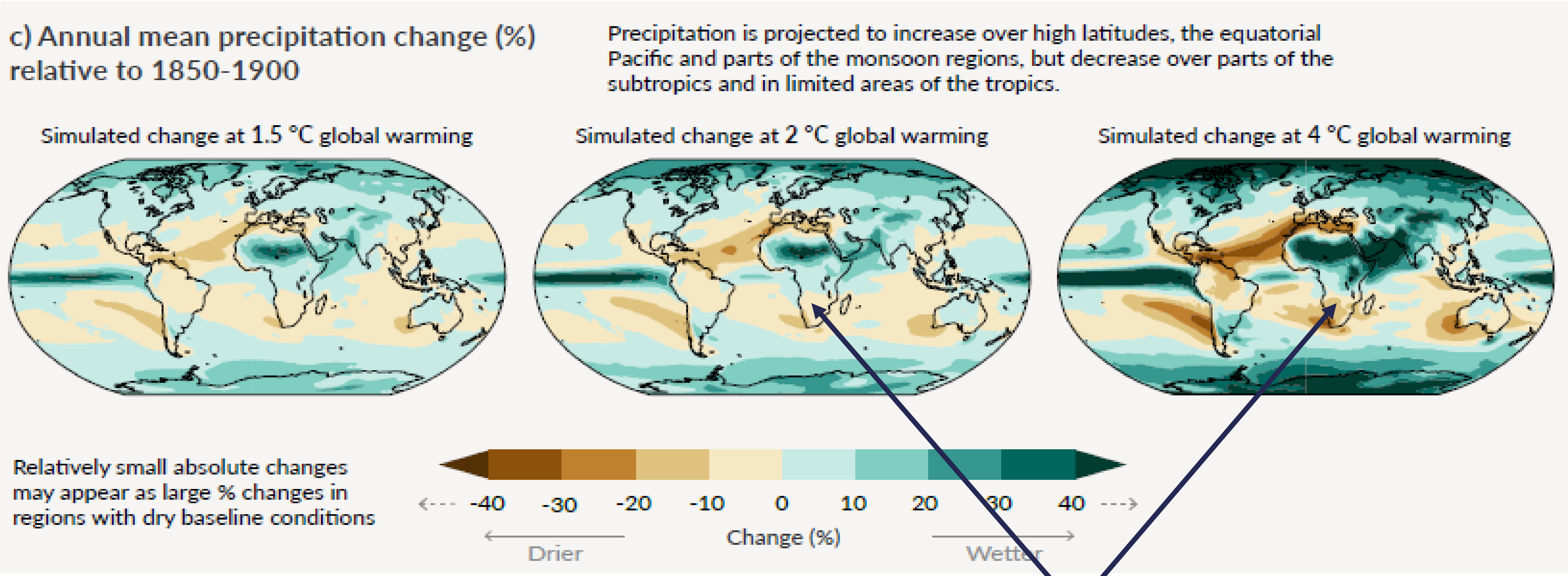
With every increment of global warming, changes get larger in regional mean temperature



Warming > 2.5 °C when global warming increase is 2 °C

IPCC AR6 WGI, 2021

With every increment of global warming, changes get larger in regional mean precipitation



Precipitation is projected to **decrease** over parts of the subtropics, and Mediterranean climates.

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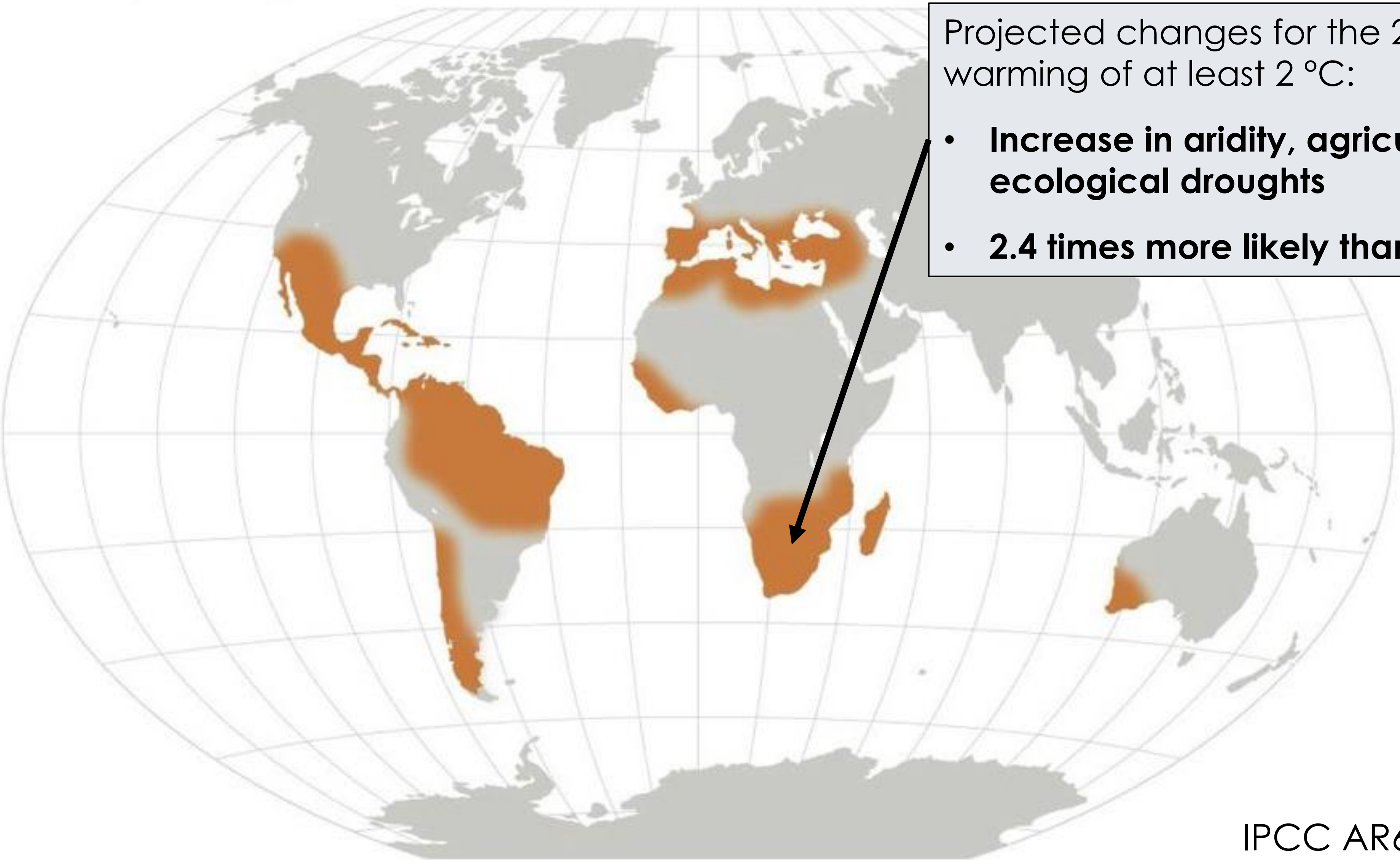
IPCC AR6 WGI, 2021

Drought is expected to increase under future warming in some regions



Projected changes for the 2050s with warming of at least 2 °C:

- **Increase in aridity, agricultural and ecological droughts**
- **2.4 times more likely than in 1850-1900**

IPCC AR6 WGI, 2021

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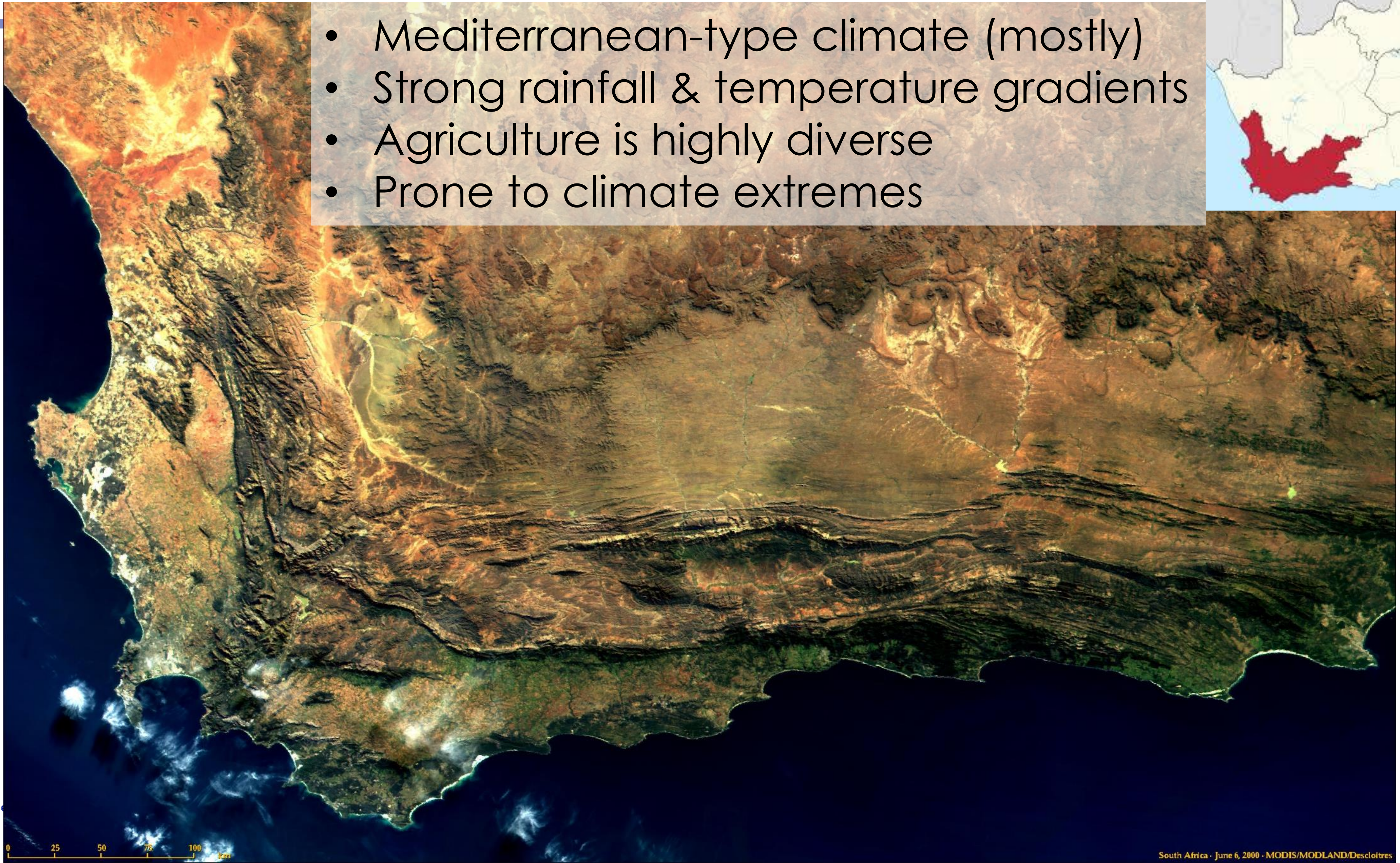
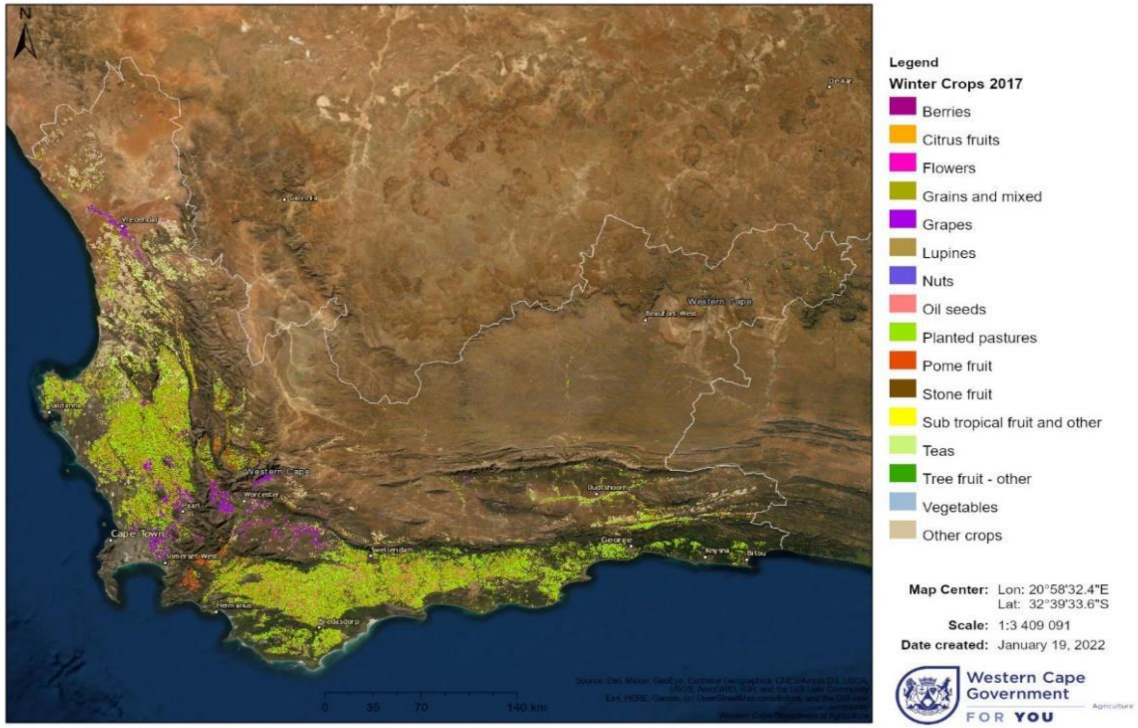
Western Cape province - background

- Mediterranean-type climate (mostly)
- Strong rainfall & temperature gradients
- Agriculture is highly diverse
- Prone to climate extremes



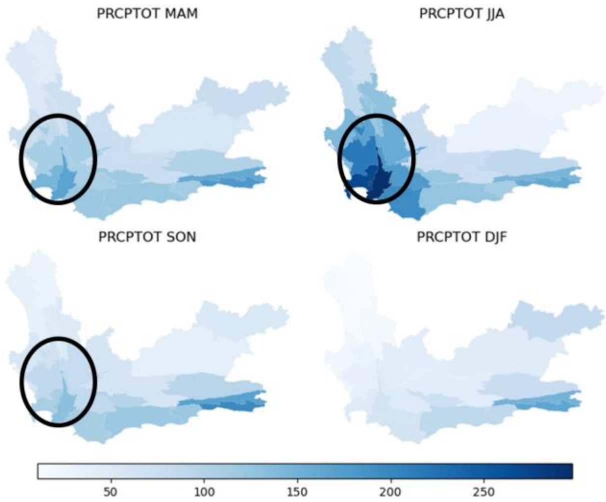
Profile of agriculture in the Western Cape Province of South Africa

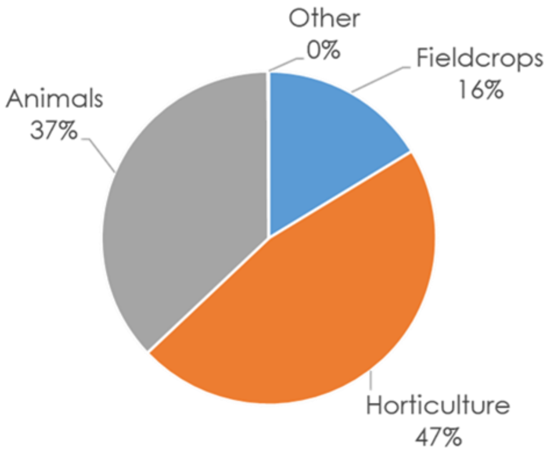
- Approx. 2 million hectares under crop production.
- Approx. 11.5 million hectares farmland.
- Leading national producer of grapes, apples, peaches, pears, plums, berries, onions, canola, wheat, barley and oats.
- Share of national agricultural exports is 49% - table grapes, citrus, bottled/bulk wine, apples/pears, blueberries.

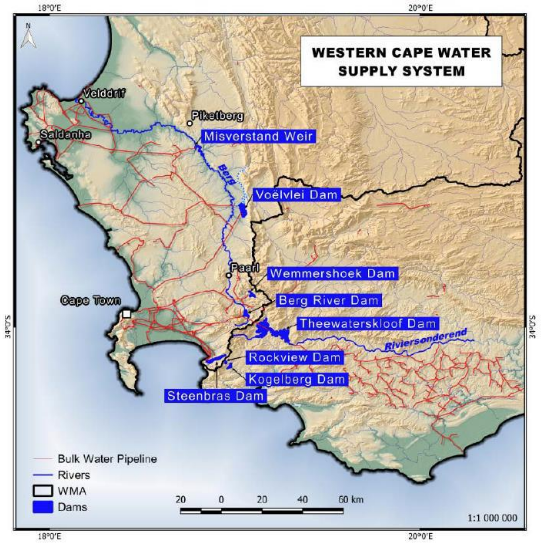


Water resource under pressure in Western Cape Province

- Mediterranean-type climate - mainly winter rainfall.
- Horticulture depends on irrigation water; water storage and irrigation infrastructure is critical.
- Western Cape Water Supply System (WCWSS): integrated and collectively managed system of dams, pipelines and tunnels.
  - Total: 542 m^3 million; **agriculture: 186 m^3 million (34%) - capped**; balance for City of Cape Town
  - Low level of assurance for agricultural use; very few new built infrastructure options
- Other sources outside the system: smaller farm dams, direct river abstraction, groundwater



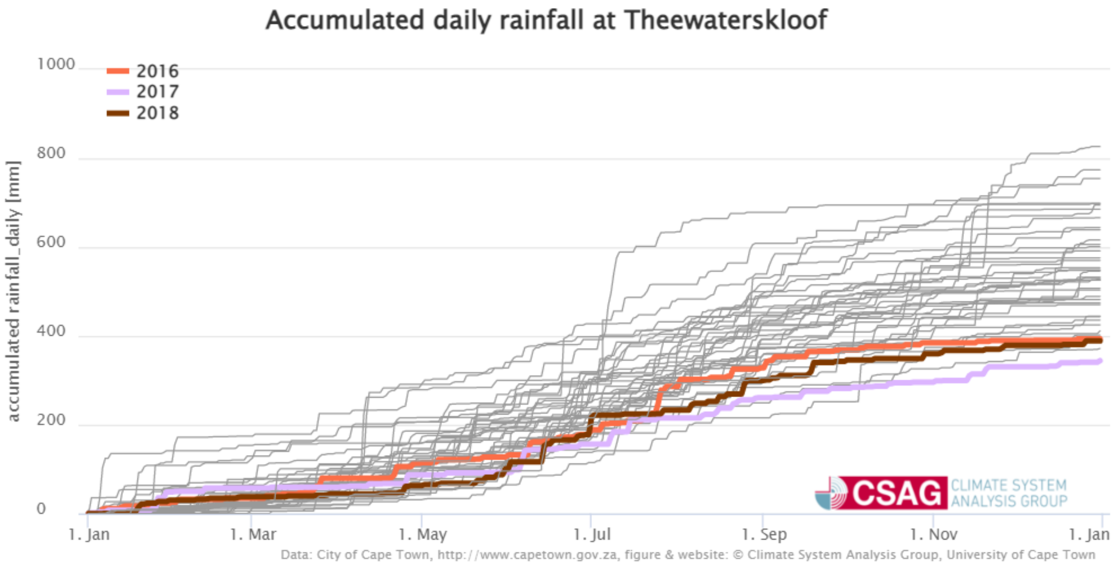




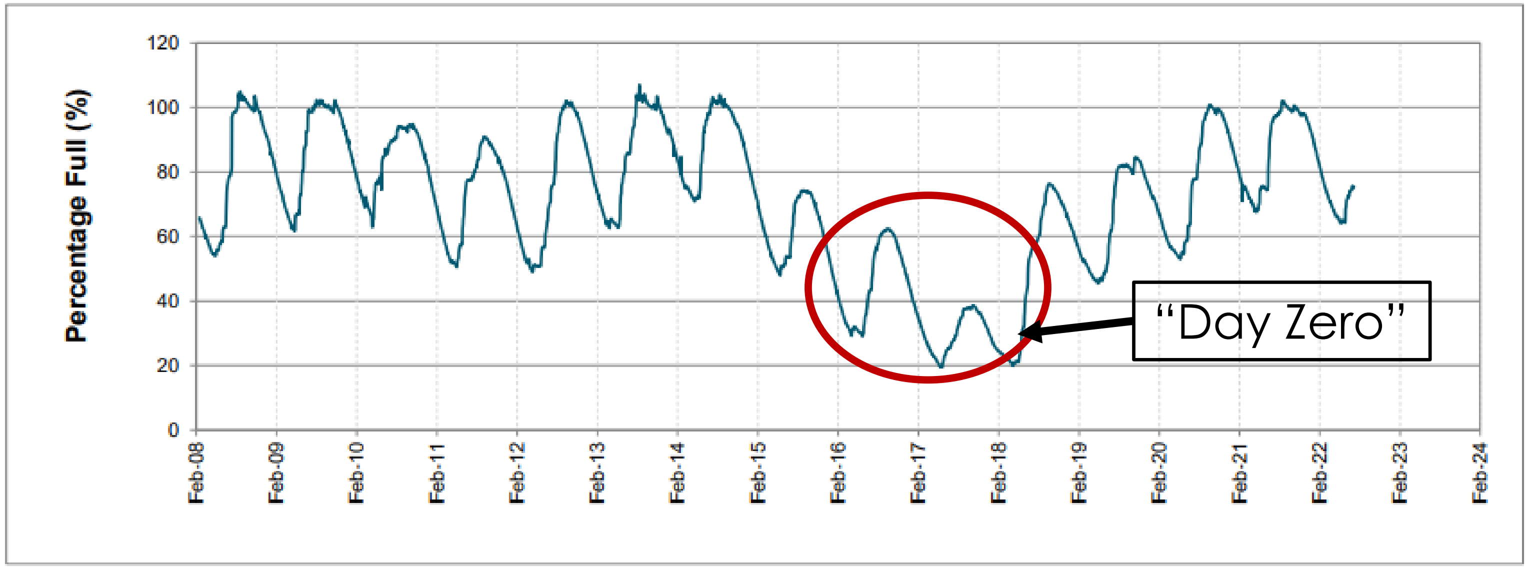
Climate trends in South Africa and Western Cape

- Strong evidence that the climate of South Africa is shifting and will continue to shift into the future (MacKellar et al., 2014; Engelbrecht et al., 2016; Jack et al., 2022).
- Increases in temperature across most of the region and all seasons over the past century. More hot days and fewer cold days.
- Some uncertainty and complexity remain, especially with regard to changes in rainfall.
- Increasingly variable and unpredictable weather.

Rainfall and dam levels during the 2015-2018 “Day Zero” drought



WCWSS Storage Record (2008 - Present)



Climate change attribution study (Otto et al., 2018): The drought was **3x more probable** because of the influence of climate change.

The WC Agricultural "Incident" chart

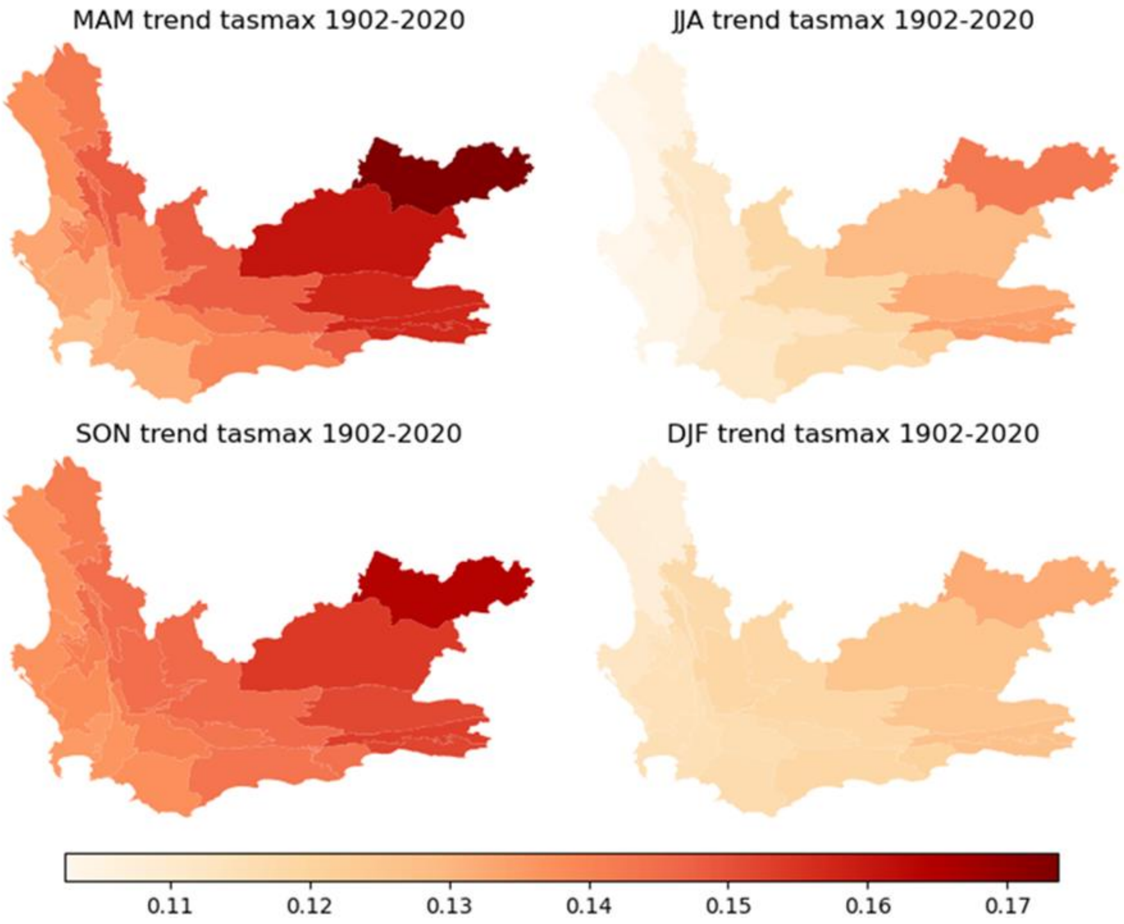
Disasters	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Floods	X	X	X	X					X	X	X	X
Drought					X	X	X	X	X	X	X	X
Fire						X	X	X	X	X	X	
Avian Flu	X	X					X				X	X
Pests						X		X	X		X	X
Hail damage					X						X	
COVID19										X	X	X
African swine flu											X	X
Locust swarms											X	X

> "Climate change impacts and risks are becoming increasingly complex and more difficult to manage. Multiple climate hazards will occur simultaneously, and multiple climatic and non-climatic risks will interact, resulting in compounding overall risk and risks cascading across sectors and regions." IPCC 2021

WC climate change – trend analysis

Significant increases in **temperature** (T_{max}, T_{min}) across all agro-climatic zones and all seasons over the past century.

Higher rates of increase in the shoulder seasons (**spring**, **autumn**) when irrigation is lower than in summer.



Mean seasonal daily maximum temperature trends (°C/decade) based on the CRU TS4.05 dataset from 1902-2020.

Jack et al. (2022) Climate System Analysis Group

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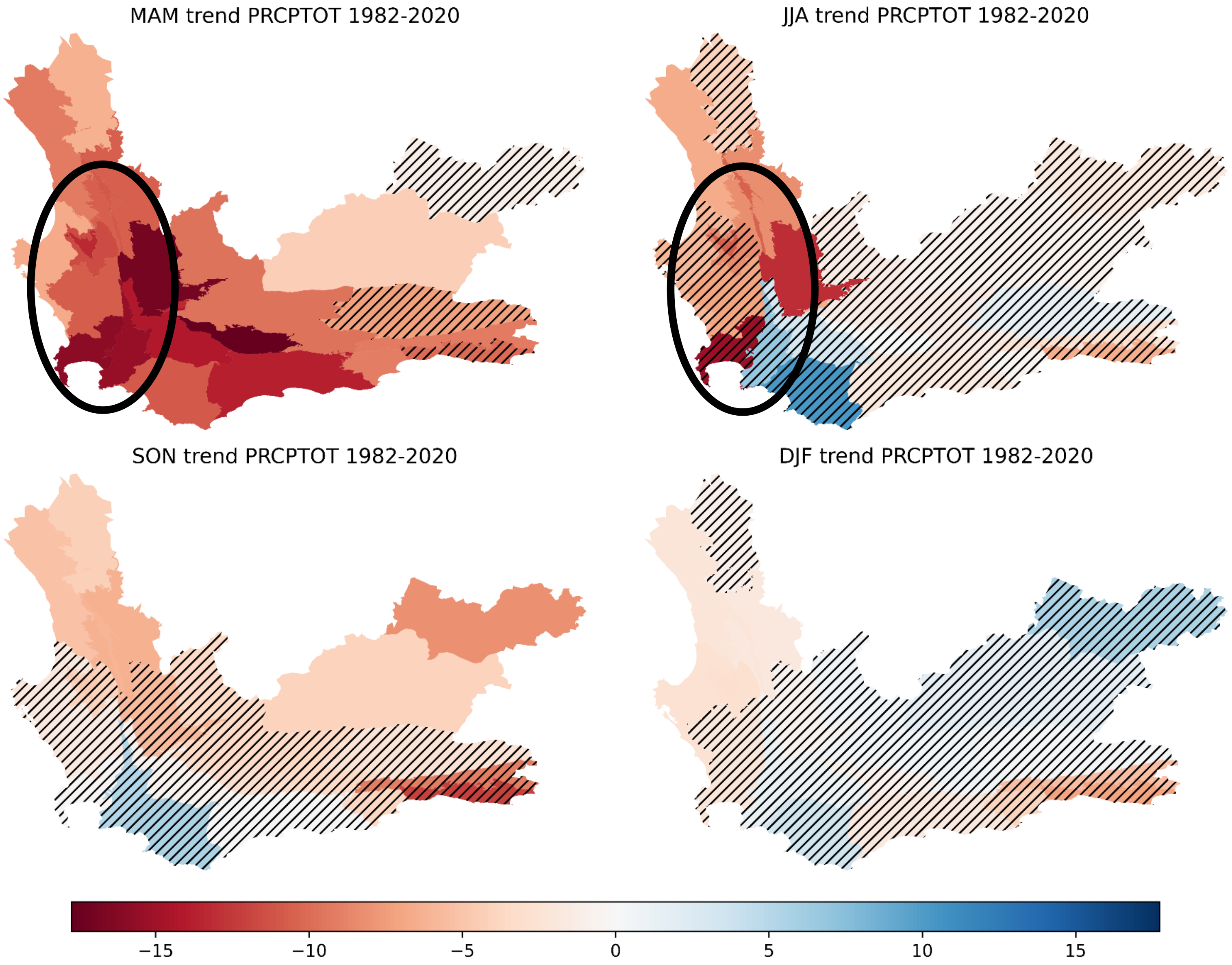
WC trend in seasonal rainfall (mm/decade)



Significant drying in autumn (all fruit and winter grains zones),
and in winter (northern fruit zones)

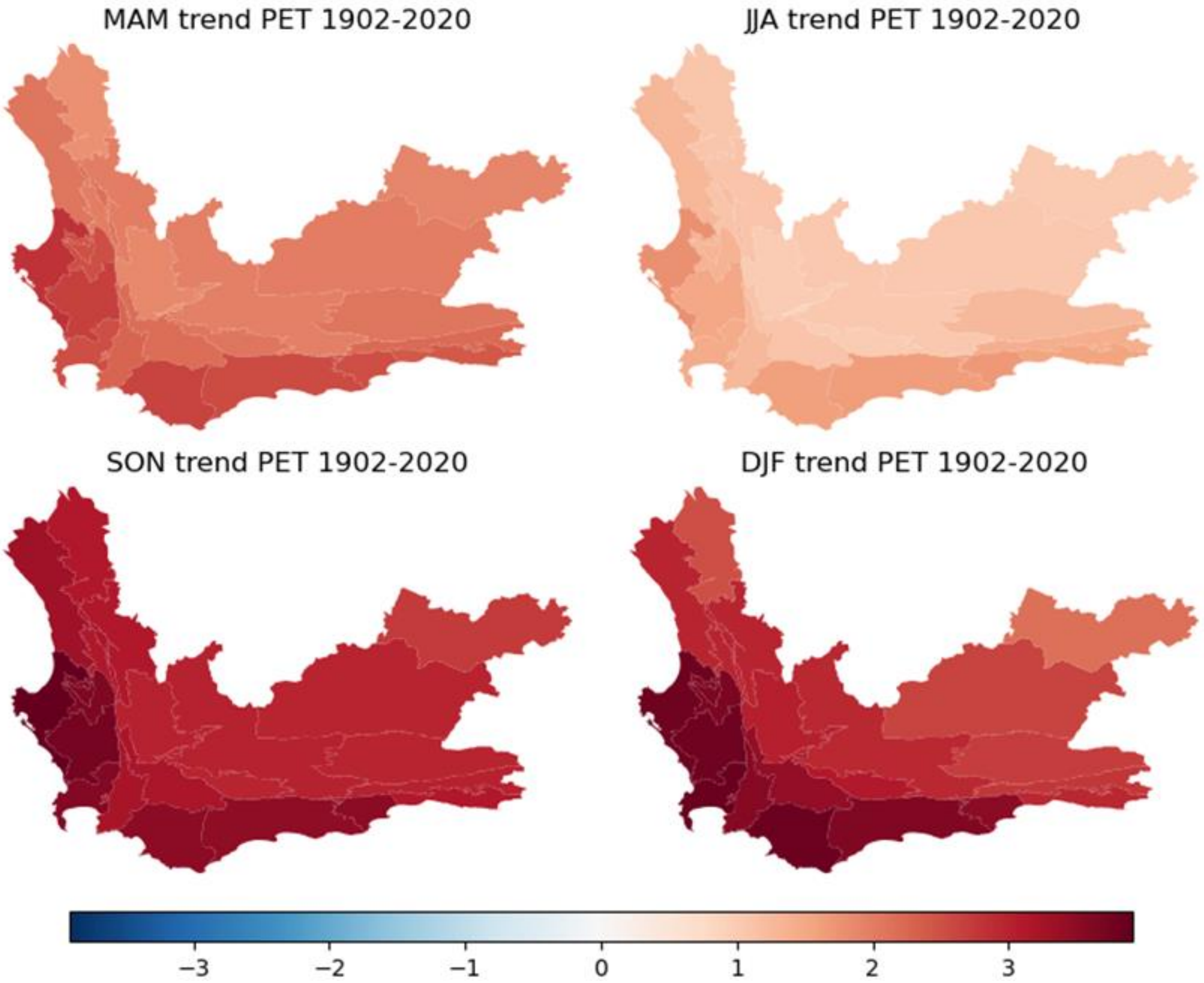
Includes the drought years: 2015-2018.

Based on the CHG CHIRPS merged rainfall product over the period 1982-2020.

Diagonal hashing indicates trends that are not statistically significant with a p-value threshold of 0.05.

Jack et al. (2022) Climate System Analysis Group

Trend in seasonal Potential Evapotranspiration (PET, mm/day)



Water balance - drying

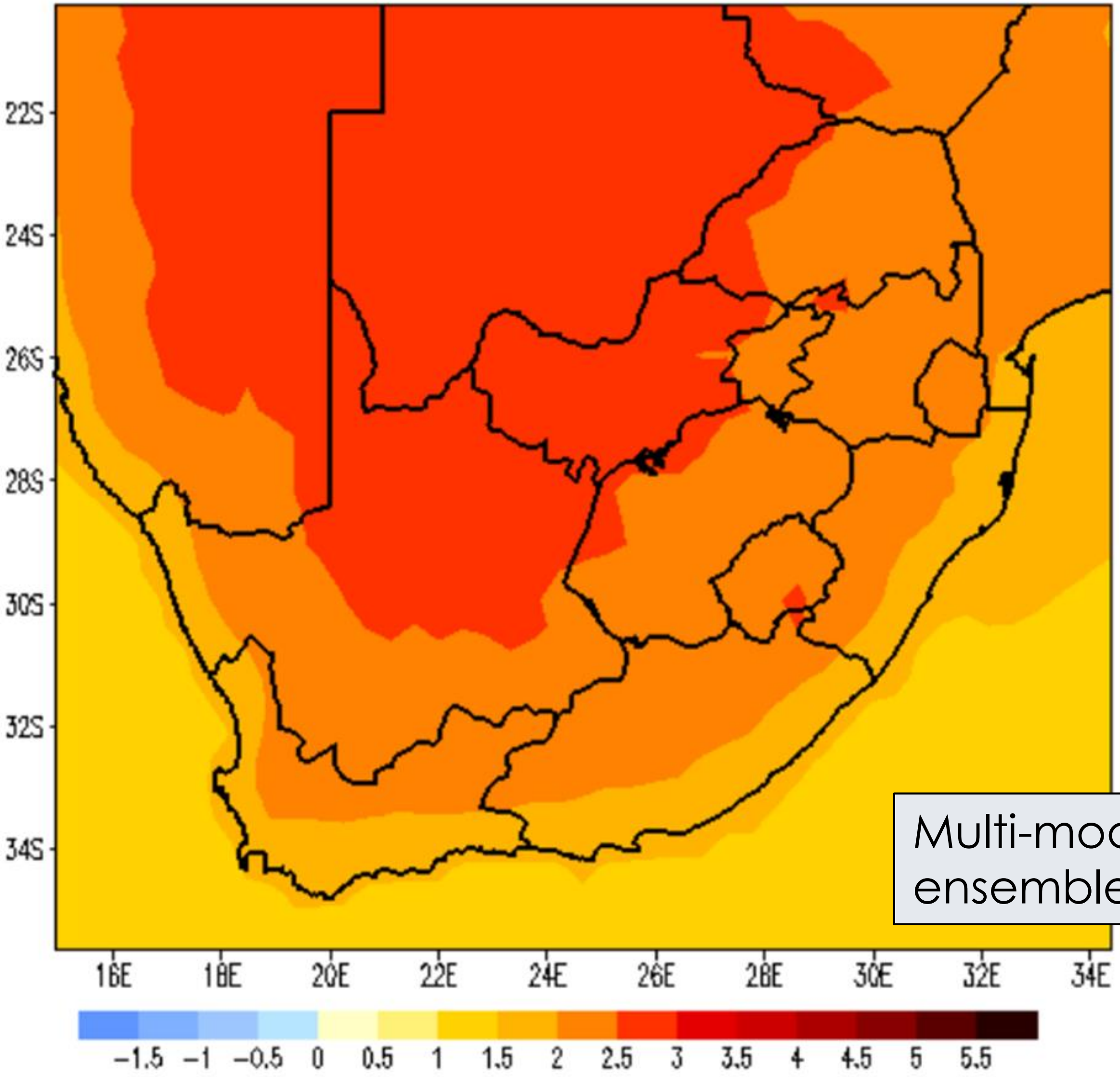
Increased irrigation demand, especially in spring and summer.

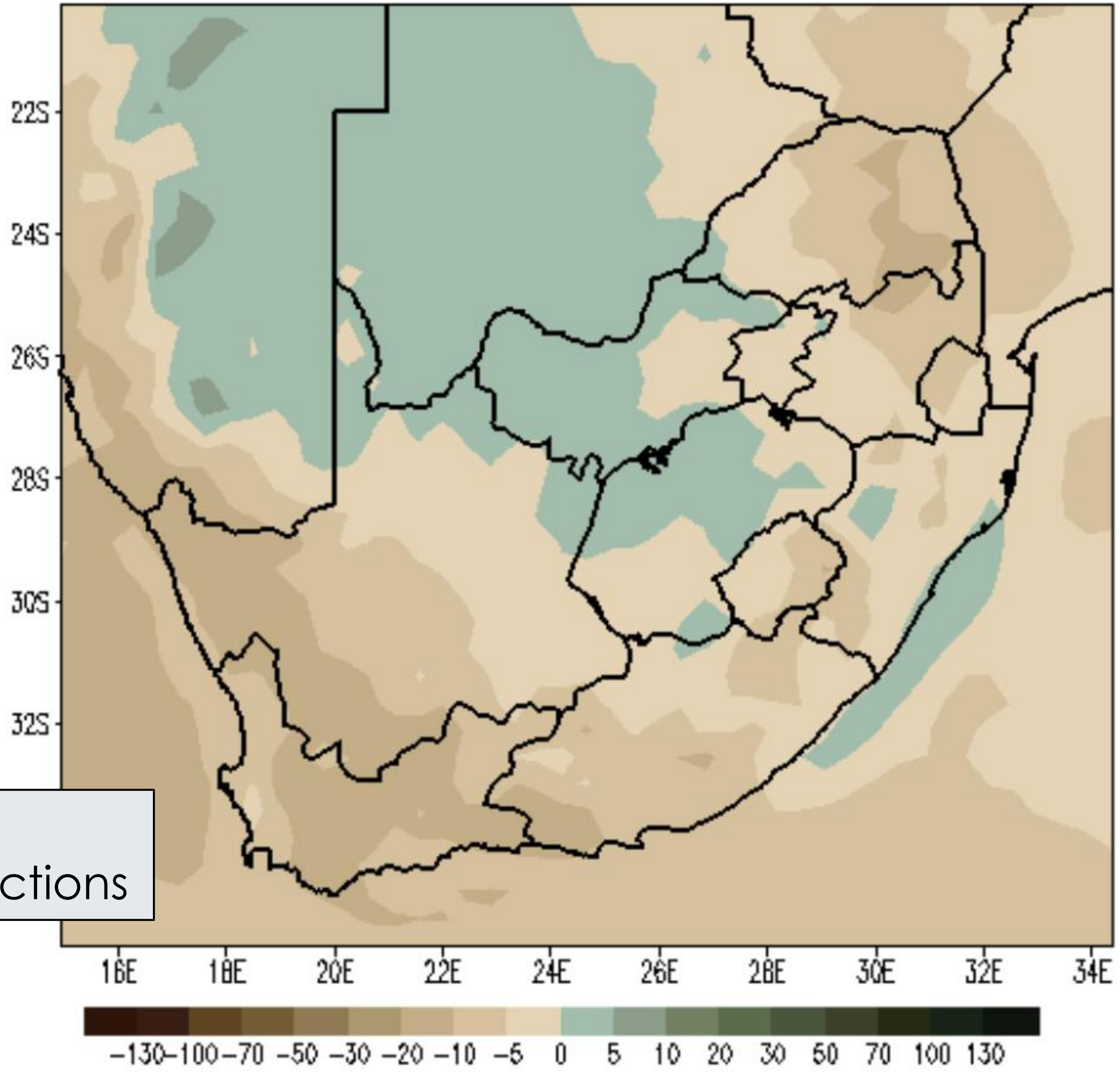
Based on the CRU TS4.05 product over the period 1902-2020.

CRU PET is calculated using the **Penman-Monteith method**.

Jack et al. (2022) Climate System Analysis Group

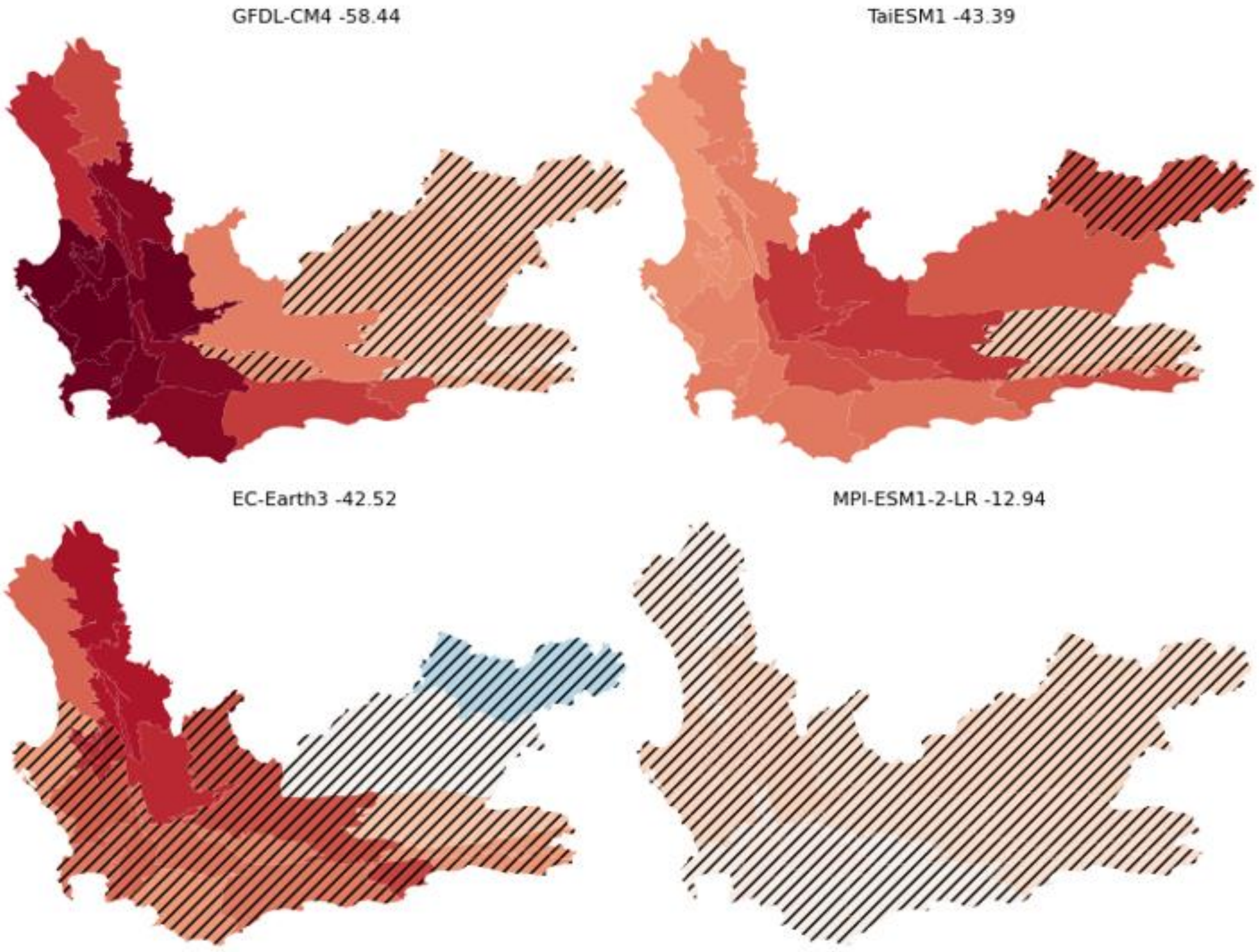
Downscaled modelling of temp and rainfall in Southern Africa (2046-2065)





Multi-model ensemble projections

WC “Archetypes” of projected change in future mean annual rainfall



Archetype model name	Provincial scale projection
MPI-ESM1-2-LR	Almost no rainfall change, low magnitude temperature increase (~1.2°C)
TaiESM1	High temperature increases (~2.4°C), large rainfall reduction
GFDL-CM4	Moderate temperature increases (~1.7°C), large rainfall reduction
EC-Earth3	Moderate temperature increases (~1.7°C), mixed spatial pattern of rainfall change (increases in Nelspoort region, decreases elsewhere). [Note, this pattern occurs in multiple models, hence identifying it as plausible archetype]

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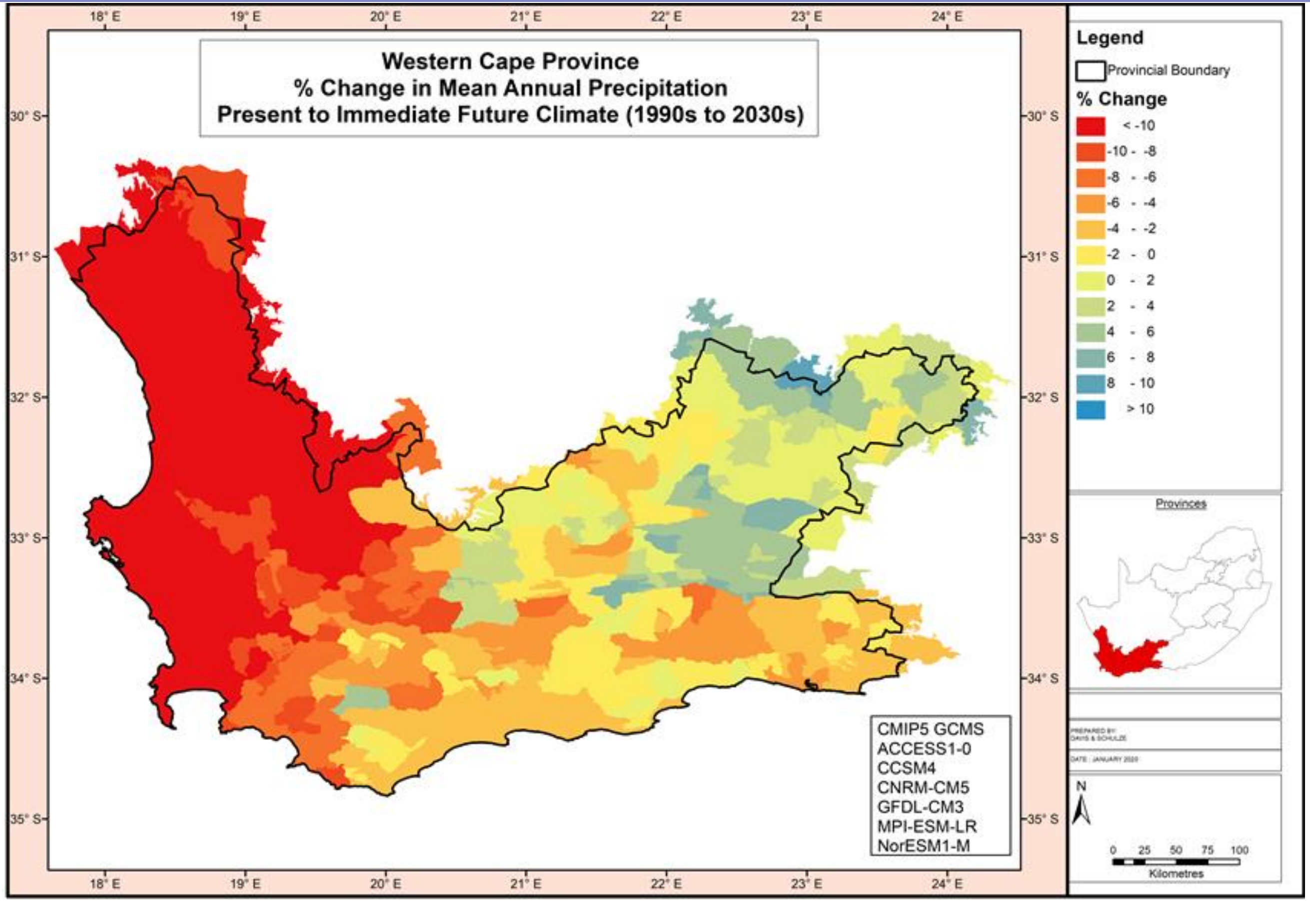
WC Projected change in future mean annual rainfall

Reductions in rainfall expected across the province (maybe not in north-east).

Even without changes in rainfall, **increasing temperatures (high certainty) will almost certainly bring significant water balance challenges to agriculture**.

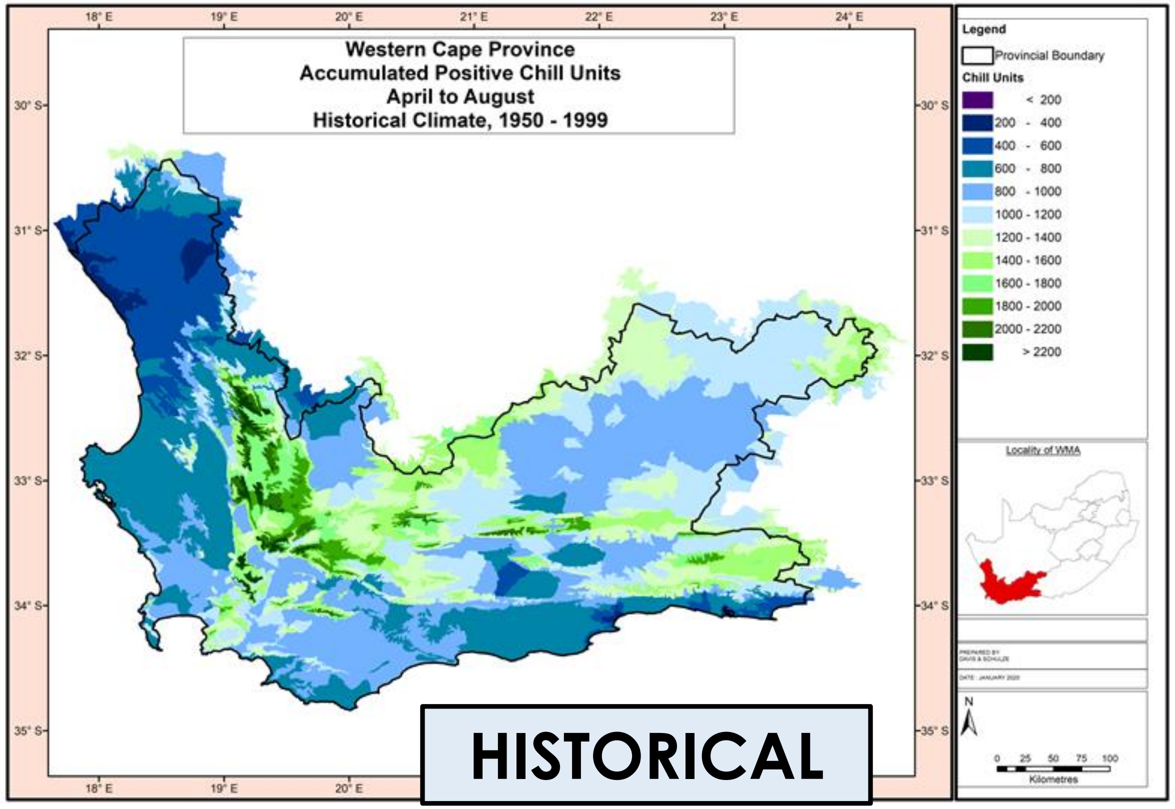
Other hazards: drought, flood, hail, strong wind, pests & diseases.

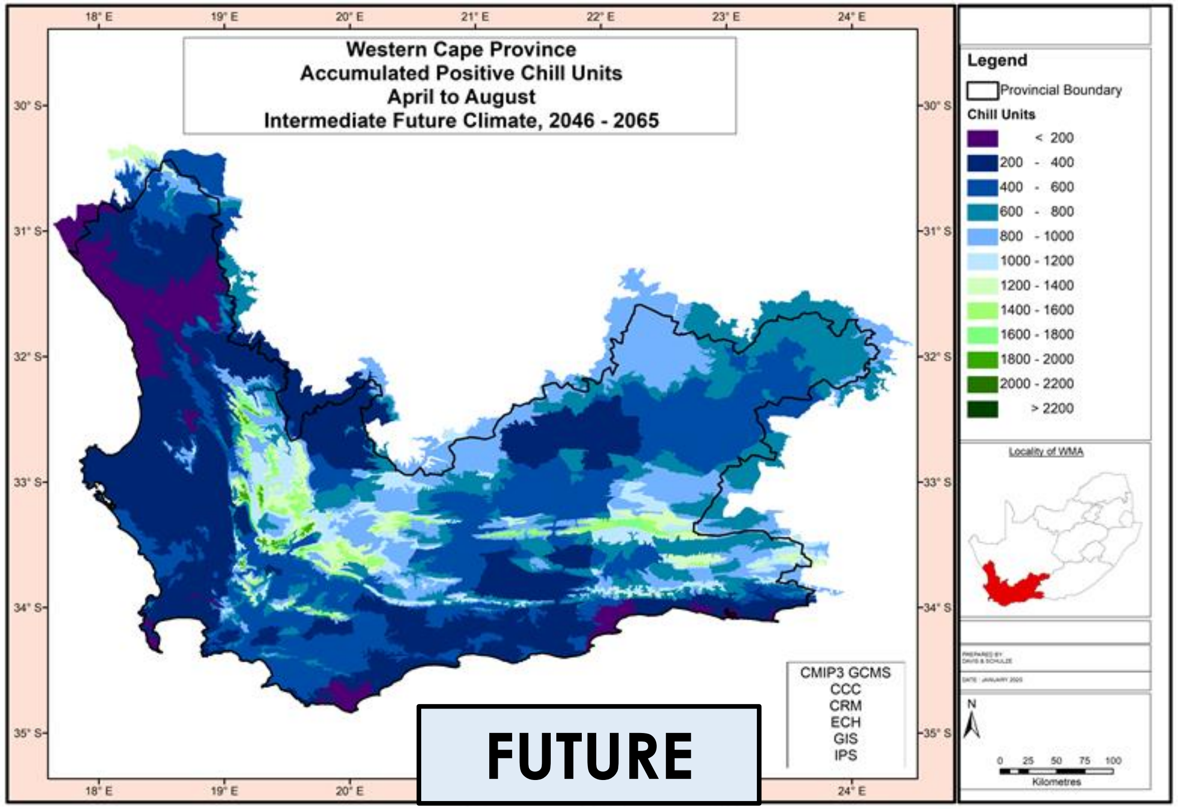


Projected changes in MAP (%) between 1990s and immediate 2030s. Derived from as yet unpublished outputs of 7 bias-corrected CMIP5 GCMs and RCP 8.5

Midgley et al. (2021) Report to Hortgro Science

Accumulated seasonal chill units – April to August (2046-2065)





Historical period:
Pome fruit regions: 800 – 2000 PCUs
Stone fruit regions: 600 – 800 PCUs also common

Intermediate future: Reductions of 250-500 PCUs
Pome fruit regions: 200 - 1600 PCUs
Stone fruit regions: 200 - 600 PCUs also common

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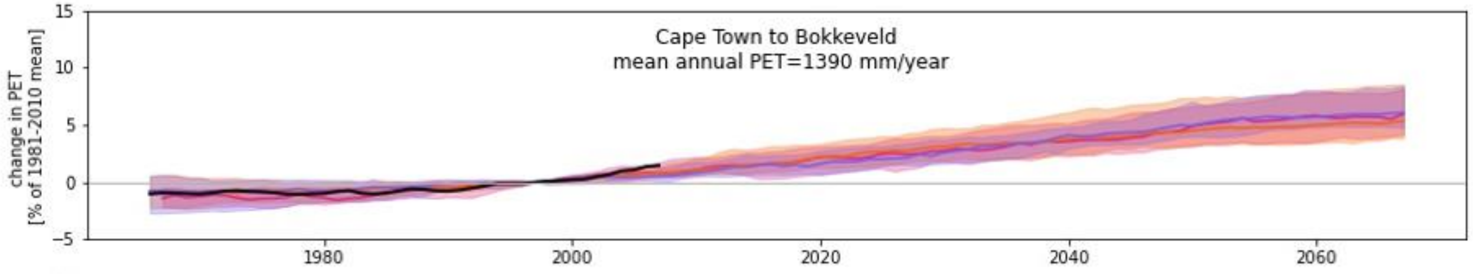
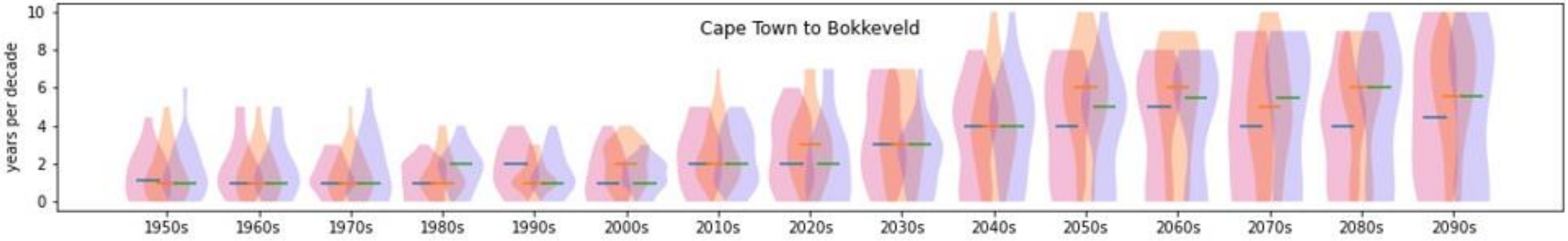
Midgley et al. (2021) Report to Hortgro Science

Evolution of rainfall variability, PET, hydrology, SPEI (drought index)

- Increasing variability of rainfall
- Increasing Pot. Evapotranspiration



- Changes in hydrology: runoff, stream flow, groundwater recharge
- More frequent dry years and consecutive dry years and droughts



Changes in years/decade with SPEI(12) < -1.0 (moderate drought)
SPEI = Standardized Precipitation-Evapotranspiration Index

Jack et al. (2022) Climate System Analysis Group

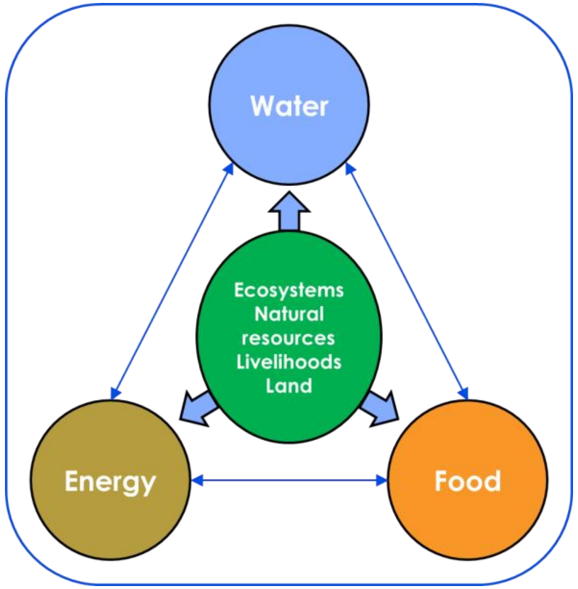
Climate change response - principles (for agricultural landscapes)

- The foundation for our response must lie in **regeneration of our landscapes** using a **systemic, holistic approach -** soil, water, biodiversity, social factors, economic factors, energy**.**

- **Local context is critical.**

- Get better at understanding the linkages between **multiple crises in agricultural landscapes** so that we can halt the mounting pressures:
  climate change, biodiversity loss, soil degradation, water scarcity, energy crisis, uncontrolled land use change, human and livestock pandemics, conflict, food insecurity.

- *Adaptation and mitigation* must go hand in hand – awareness of **synergies and trade-offs.**



SmartAgri Plan and Implementation

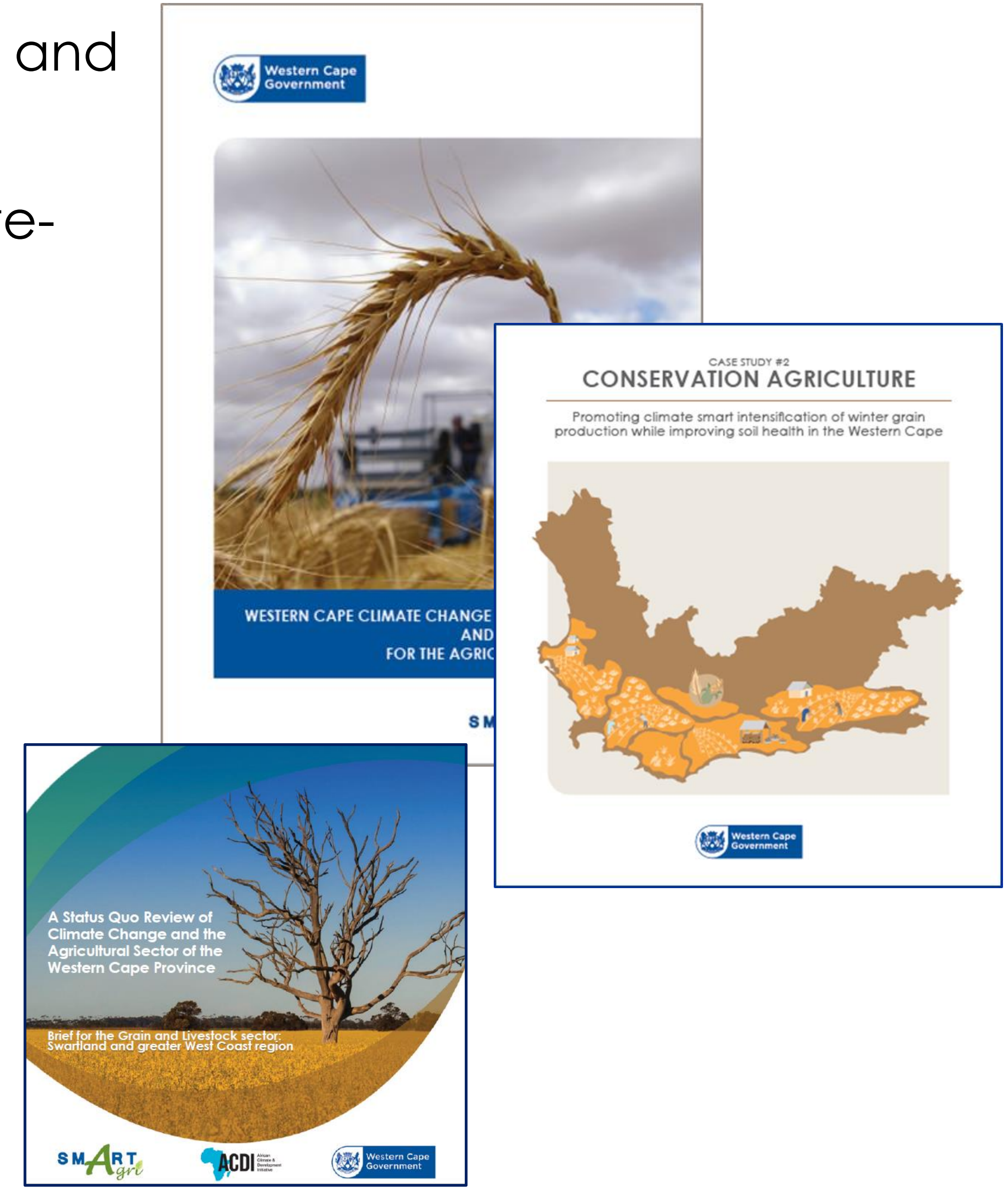
- Western Cape Climate Change Response Framework and Implementation Plan for the Agricultural Sector (2016)
- Provides a “roadmap” to ensure a low-carbon, climate-resilient agricultural sector in the WC

2016-2020 – fast-track implementation

Awareness, priority projects, DOA programmes

2021 onwards – wider and deeper implementation

www.greenagri.org.za



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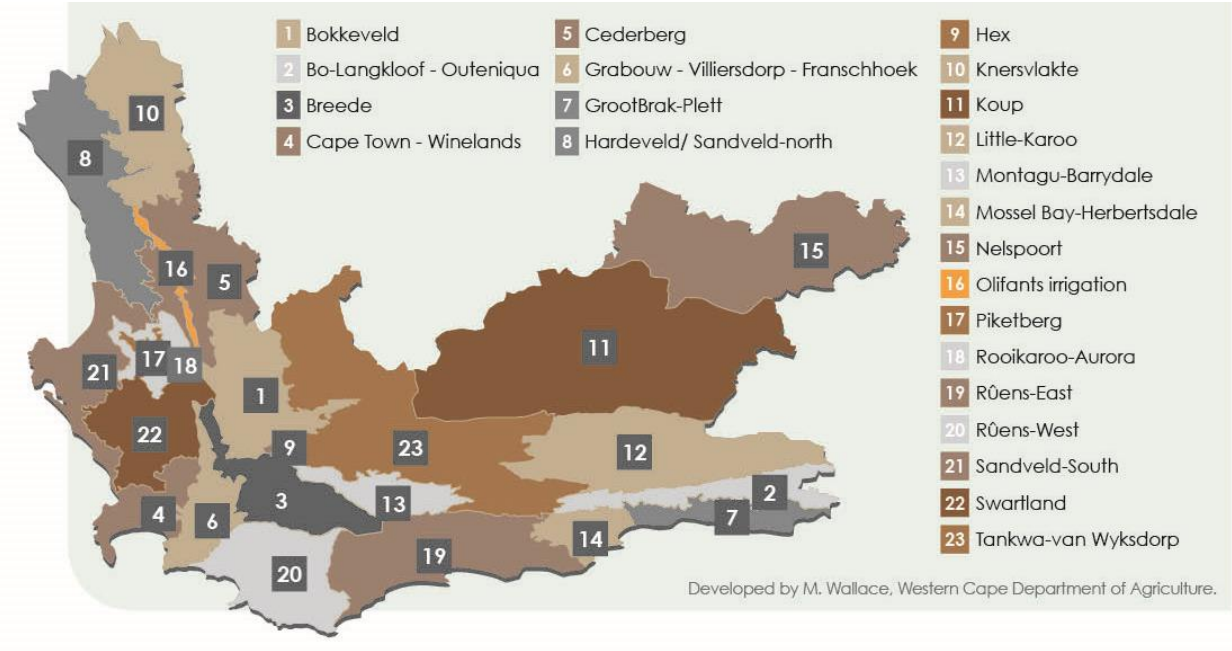
SmartAgri approach

- Identified historical and future climatic risk at an **appropriate scale** i.e. per agro-climatic zone (x23), commodity-focused.
- Identified what is already being done to manage climate risk, **build on strengths**.
- **Intensive stakeholder engagement**: co-developed locally-informed, practical and relevant responses in a systemic way.
- **Balance of short-, medium- and long-term actions**, some more incremental, some more transformative.



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Central role of intensive stakeholder engagement

- Multi-stakeholder participation in various forms.
  - *Capture needs, experience and current initiatives.*
- Need to respond to on-the-ground receptivity and build buy-in.
- Multi-sectoral: Alignment with water, environment & conservation, land use planning, local government, disaster management, value chain (processing), etc.

SmartAgri Plan

VISION

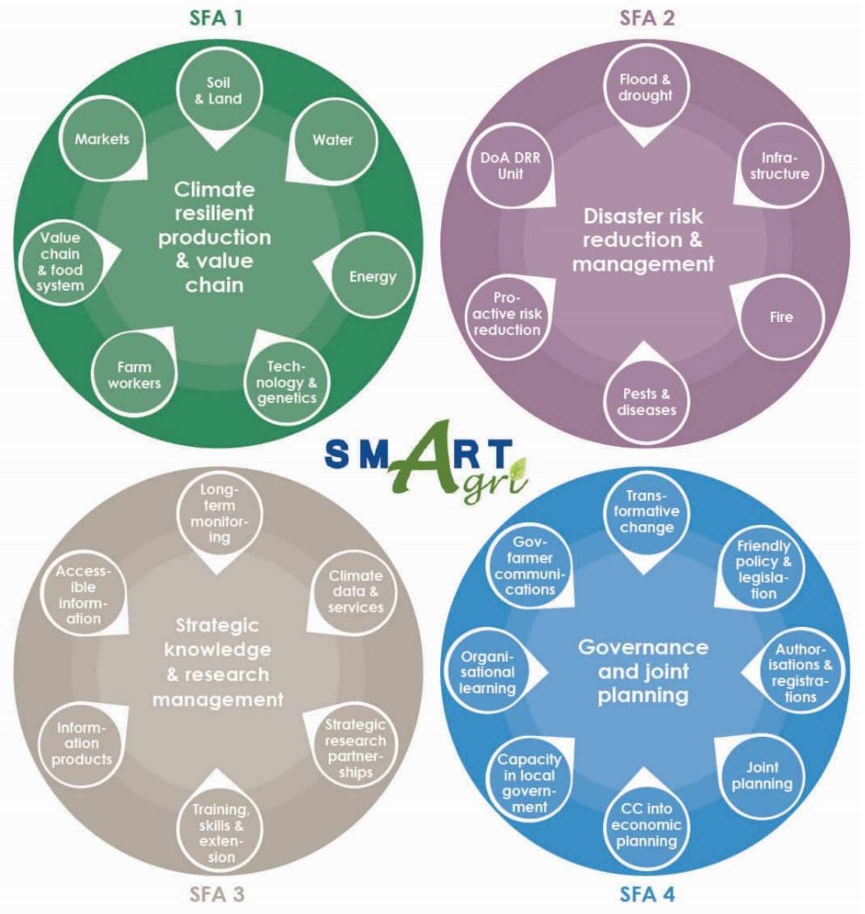
Leading the Way to a Climate Resilient Agricultural Future for the Western Cape

GOAL

To Equip Agriculture to Respond to Climate Change Risks and Opportunities Through Innovation, Leadership and United Strategic Action

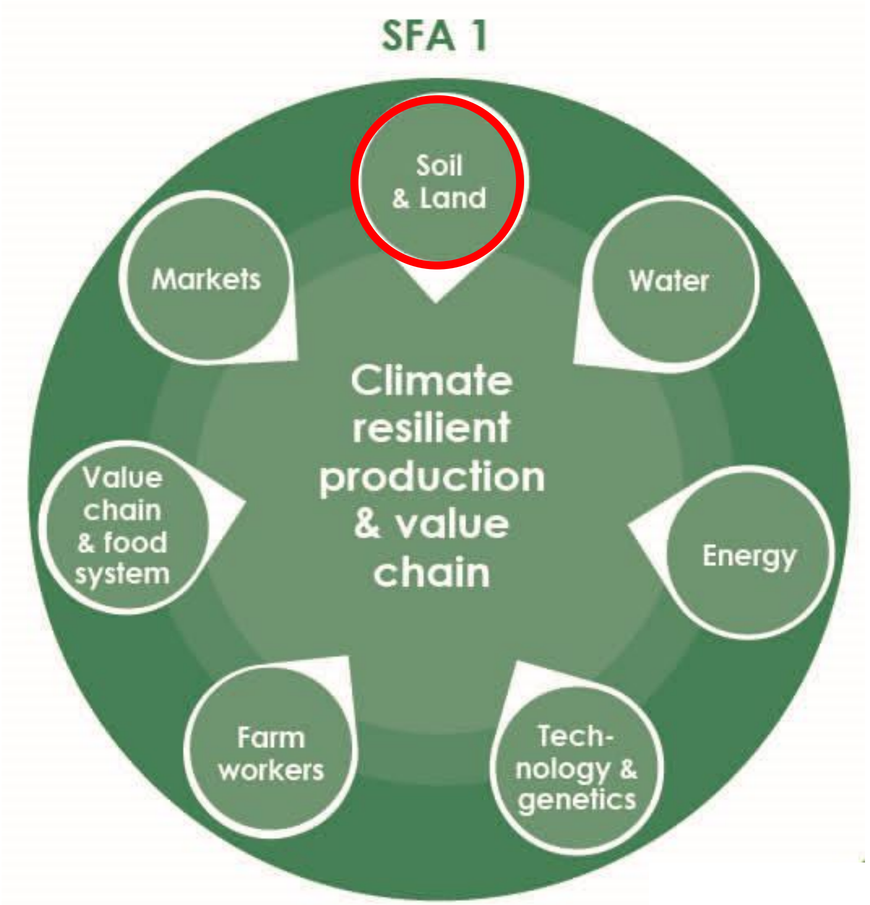
STRATEGIC FOCUS AREAS

1. Promote a climate-resilient low-carbon production system that is productive, competitive, equitable and ecologically sustainable across the value chain
2. Strengthen effective climate disaster risk reduction and management for agriculture
3. Strengthen monitoring and data and knowledge management and sharing, and lead strategic research regarding climate change and agriculture
4. Ensure good co-operative governance and joint planning for effective climate change response implementation for agriculture



OBJECTIVE 1.1: Promote climate smart soil and land use management practices
OUTCOME: Soil and land use are managed in accordance with agro-ecological principles that take climate change into account
OUTCOME INDICATOR: Continued long-term productivity of soils and agricultural landscapes

1.1.4 Integrate and optimise land use planning at provincial and local level to protect agricultural land that holds long term agricultural and food security value in the face of climate change



Key enablers:

Revised norms and standards;

updated planning maps

WC Department of Agriculture activities (selection)

- **Conservation Agriculture (CA, Plant Sciences):** a flagship CSA project to build soil health and resilience; long-term research trials and farmer support; proven benefits during drought.
- Research on **genetic determinants of heat stress resilience in ostrich and sheep (Animal Sciences)**. Results provide a foundation for climate-adapted breeding programmes and management strategies.
- Research for the development of **veld management principles and guidelines (Plant Sciences)** for sustainable land-use in rangelands as a means to mitigate the effect of climate change.
- **Disaster risk assessment (DRR Sub-Programme):** optimised disaster assessment and relief; pro-active disaster risk reduction / climate change adaptation; in collaboration with stakeholders.
- Climate smart agricultural **technologies and tools (GIS unit)**:
  - **FruitLook**: a web-based portal to assist farmers in optimising in-field water use through satellite-based data and data products.
  - **Cape Farm Mapper**: an online mapping tool to assist farmers with decision making in production and environmental management.
- **Climate change awareness and capacity building (Climate Change unit):** focused presentations at Farmer Days etc. to raise awareness and encourage farmers to take up Climate Smart Agriculture practices.

Climate Change and Agriculture Youth and Young Researchers' Convention

20-21 July 2022
Elsenburg

FruitLook: web-based digital tool to track growth, water use, N use

Assists growers in optimising in-field water use through satellite-based data and data products

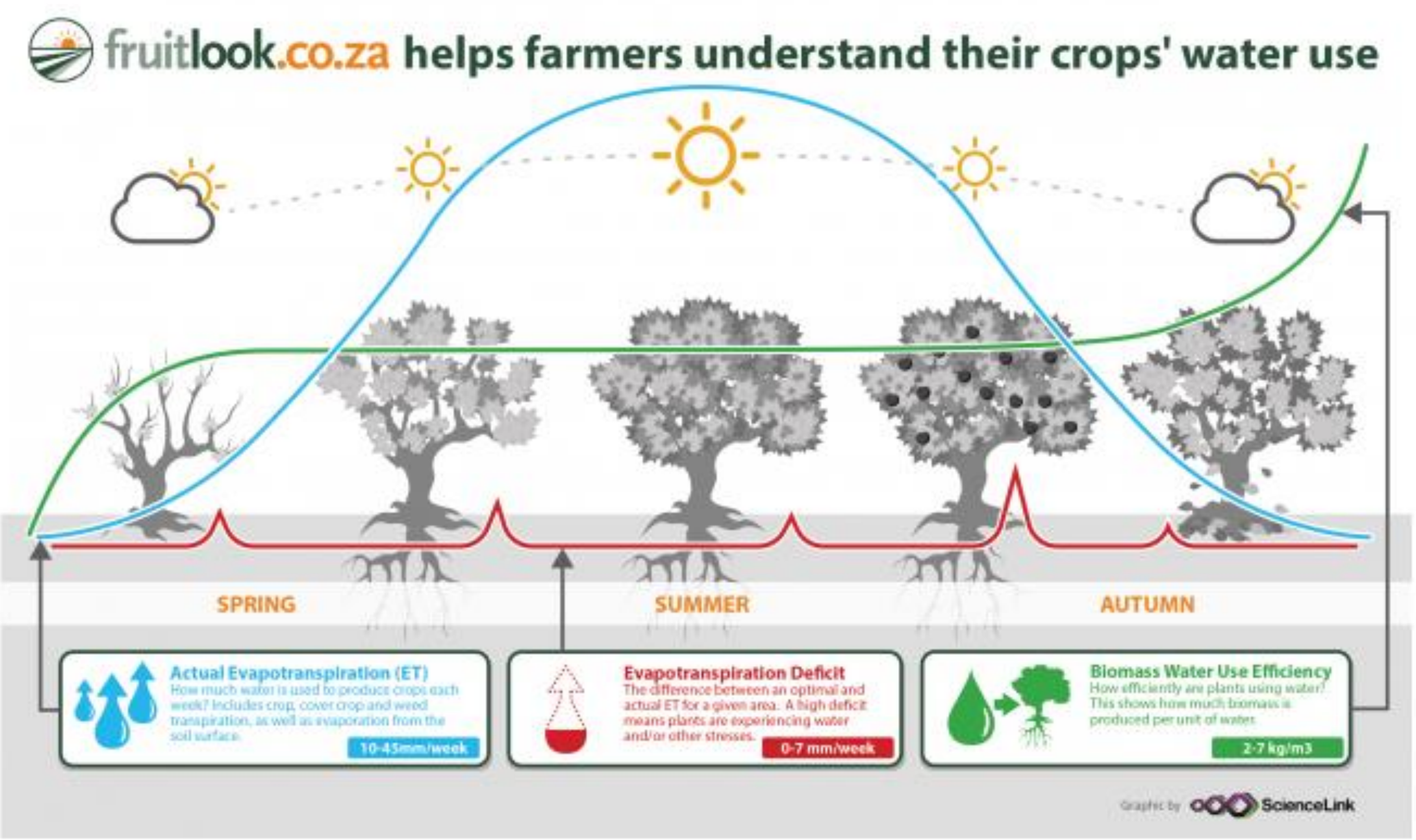
Pixel maps at a resolution of 20 x 20m

Water use savings: 11-20% (grapes, pome); 21-30% (stone)

Can be used on any crop

http://www.fruitlook.co.za

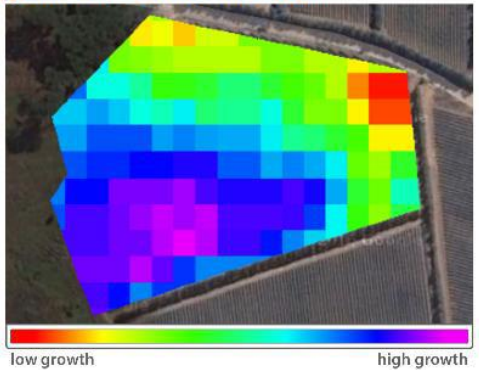
C. Jarmain et al.



Applications: identify under-irrigation, identify over-irrigation and probe placement

- Data since 2011
- FruitLook now covers 9.5 million hectares in the Western Cape
- Free of charge - subsidized by the Western Cape Department of Agriculture

FruitLook shows clear growth variation in this block



Restore water-related ecological infrastructure (nature-based solutions)

Clearing of infestations of invasive alien trees (e.g. pines) from naturally tree-less catchments **increases available water resources by 15 – 29 %** (Rebelo et al., 2022, Research Square).

Increases water base flows, flow regulation, improved water quality, fire risk reduction, **significant job creation** (Olesen et al. 2021, Restoration Ecology 29(7), p. 13423).

Reduces the impact of climate change on **hydrological drought severity** (Holden et al. 2022, Communications Earth & Environment 3(1), 1-12).

Public programme, but works best in **partnership with landowners** (Midgley et al., 2021, Ambio).

Midgley et al. (2021) Ambio 50: 1587–1609

Ambio
https://doi.org/10.1007/s13280-021-01531-z

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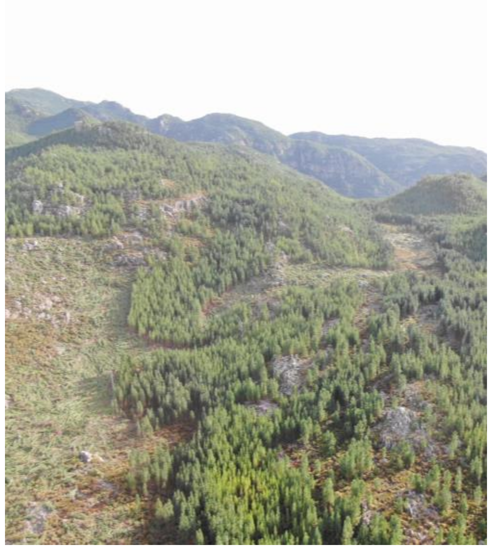
NATURE-BASED SOLUTIONS IN RIVER LANDSCAPES

Typologies of collaborative governance for scaling nature-based solutions in two strategic South African river systems

Stephanie J. E. Midgley, Karen J. Esler, Petra B. Holden, Alanna J. Rebelo, Sabine I. Stuart-Hill, James D. S. Cullis, Nadine Methner



Increase fruit crop water productivity

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Physical/Economic Crop Water Productivity (WP):

kg/ZAR of marketable fruit produced per m^3 of water used

Expressed on the basis of whole tree seasonal transpiration (T) – calculated from sap flow
and on seasonal evapotranspiration (ET) - modelled

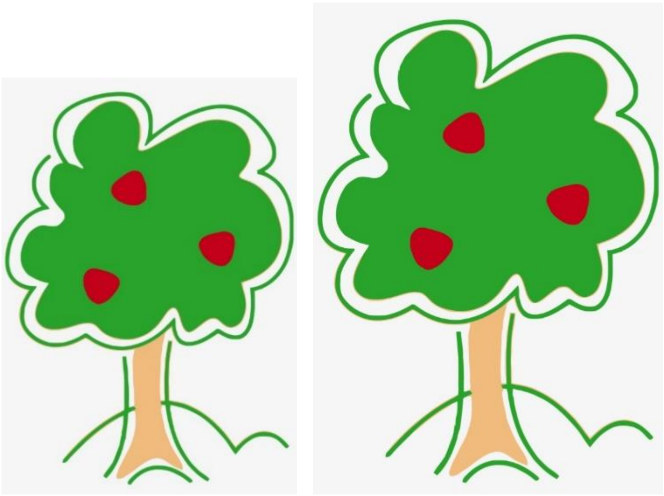
WP = yield/Tc

WP = yield/ETc

Three different field studies (2014-2022): well-watered, unstressed

Accurately quantify the water productivity of 'Golden Delicious' and 'Cripps Pink' / 'Rosy Glow' apple orchards in two production regions:

1. Different canopy sizes (ages)
2. Different rootstocks of varying vigour potential
3. White fixed (flat) net and black draped net compared to open



Dzikiti et al. (2018) Agricultural Water Management 208: 152–162
Midgley et al. (2020) Acta Horticulturae 1281: 479-486
Muchena et al. (2021) Acta Horticulturae 1300: 201-209
Lulane et al. (2022) Scientia Horticulturae 305, 111439

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Stellenbosch University: School for Climate Studies

Stellenbosch University Iyunivesithi Universiteit

A world-class academic faculty conducting interdisciplinary and transdisciplinary climate-related research in and for Africa

Research and development

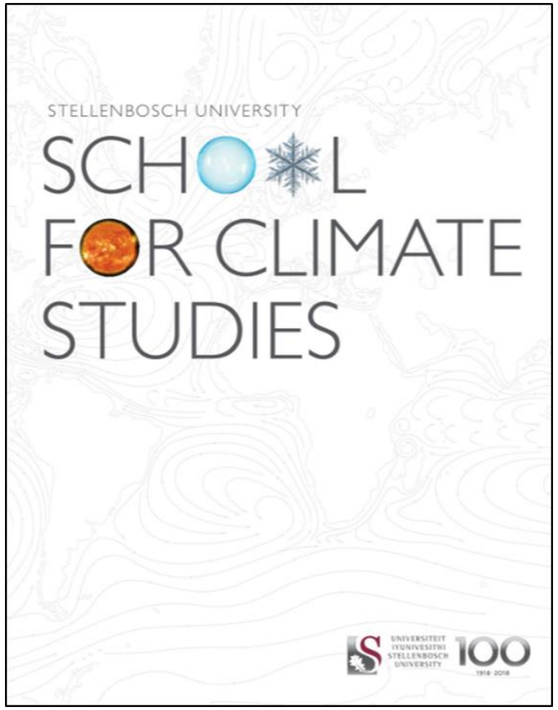
- Africa-relevant research programme that responds to existing and emerging issues in climate change impacts, adaptation and mitigation responses

Collaboration and capacity building

- Facilitating, strengthening and expanding climate related multi- and inter-disciplinary collaborations at SU
- Establishing new strategic partnerships and collaborations regionally and internationally.

Learning and teaching

Commercialisation and social impact



https://climate.sun.ac.za/

CST Centre for Sustainability Transitions

TerraClim

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Summary

- The scale of the challenge is enormous.

- We already have a good basis of scientific understanding, planning, practical approaches and tools, and some uptake by farmers and the value chain.

- Collaborative research and teaching is needed on risks and impacts, and the scientific and socio-economic case for more transformative actions,
  e.g. regenerative agriculture, new and more nutritious foods, tools and technologies for resource-poor farmers, and other themes.

Thank you

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