CLIMATE-CROP INTEGRATED ASSESSMENT OF MID-CENTURY CLIMATE CHANGE IMPACTS ON SUGARCANE PRODUCTION IN SOUTH AFRICA

AgMIP The Agricultural Model Intercomparison and Improvement Project

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SASRI USDA UKaid from the British people

1. Introduction

Background

- The **South African sugar industry** covers 350 000 ha, with great spatial variation in soil types, annual rainfall (550-1200 mm), altitude (0-700 m), and water management (20% irrigated).
- **Positive impacts of climate change on sugarcane yields** have been reported but limitations in methodologies make it **difficult to quantify impacts reliably at regional and industry scales**.
- **AgMIP** (Agricultural Model Intercomparison and Improvement Project) has developed a set of consistent regional integrated climate change impact assessment protocols.

Objective

Use the **AgMIP protocols** to provide a **robust indication of climate change impacts on the South African sugar industry for the period 2040-2070**.

2. Methodology

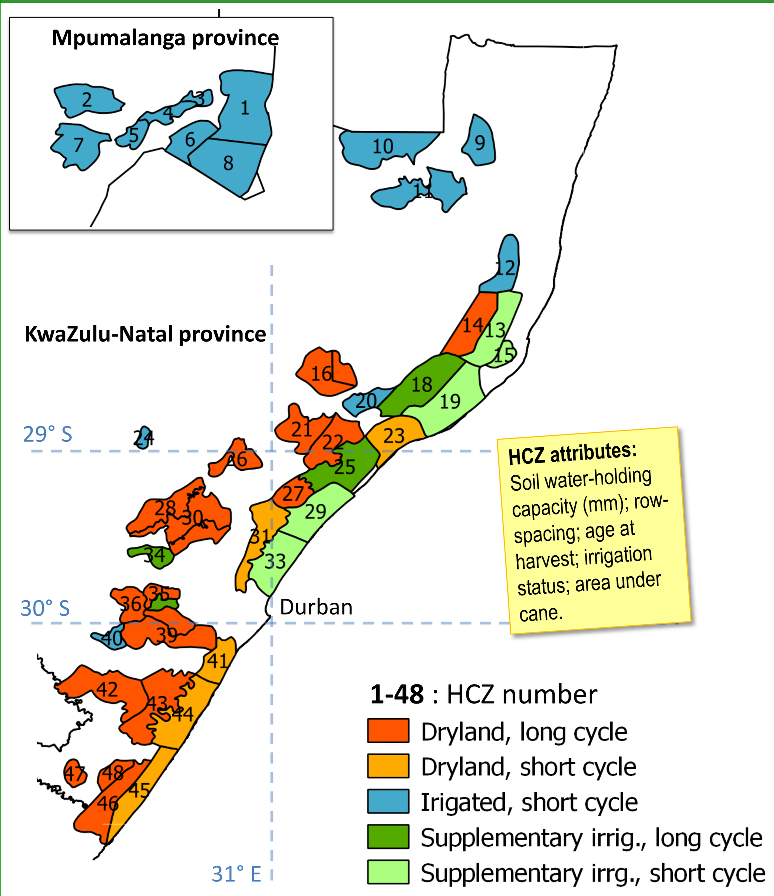

Figure 2.1 Homogenous climate zones[1]

1. Observed **daily weather data** were assembled for **47 homogenous climate zones** (HCZs[1], see Fig 2.1) for 1980-2010.
2. Delta-downscaled **future weather data** were generated from five global climate models (GCMs) using AgMIP climate tools[2] for the RCP 8.5, mid-century scenario (CO_2 = 571 ppm).
3. The modified **DSSAT-Canegro[3] model** (cv. NCo376, see Fig 2.2) **was used to simulate baseline and yields**, for nine monthly harvest dates, at each HCZ, over 30 seasons, for the following scenarios:
   a. **Baseline** management (no changes), at all HCZs
   b. **Adaptation 1**: age at harvest reduced so future seasonal thermal time accumulation (base 16°C) matched baseline (for selected HCZs)
4. Area-weighted **average change in yields** was calculated (baseline to future, without adaptation) and **multiplied by 2008-2013 average seasonal production** to estimate potential change in total industry production.

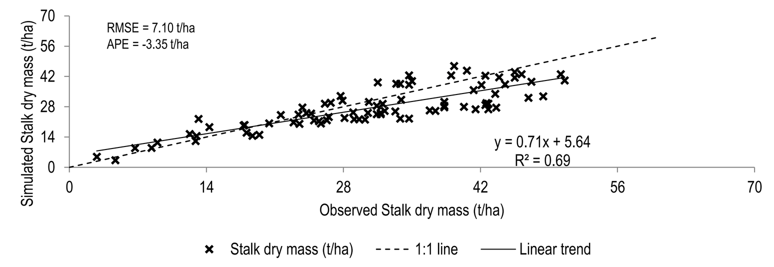

Figure 2.2 Performance of the DSSAT-Canegro model for predicting dry sugarcane stalk yield, at two sites in South Africa (La Mercy (rainfed) and Pongola (irrigated)).

3. Results and discussion

HCZ-scale impacts: climate changes, impacts on yield, effects of adaptation:

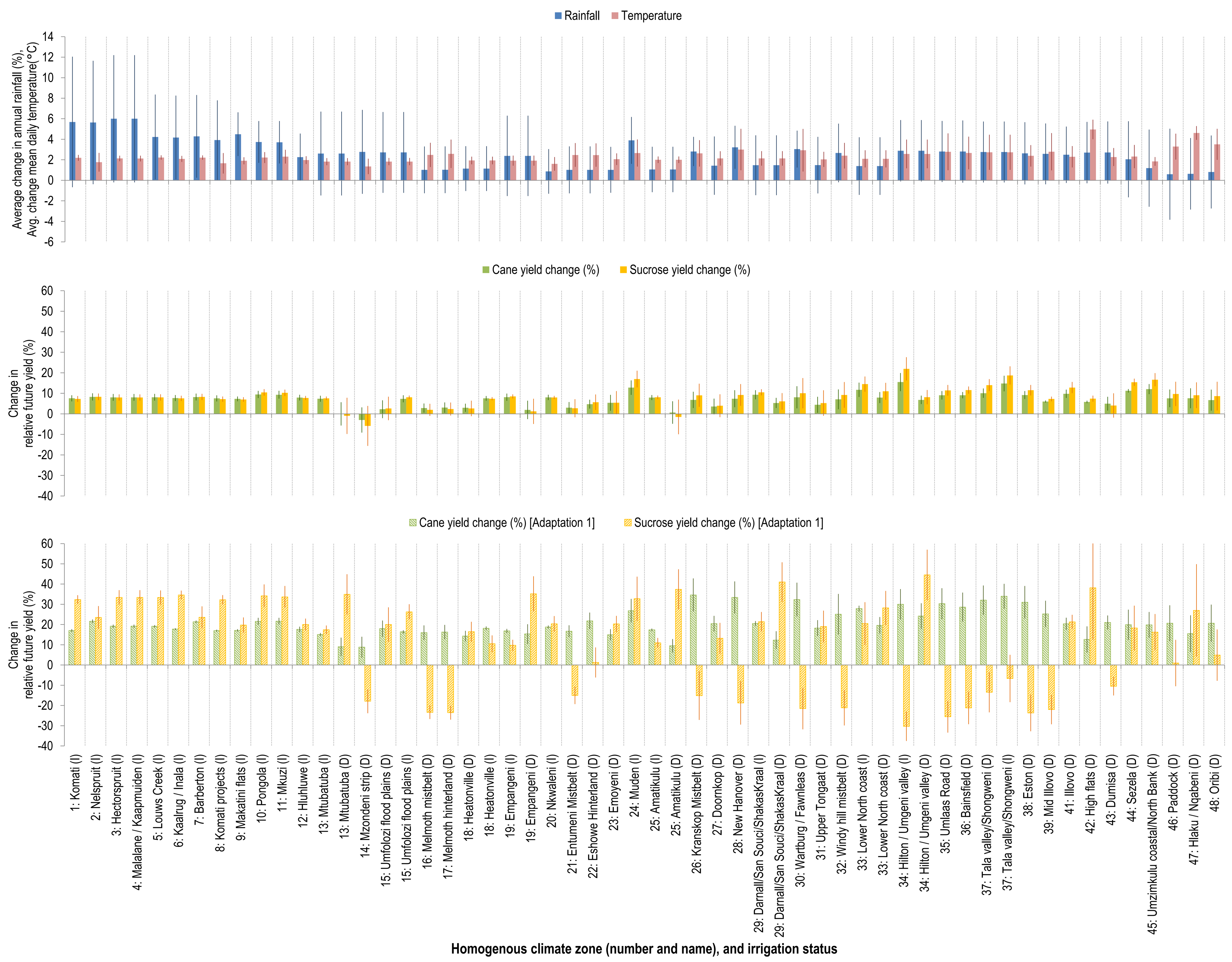

Figure 3.1 Projected climate changes, and simulated future (2040-2070, five GCMs) sugarcane and sucrose yields relative to baseline (1980-2010), under baseline and adapted management, for irrigated ('I') and dryland ('D') homogenous climate zones. Error bars indicate the range in values for different GCMs.

Non-adapted future

- **Cane yield increases are attributed to** greater radiation interception from higher temperatures and increased water use efficiency from elevated atmospheric CO_2 concentration.
- **Sucrose yield increases are attributed to** greater end-of-season water stress and increased physiological age of stalks at harvest
- The increases in potential yield will be conservatively considered a **buffer against future increases in limiting factors**, such as pests and diseases, and reduced irrigation supply.
- This study permits investigation of **climate change impacts and adaptation options at a localised scale**.

Adapted future

- Cane yield increases due to reduced harvest age: smaller overall burden of maintenance respiration and losses from lodging.
- Impacts on sucrose vary greatly by HCZ; sensitivity analysis may assist in identifying harvest age reductions on a per-HCZ basis.

Repeating this analysis with a **greater number of GCMs, and additional sugarcane crop simulation models**, will allow increased insights into the uncertainty of these projections of climate change impacts.

Harvest age adaptation could be considered for **future bioenergy production from fibre** – this could be explored using the AgMIP economic impacts analysis protocol

4. Conclusion

Industry-scale impacts

Climate change with baseline management resulted in increased industry yields:

Sugarcane: +13.0%

Sucrose: +11.9%

with the potential to produce an **additional**

- **2 050 000 t sugarcane** and
- **210 000 t sucrose**

with **greater increases possible** with regionally-selected harvest age reductions.

- Potential **sugarcane and sucrose yields are set to increase overall** in the mid-century future, in the South African sugar industry.
- **Reduced harvest age is a possible climate change adaptation**
- Additional sugarcane growth models, GCMs and downscaling techniques will reduce **uncertainty** of climate change impact projections.
- Our involvement in **AgMIP facilitated the development of this framework, thereby increasing the capacity of the RSA sugar industry** to assess climate change impacts and options, for continued sustainable production into the future.
- Financial support from UK DFID and USDA is gratefully acknowledged.

[1]Bezuidenhout CN and Singels A (2007). Operational forecasting of South African sugarcane production: Part 1 – System description. *Agricultural Systems* 92:23-38.
[2]Hudson, N and Ruane, AC (2013). Guide for Running AgMIP Climate Scenario Generation Tools with R. AgMIP.
[3]Singels A, Jones MR, Marin F and Olivier F (2013). Improving the suitability of the DSSAT Canegro model for simulating responses to climate change. American Society of Agronomy annual meeting held from 3 to 6 November 2013 in Tampa, Florida.