CLIMATE CHANGE AND IRRIGATED SUGARCANE PRODUCTION IN SOUTH AFRICA: THREATS, OPPORTUNITIES AND UNCERTAINTIES

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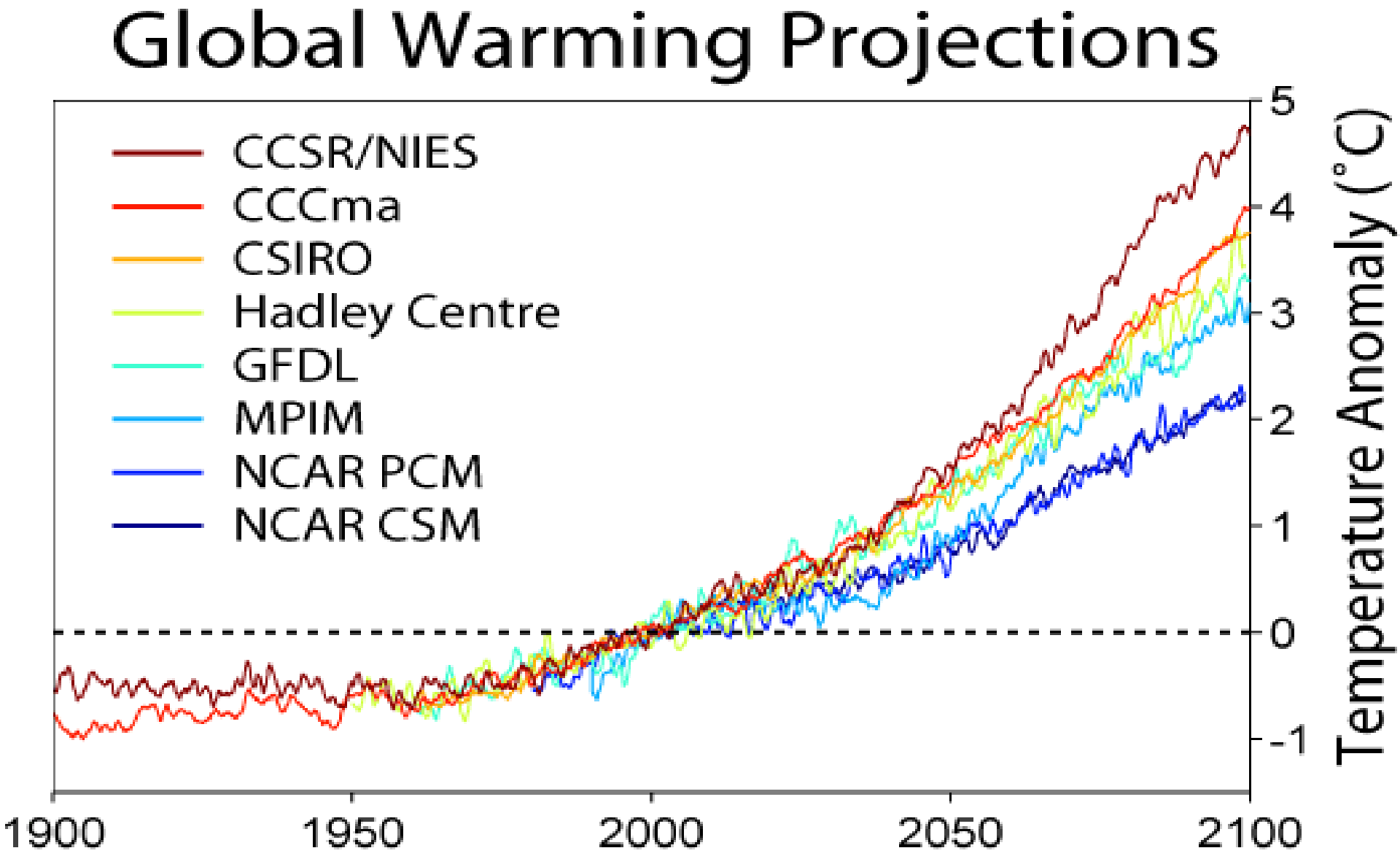
SANCID 2018

Climate change is real!



A new UN report says Earth only has until 2030 to stem climate change.

- Global agriculture, including sugarcane production in SA, will be hugely affected by changing climate
- Drastic action required before 2030! – Mitigation and adaptation
- Reliable predictions of crop response are required to plan adaptation of crop production

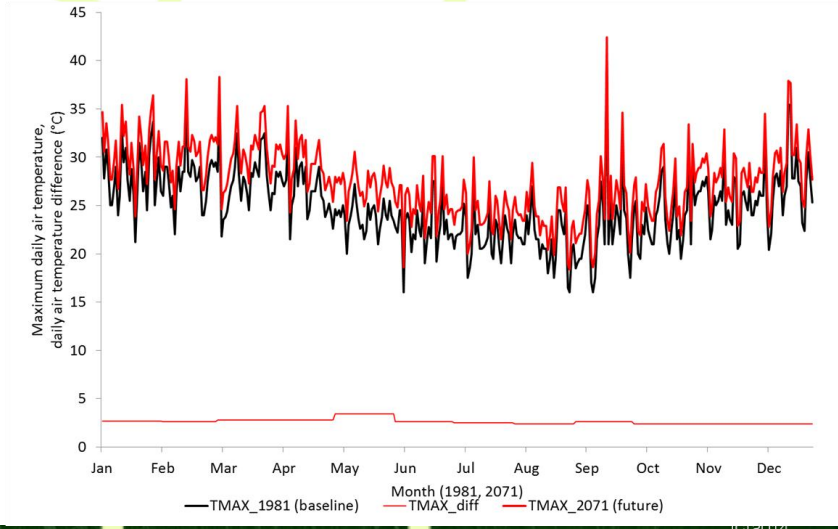
Background:
Climate change impact research

Approach

- Climate models (GCMs) project changes in climate at low temporal and spatial resolutions
- Downscale GCM climate projections to high resolution weather data (daily, local)
- Hydrological model + projected weather data -> runoff and water supply
- Crop model + projected weather data -> Crop growth and water balance

Issues

- Climate data: Emission scenario, which GCM(s),
- Weather data: Downscaling method
  - Dynamic vs empirical
  - Shortcoming of "Delta" methods
  - Assumptions about Srad, RH, wind speed
- Water supply assumptions, projections
- Spatial resolution of model inputs and outputs
- Crop model: CO_2 effects on transpiration and photosynthesis, high temperature effects, water deficit effects on water use and yield)



Objectives

1. Review recent predictions of climate change impacts on irrigated sugarcane production in South Africa
2. Highlight potential threats and opportunities that need to be considered
3. Identify knowledge gaps that need attention

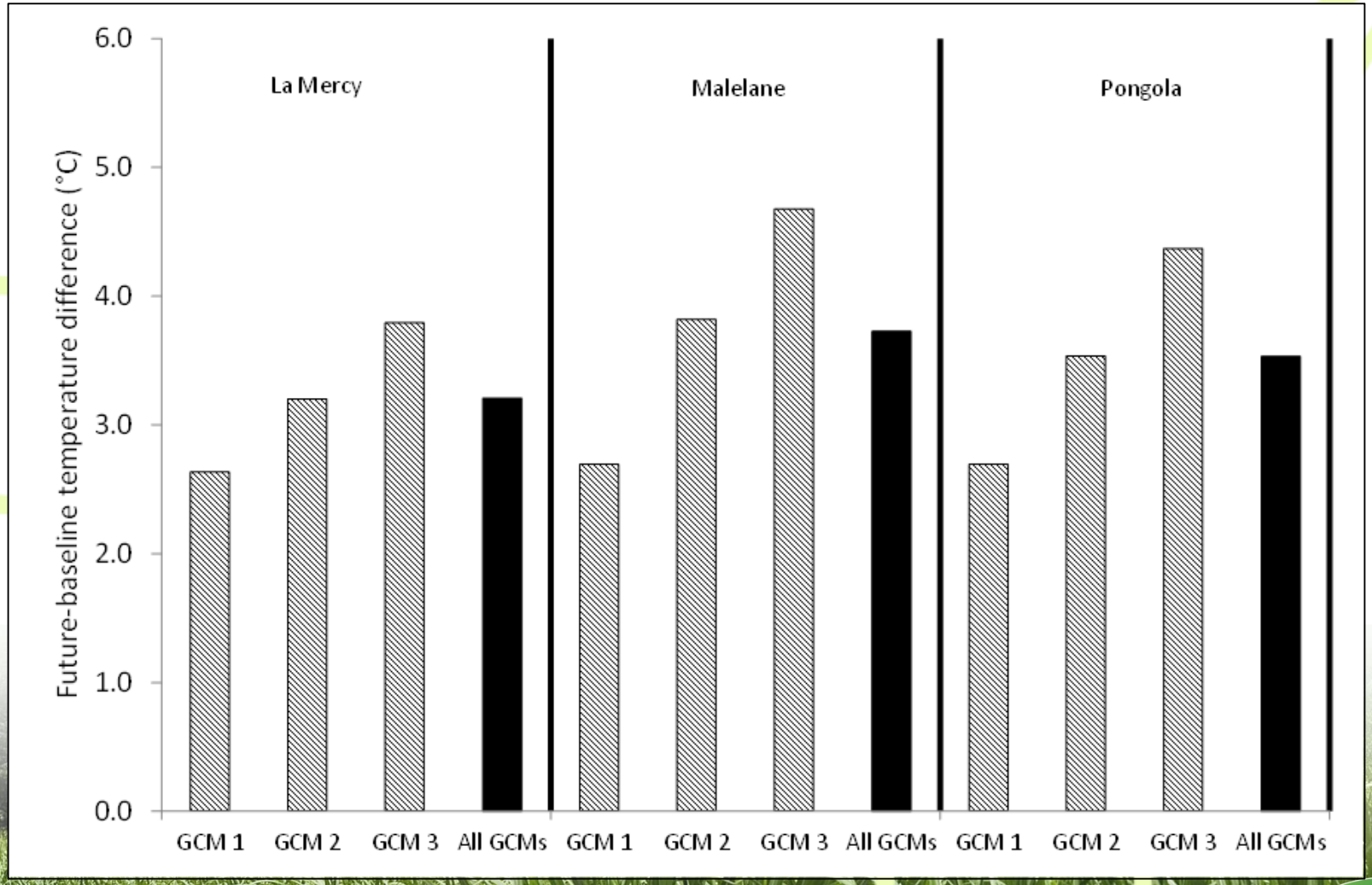
Previous work

Reference	Location	Period	GCM	Down scaling	Crop model	CO_2 effect	Yield change	CWU change	Irrigation change
Knox et al (2010)	Mhlume, Swaziland	2050s	HadCM3	Monthly delta	Canegro v3.1	Reduced CWU, on and off	+5-16%	+26%	+21%
Schulze and Kunz (2010)	SA	2050, 2090	MPI Echam5 et al		Smith model				+10-20%
Walker and Schulze (2010)	SA	Sensitivity analysis		Annual delta	APSIM-Sugar		+	+	+
Weepener et al (2015)	Eastern SA	2015, 2030, 2060, 2090	Six	Monthly delta	Thompson production function	No			
Jones et al (2015)	Malalane, Pongola	2085s	HadCM3 MPI Echam5 MIROC3.2	Monthly delta	Canegro v4.5	Reduced CWU Small + RUE effect	+10-12%	+11%	13%
Singels et al (2017)	Eastern SA	2050s	CSIROmk3.5 GFDLcm2.1 MPI Echam5	Empirical CSAG	Canegro v4.5_c2.2	Reduced CWU Zero RUE effect	+1-5%; +10-17%	+8-10%	+8-10%

Content

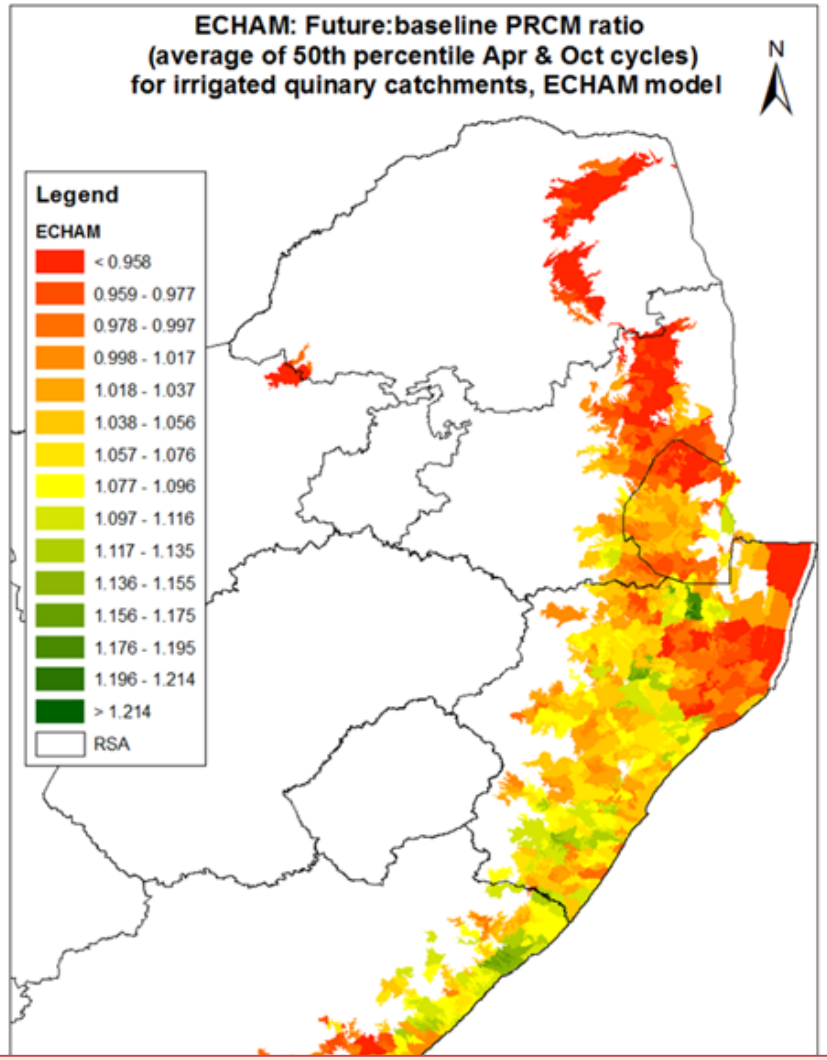
- What will our future climate look like?
- How will sugarcane crops respond?
- How can we adapt our crop management?
- Key messages

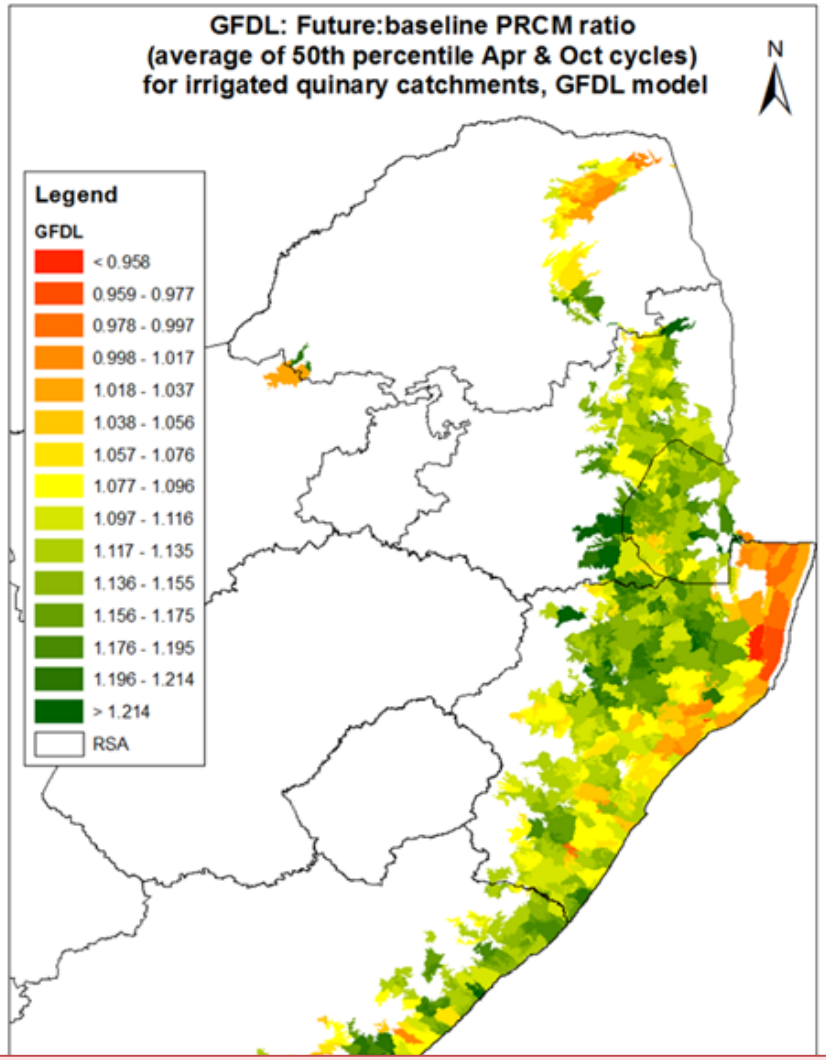
Temperature around 2085



Jones MR, et al. 2015. Simulated impacts of climate change on water use and yield of irrigated sugarcane in South Africa. Agric. Systems 139: 260–270

Annual rainfall around 2050

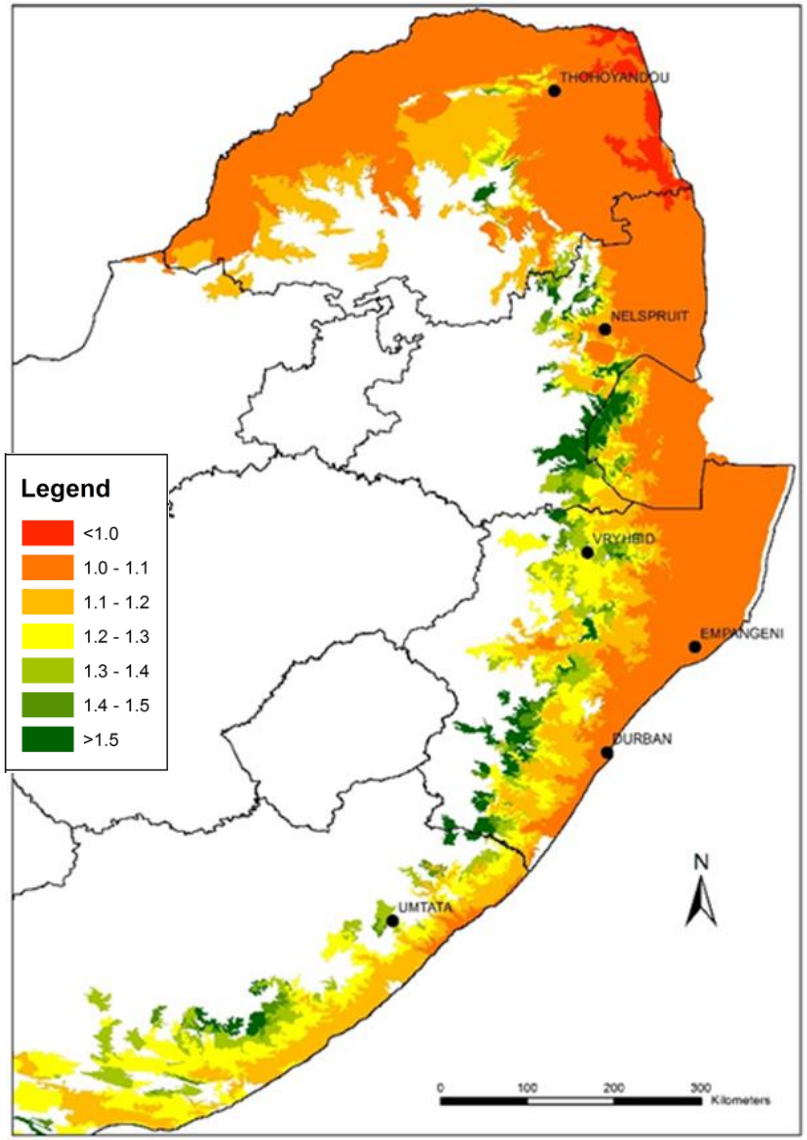




Singels A, et al. 2018. Sugarcane productivity and water use in South Africa under a future climate: What can we expect? Proc. S. Afr. Sug. Technol. Ass. 91: 57-61

Cane yield ratios
Future (2050) : Present (1980)

- Marginal increases in cane yield (1-5%) in current production areas
- Larger increases for cool areas (Midlands)
- Yield increases much lower than previous predictions



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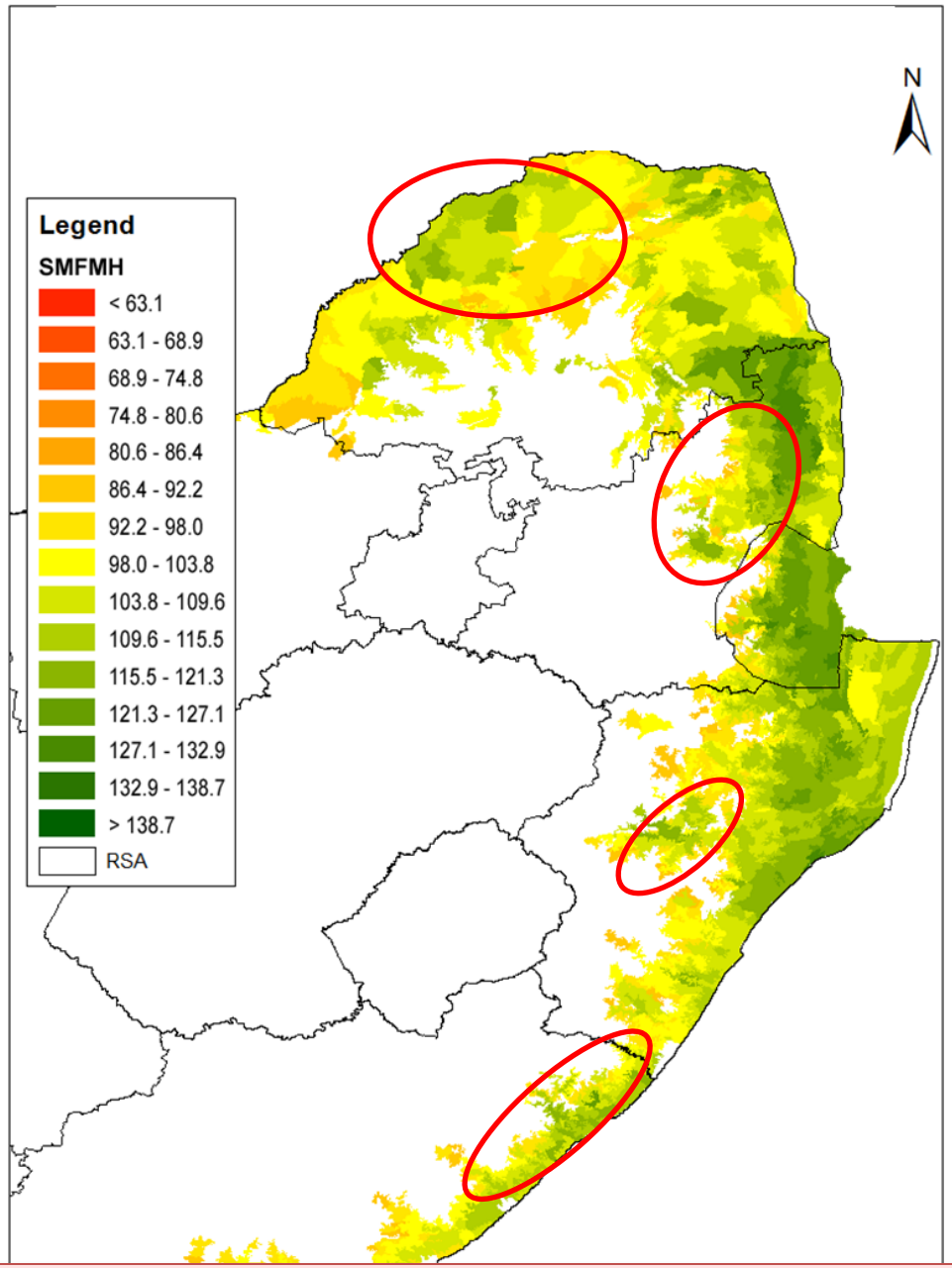
Cane yields (t/ha) around 2050

	LTM	Δ (%)
Mpumalanga	142	+1
Pongola	139	+5
Zululand	132	+5
North Coast	139	+10
Midlands	128	+17
South Coast	132	+13



Potential new areas (future cane yield > 90 t/ha/an):

- Northern Limpopo
- High lying areas in Mpumalanga and KZN
- Northern Eastern Cape

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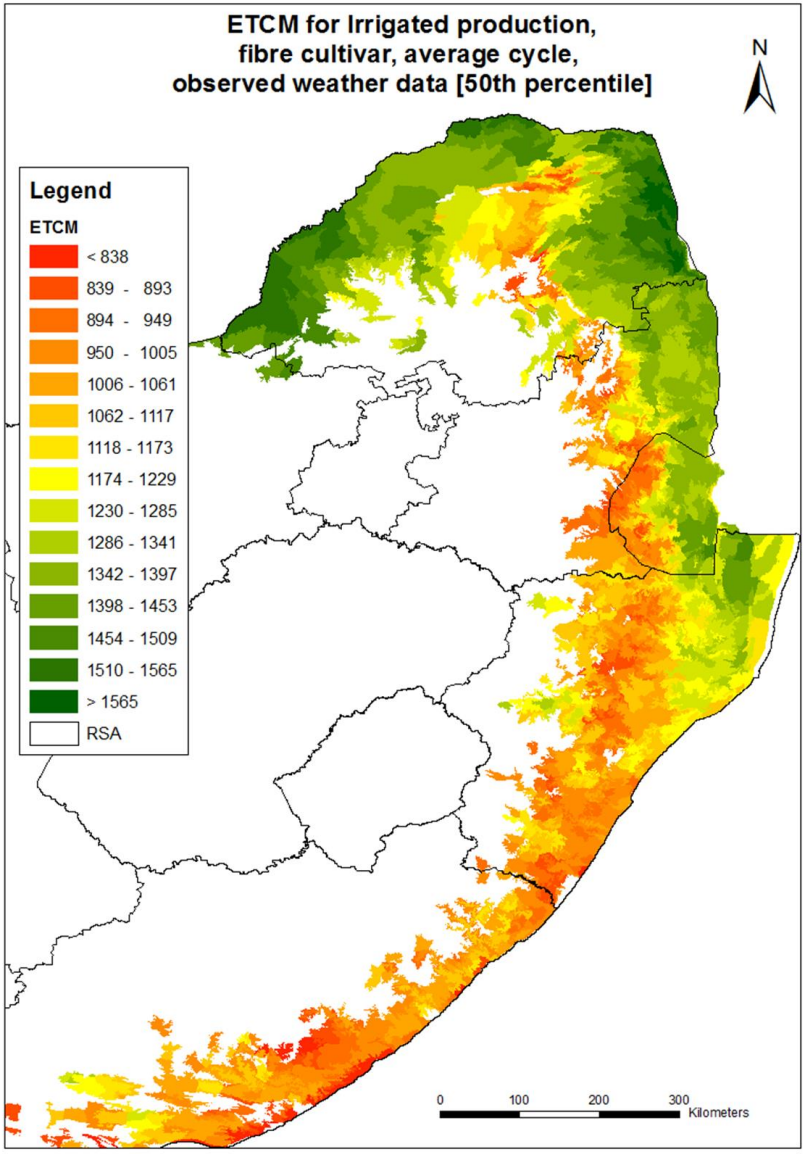
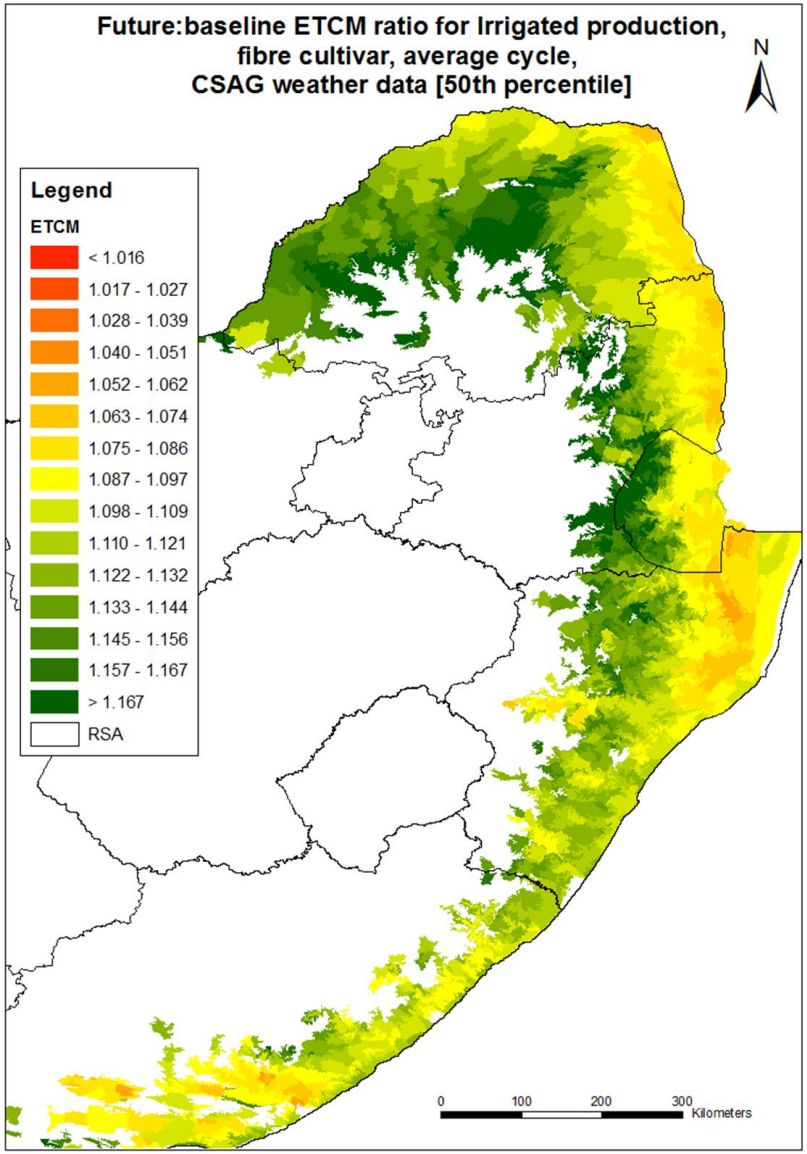
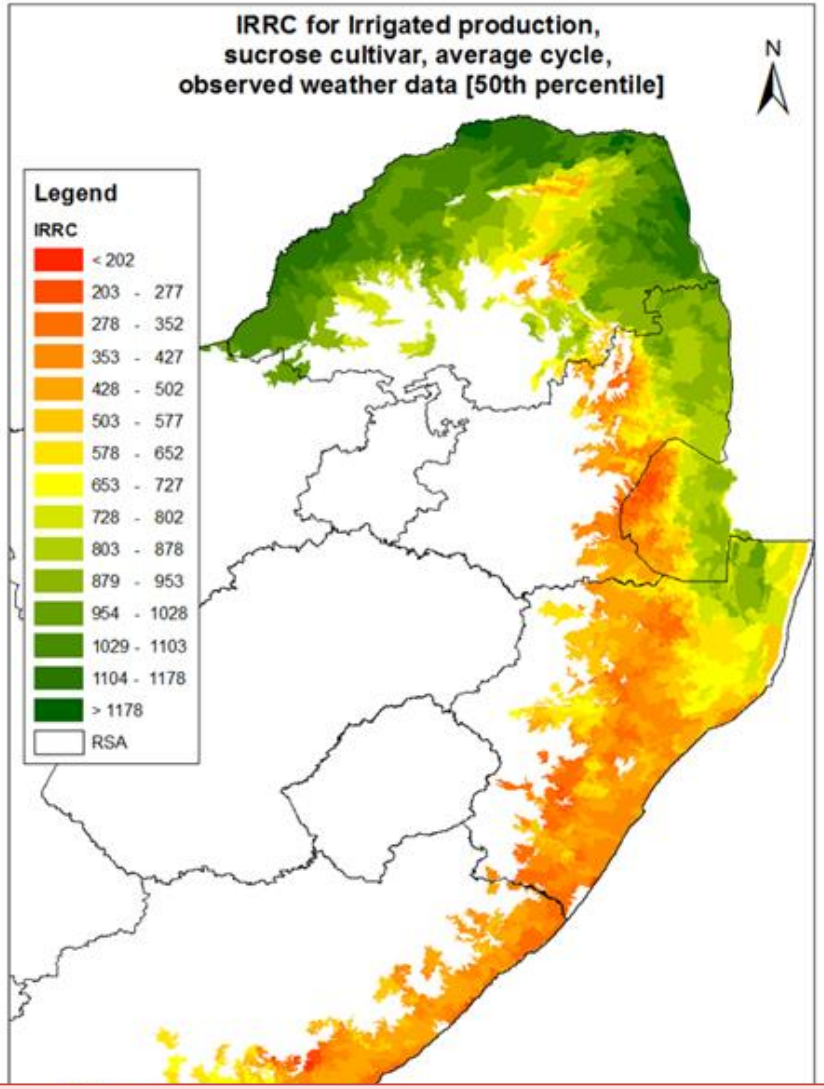
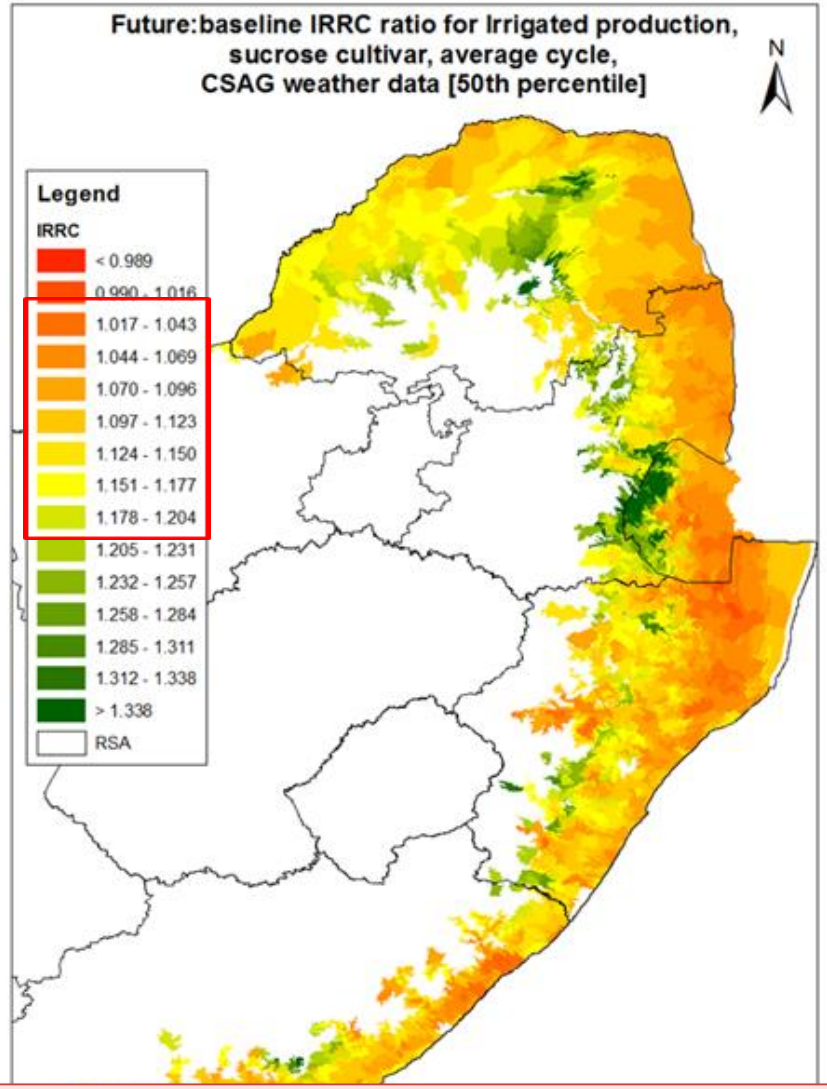
Crop water use around 2050 with adequate water supply





Irrigation requirements around 2050





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Summary: 2050 climate impacts

Region	Cane yield		Water use		Irrigation demand	
	LTM (t/ha/an)	Δ (%)	LTM (mm/an)	Δ %)	LTM (mm/an)	Δ (%)
Mpumalanga	142	0.7	1398	8.9	868	8.1
Pongola	139	5.3	1325	7.8	765	4.9
Zululand	132	5.4	1148	9.4	344	6.7
North Coast	139	9.8	1230	9.5	539	10.1
Midlands	128	17.0	1160	8.5	358	11.1
South Coast	132	13.4	1120	10.0	590	10.9

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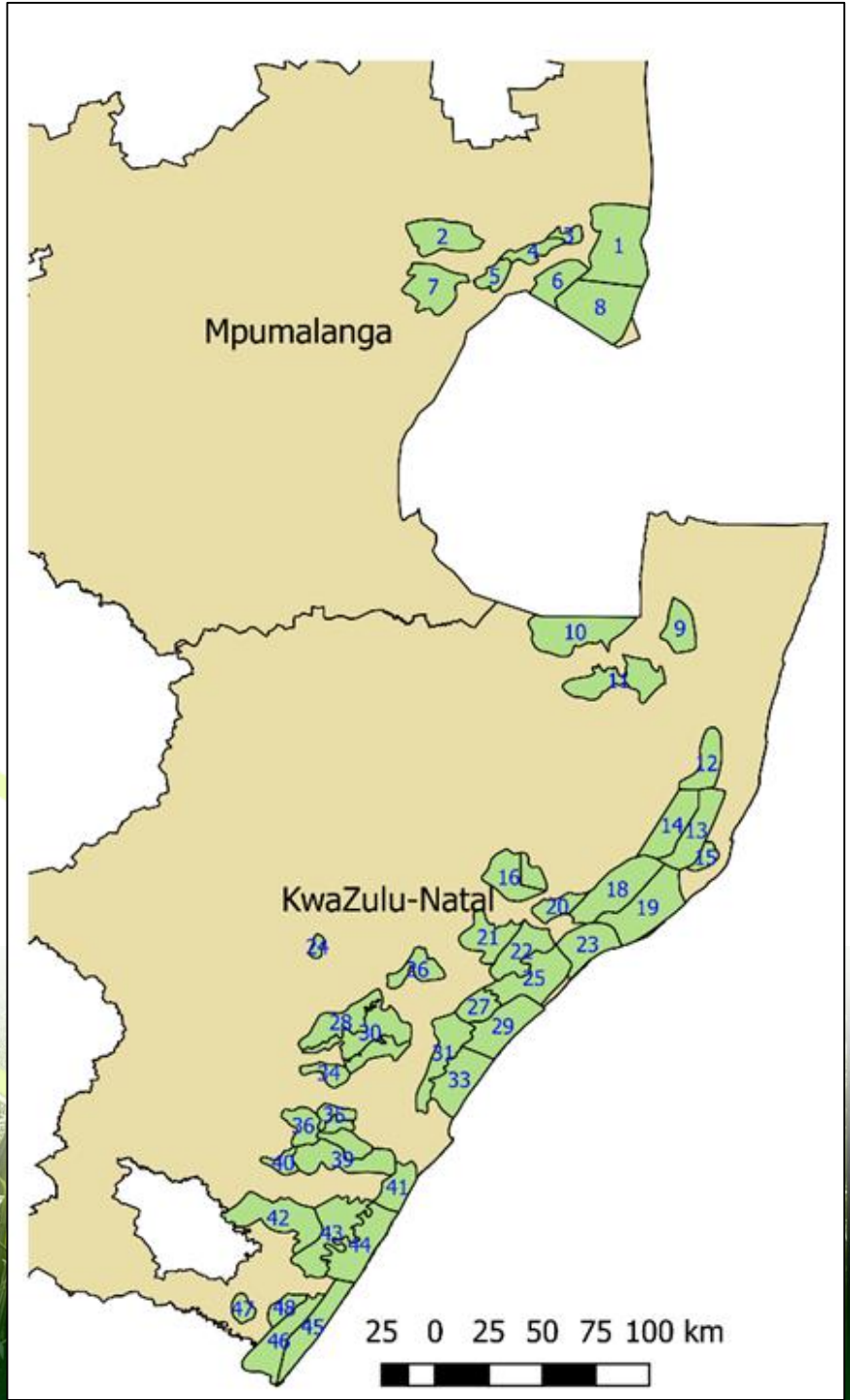
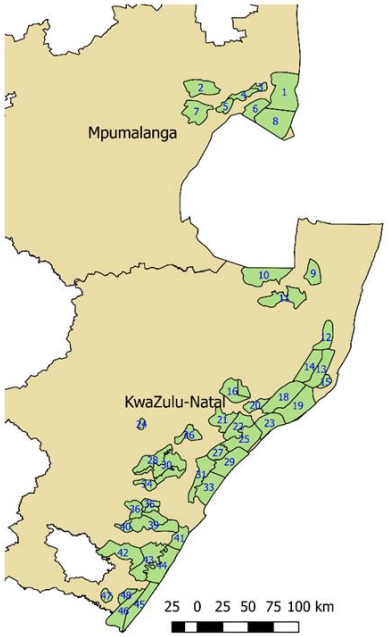
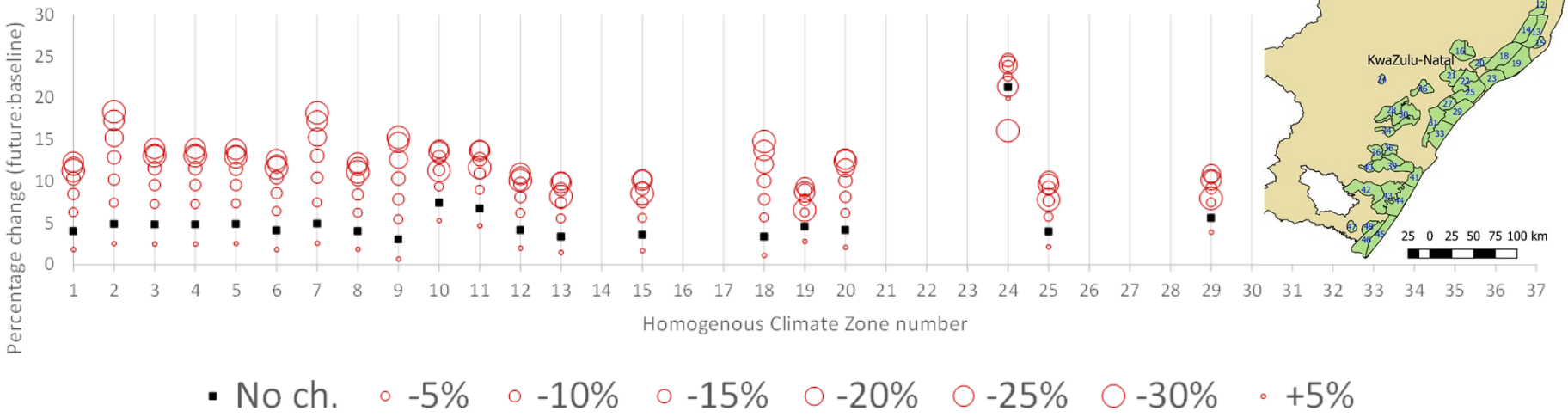
Management adaptations

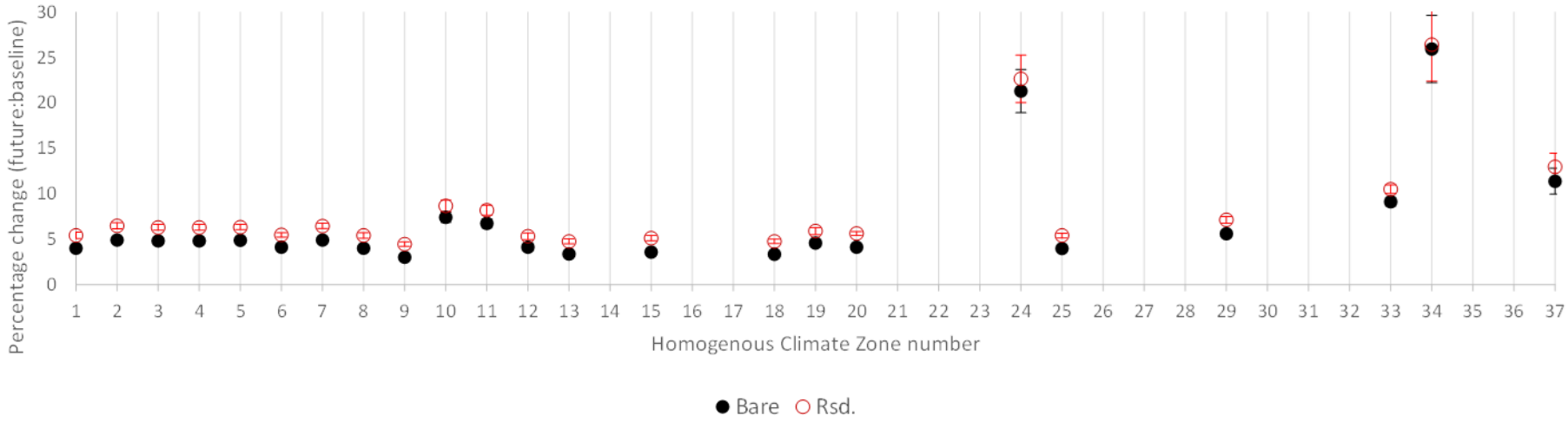
- To be considered
  - Weeds (shorter period of control required?)
  - Pests and diseases (acceleration of life cycles, habitat shifts)
  - Chemical ripening (expected decreased quality need to be addressed)
- Reduced harvest age
- Soil mulching
  - GCMs: CCSM4, ESM2M, HadGEM2-ES, MIROC5, MPI-ESM-MR
  - 2040-2070 compared to 1980 to 2010
  - DSSAT Canegro v4.5
  - 48 agro-climatic zones



Management adaptations: Reduced harvest age and mulching





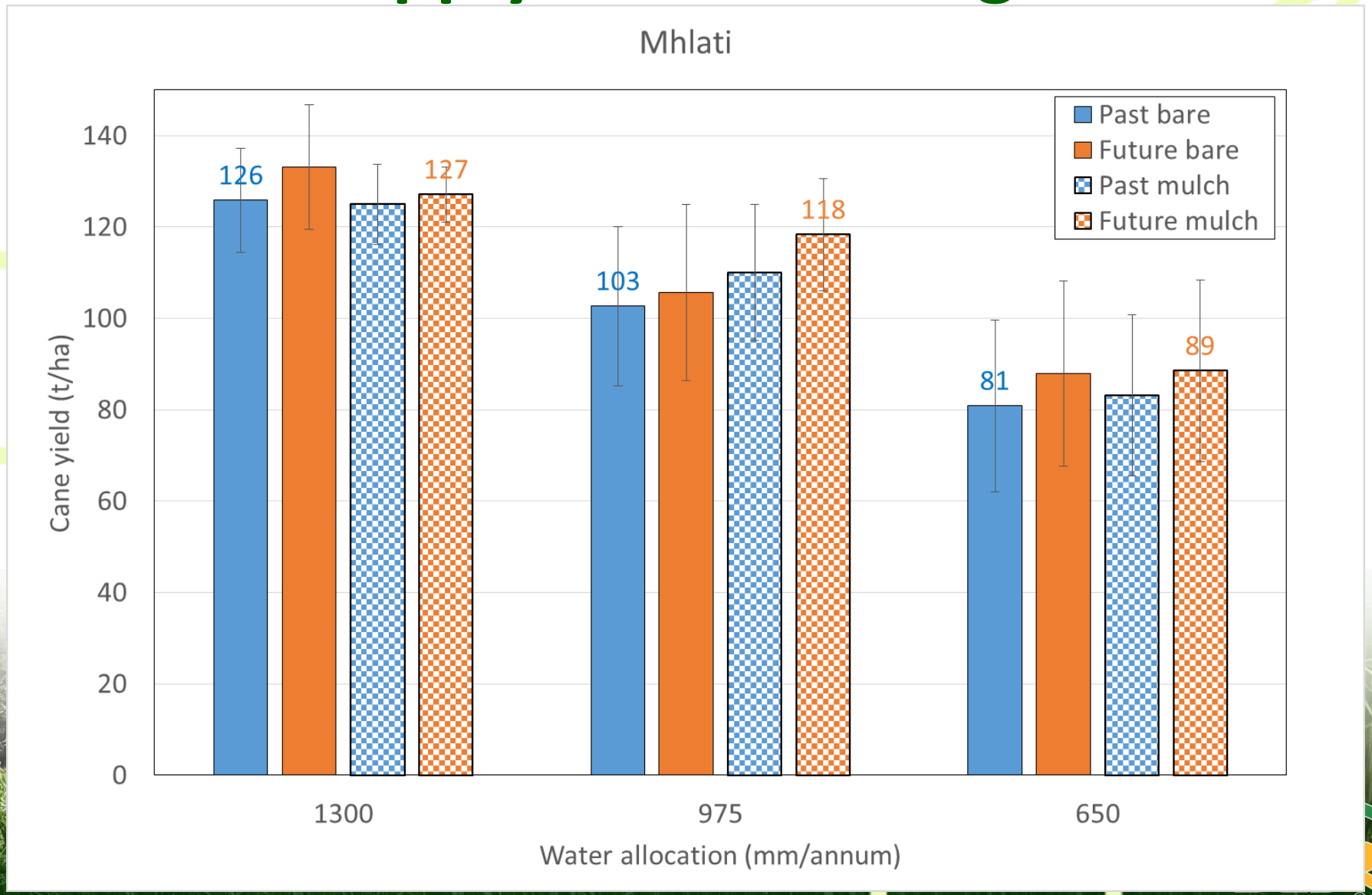


Predicted impacts for Malalane

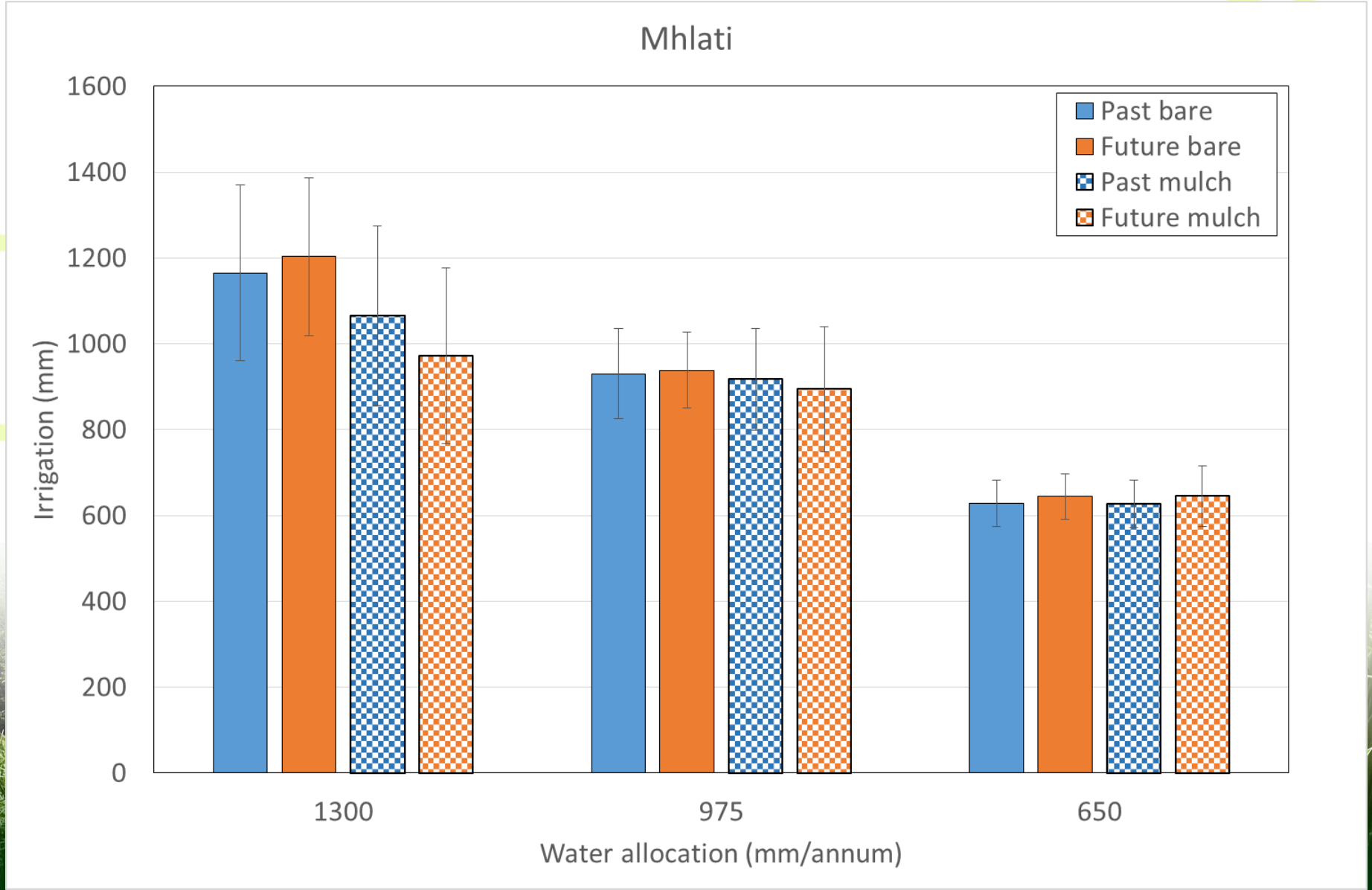
- Climate scenarios
  - Weather data for 2041-2070 from 16 GCMs:
    - Downscaled using monthly Delta method
  - Past weather data for 1981-2010
- Water allocation scenarios: 50, 75 and 100% of 1300 mm distributed according to LTM crop demand
- Mulching scenario: Bare soil (burnt cane), crop residue cover

- MyCanesim® model
  - 12 month crops started in April and October
  - Soil: Available water holding capacity of 75 mm AWC
  - Irrigation settings
    - Overhead irrigation: 26 mm X 4d
    - Pro rata scheduling rule ADL =45 mm

Predicted impacts: Climate, water supply and mulching



Predicted impacts of climate and soil mulch layer



Key messages

1. Temperatures to increase by 2^{o}C from 1980s to 2050s
2. Rainfall projections for eastern South African uncertain at this point. More certainty required.
3. Opportunity: Irrigated yields could increase marginally assuming adequate water
4. Threat: This is unlikely due to an expected reduction in water supply.
5. Opportunity: New areas in northern Limpopo, high lying KZN and Mpumalanga and coastal Eastern Cape
6. Management adaptations hold promise for mitigating negative impacts. Very important to maintain/increase water use efficiency of sugarcane production

Caveats and future work

- Uncertainty of rainfall predictions
- Downscaling method has limitations, e.g. length of dry and wet spells.
- Assumptions of adequate irrigation supply, no adaptation (e.g. reduced harvest age), perfect management (e.g. stalk borer impact)

- Use improved climate predictions in future work
- Assess impacts of reduced irrigation water supply on irrigated industry
- Consider P&D effects
- Work on economically viable adaptations for the industry

Acknowledgements

- Aresti Paraskevopoulos for model set up and running
- Water Research Commission funding for congress attendance through project K5/2553//4 (Assessing the water footprint of selected fuel and fibre crops in South Africa)

References

- Jones MR, et al. 2015. Simulated impacts of climate change on water use and yield of irrigated sugarcane in South Africa. Agric. Systems 139: 260–270
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- Schulze RE & Taylor MA 2016. Water and the Farmer 2: Challenges in South Africa with Climate Change. In: Schulze, R.E. Handbook for Farmers, Officials and Other Stakeholders on Adaptation to Climate Change in the Agriculture Sector within South Africa. Section B: Agriculture's Natural Capital In South Africa: A Climate Change Perspective, Chapter B7.
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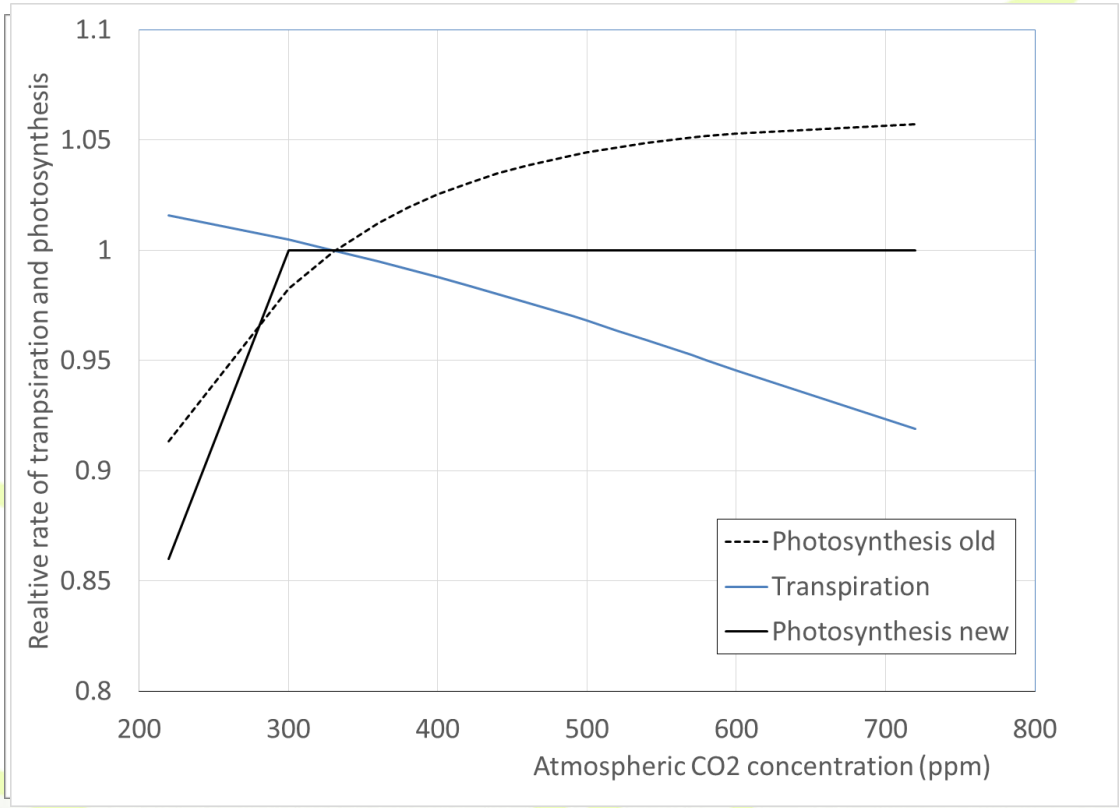
DSSAT-Canegro model improvements

- Thermal time calculations
- Crop respiration
- Elevated CO_2 effect
  - Reduced transpiration
  - Zero photosynthesis effect
- CERES water stress routine replaced with Aquacrop routine



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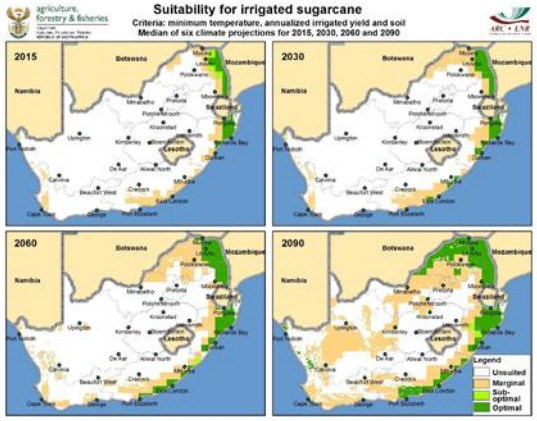
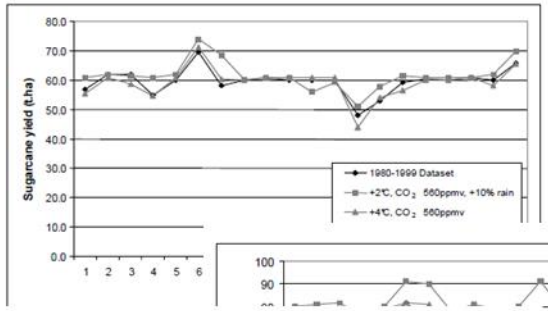
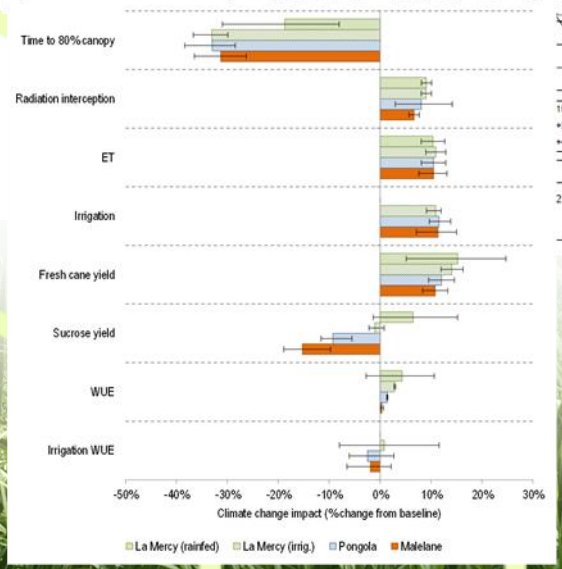
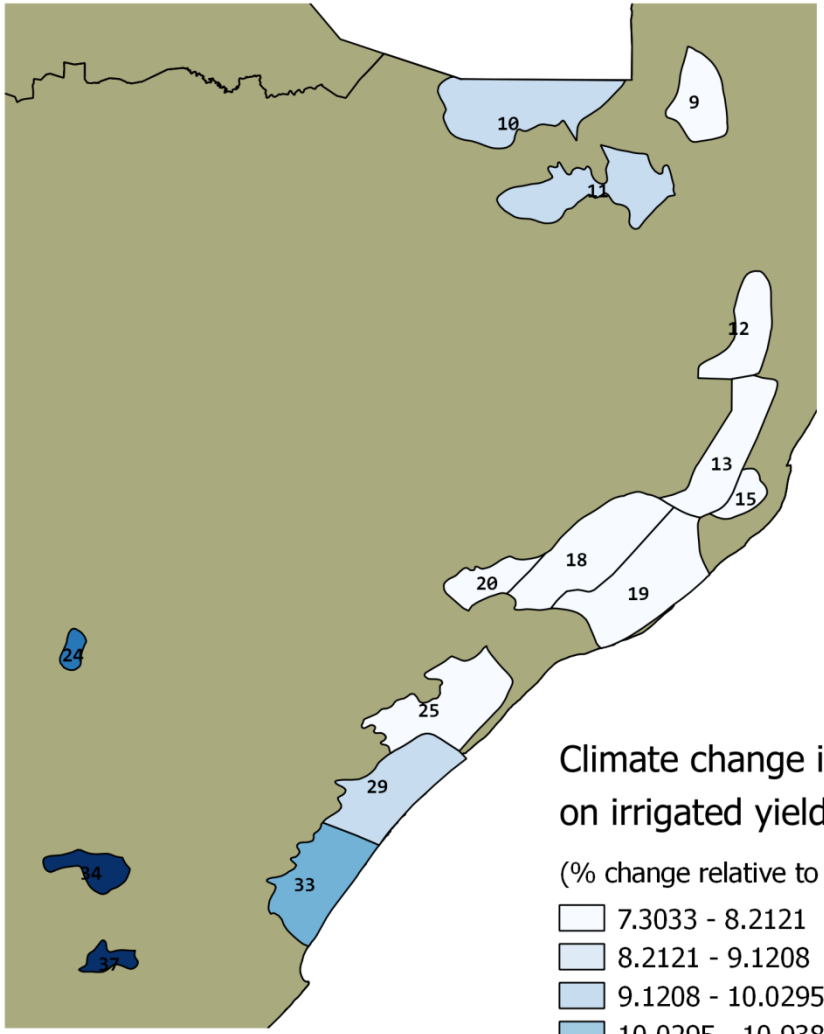

Suitability for irrigated sugarcane
Criteria: minimum temperature, annualized irrigated yield and soil
Median of six climate projections for 2015, 2030, 2060 and 2090
2015
2030
2060
2090
Botswana
Mozambique
Namibia
Swaziland
Lesotho
Legend
Unsuited
Marginal
Sub-optimal
Optimal

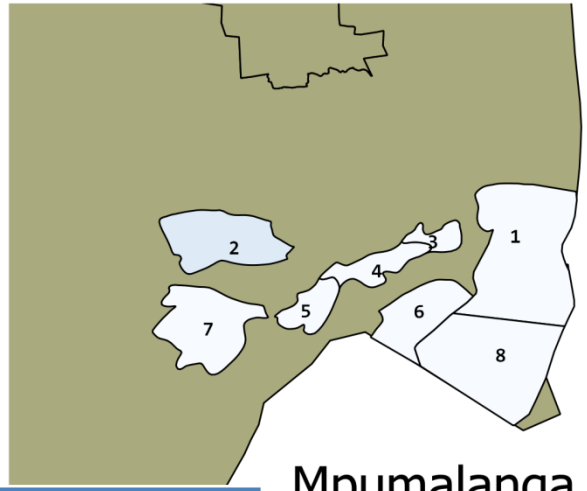

Sugarcane yield (t.ha)
1980-1999 Dataset
+2°C, CO2 560ppmv, +10% rain
+4°C, CO2 560ppmv


Time to 80% canopy
Radiation interception
ET
Irrigation
Fresh cane yield
Sucrose yield
WUE
Irrigation WUE
-50% -40% -30% -20% -10% 0% 10% 20% 30%
Climate change impact (%change from baseline)
La Mercy (rainfed)
La Mercy (irrig.)
Pongola
Malelane

Climate change impacts: irrigated yields



KwaZulu-Natal



Mpumalanga

Climate change impact on irrigated yields

(% change relative to baseline)

- 7.3033 - 8.2121
- 8.2121 - 9.1208
- 9.1208 - 10.0295
- 10.0295 - 10.9383
- 10.9383 - 11.8470
- 11.8470 - 12.7558
- 12.7558 - 13.6645
- 13.6645 - 14.5732
- 14.5732 - 15.4820

1: Komati
2: Nelspruit
3: Hectorspruit
4: Malalane / Kaapmuiden
5: Louws Creek
6: Kaalrug / Inala
7: Barberton
8: Komati projects
9: Makatini flats
10: Pongola
11: Mkuzi
12: Hluhluwe
13: Mtubatuba
15: Umfolozi flood plains
18: Heatonville
19: Empangeni
20: Nkwaleni
24: Muden
25: Amatikulu
29: Darnall/San Souci/ShakasKraal
33: Lower North coast
34: Hilton / Umgeni valley

Climate projections