The potential impacts of climate change on the water balance

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Objectives:

- Assess the impacts of climate change on daily and total water balance components during maize growing season using CROPWAT model in conjunction with climate change scenarios derived from GCMs;

- Identify the elements of water balance most likely to be vulnerable in the future climate;

- Estimate the effects of climate change on total maize yield reduction due to crop stress.

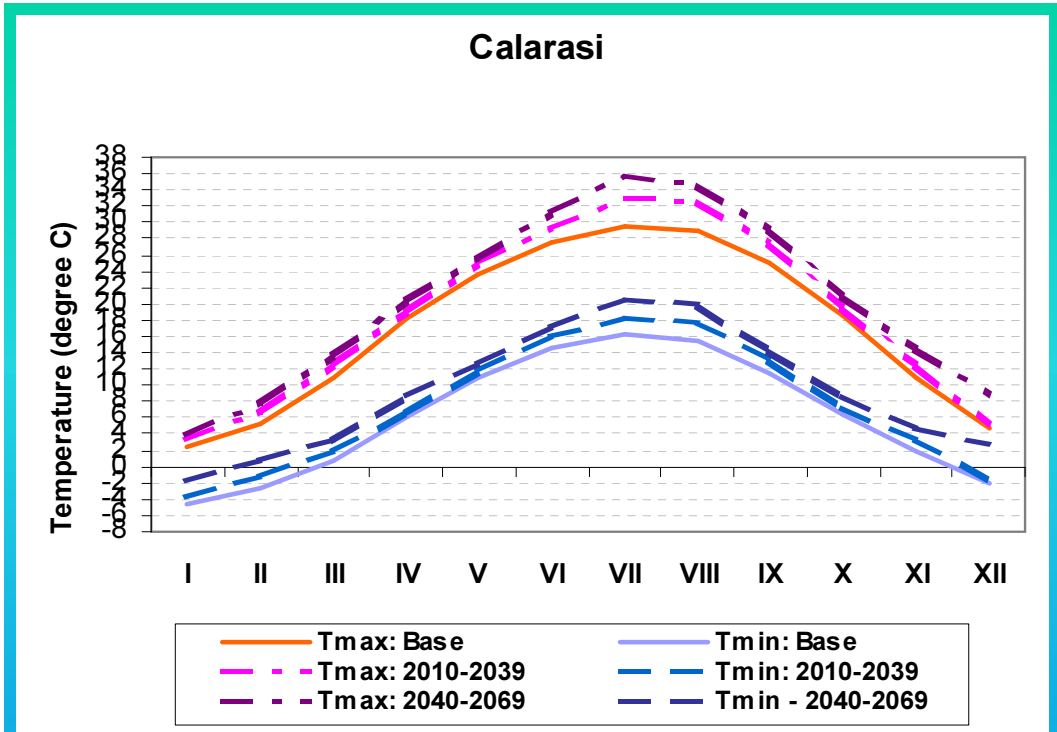
Climate change scenarios used:

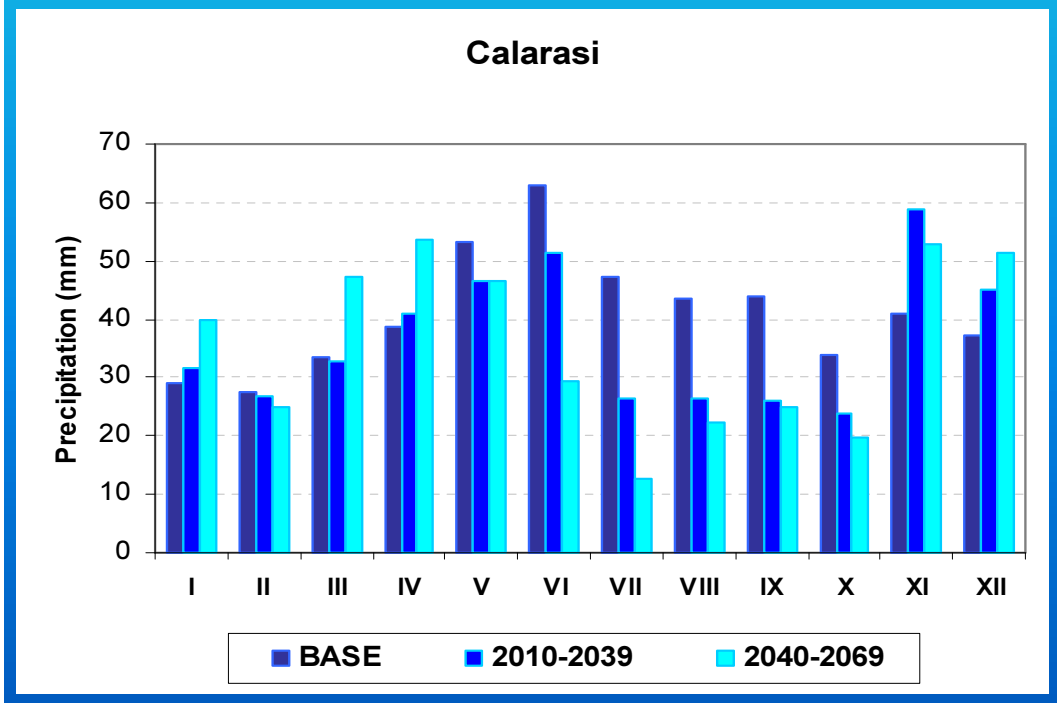
⇒ Output from Global Climate Model
HadCM3 - A2

⇒ 30-year averaged data for 2 time periods
in the future (2010-2039 and 2040-2069)
centered on the decades 2020s and 2050s

Changes in monthly means of minimum and maximum air temperature (°C) and precipitation (mm) for the periods 2010-2039 and 2040-2069 against current climate (1961-1990)

Model	Param	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
2010-2039	Tmin	0.8	1.5	1.1	0.8	0.9	1.3	2.0	2.5	1.7	0.8	1.2	0.6	1.3
	Tmax	0.7	1.5	1.5	0.8	1.2	1.8	3.3	3.4	2.5	1.1	1.6	0.5	1.7
	Prec.	2.6	-.9	-.7	2.1	-7.	-12	-21	-17	-18	-10	18	8	-
2040-2069	Tmin	2.7	3.4	2.4	2.6	1.7	2.5	4.3	4.7	3.0	2.2	2.7	4.6	3.1
	Tmax	1.3	2.7	2.7	2.3	1.9	3.8	6.2	5.4	4.2	2.6	3.7	4.0	3.4
	Prec.	11	-3	14	15	-7	-34	-35	-21	-19	-14	12	14	-





Climate change scenarios for Calarasi station

Monthly mean minimum and maximum temperature (top) and preciptation (bottom) for the baseline climate (1961-1990) and HadCM3 model, (periods 2010-2039 & 2040-2069)

CROPWAT for Windows – Input data used

Climatic data:

- Monthly means of: min. and max. temperature (°C), relative humidity (%), sunshine duration (hours), wind speed at 2m high (m/s)
- Monthly Rainfall

Crop data:

- sowing date: 20 April
- stage days: 140 d for baseline, 127 d for 2020s and 120 d for 2050s

Soil data:

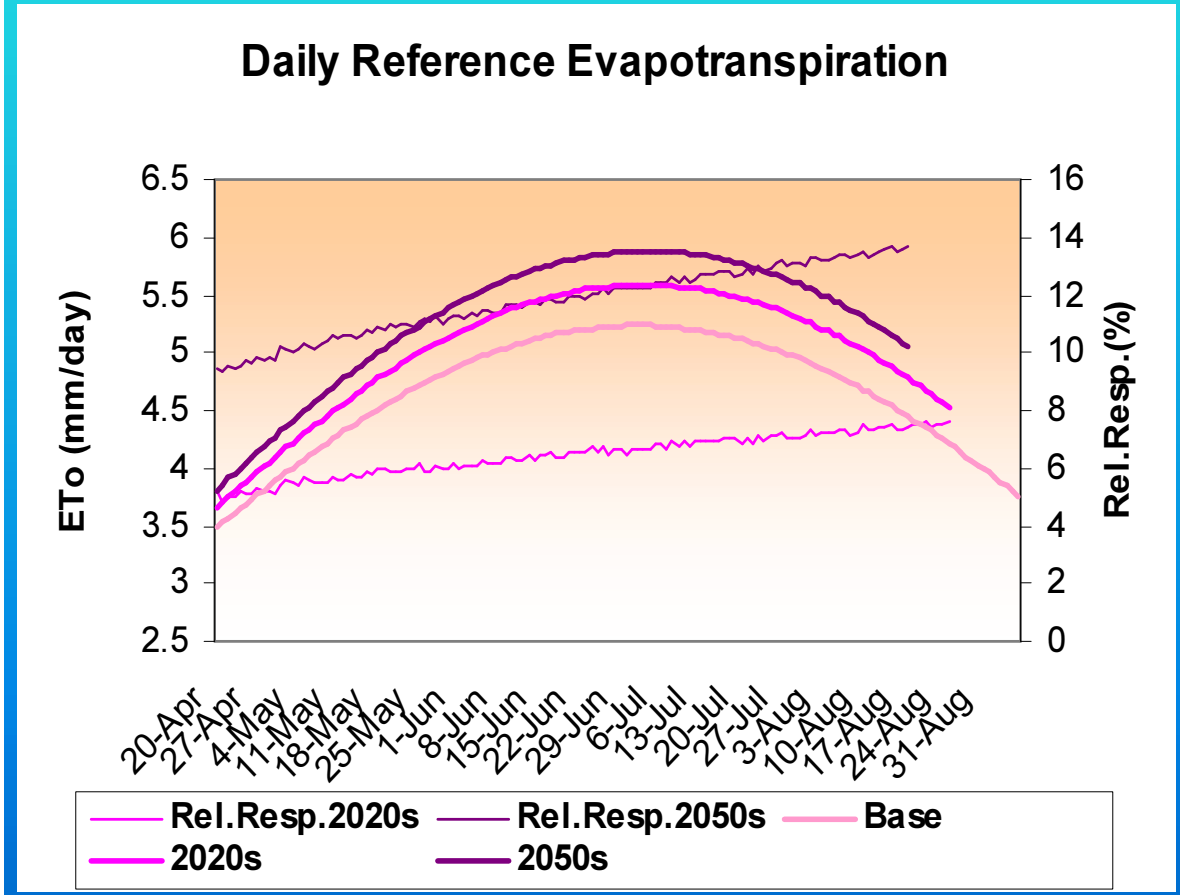
- total available moisture: 227 mm/m depth
- initial available soil moisture: 114 mm/m depth (50% of TAM)
- maximum root infiltration rate: 40mm/day
- maximum rooting depth: 1 m

CROPWAT model application

The key steps in the simulations:

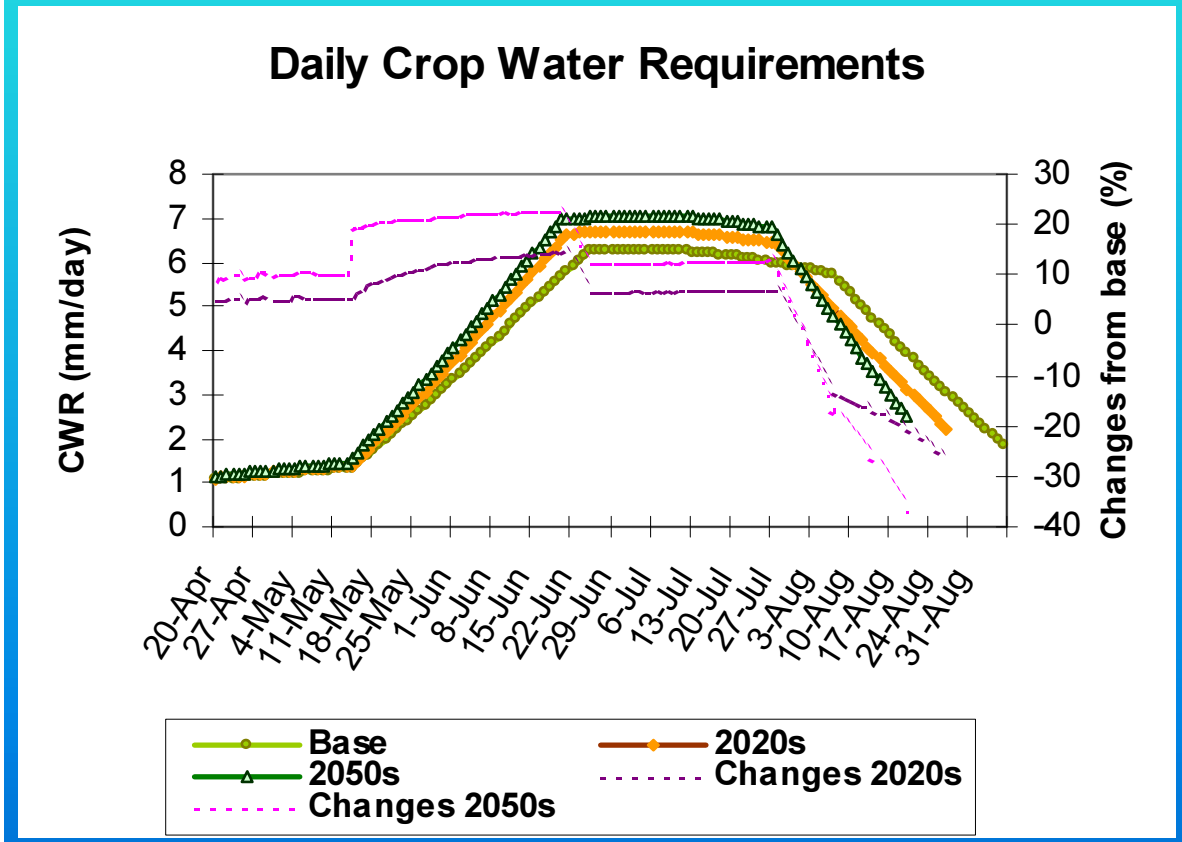
- running the CROPWAT model for the rainfed maize with the monthly means baseline climatic data for a 30 yr period (1961-1990);
- running the CROPWAT model with 30-year averaged data for two time periods in the future centred on the decades 2020s and 2050s: 2010-2039 and 2040-2069;
- comparing the model results from climate change simulations with baseline climate;
- quantifying the changes in growing season evapotranspiration, crop water requirements, precipitation, soil moisture deficit and changes in percentage of yield reduction.

Effects of climate change on reference evapotranspiration (Eto)



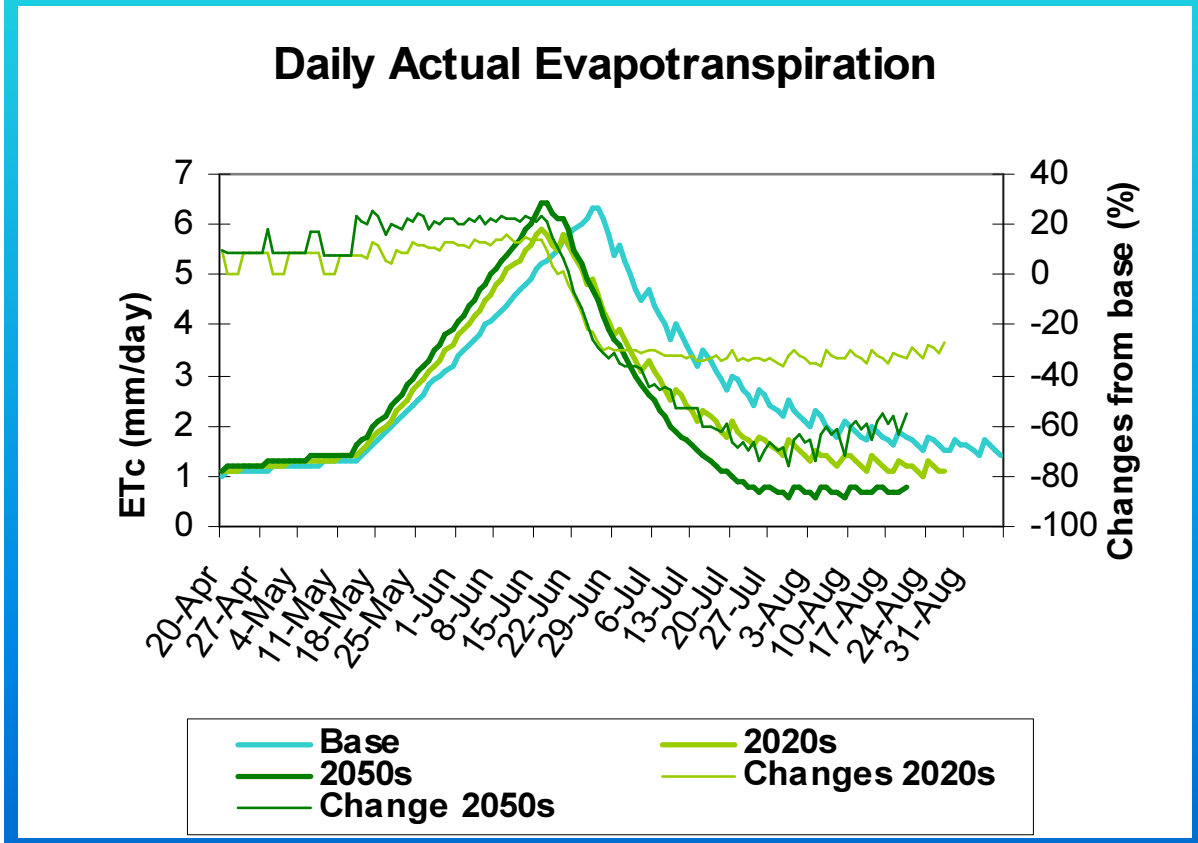
⇒ Daily ETo increases by an average of 7% for 2020s and 12% for 2050s, as compared with the baseline climate period, as a result of increasing temerature;

Effects of climate change on daily crop water requrements (CWR)



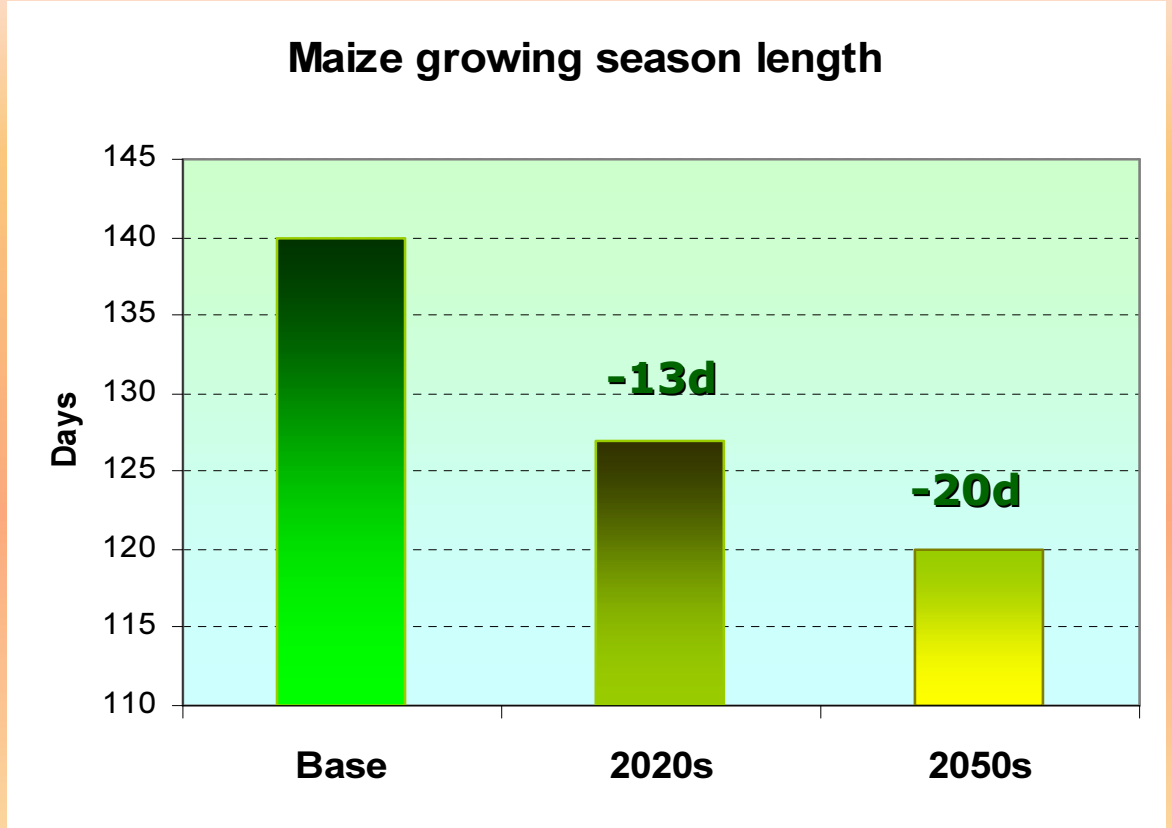
→ Daily CWRs increase in the initial stage and mid-season by an average of 10% for 2020s and 16% for 2050s, and decrease in the late season up to 26-36% for the two HadCM3 scenarios;

Effects of climate change on daily actual crop evapotranspiration (ETc)



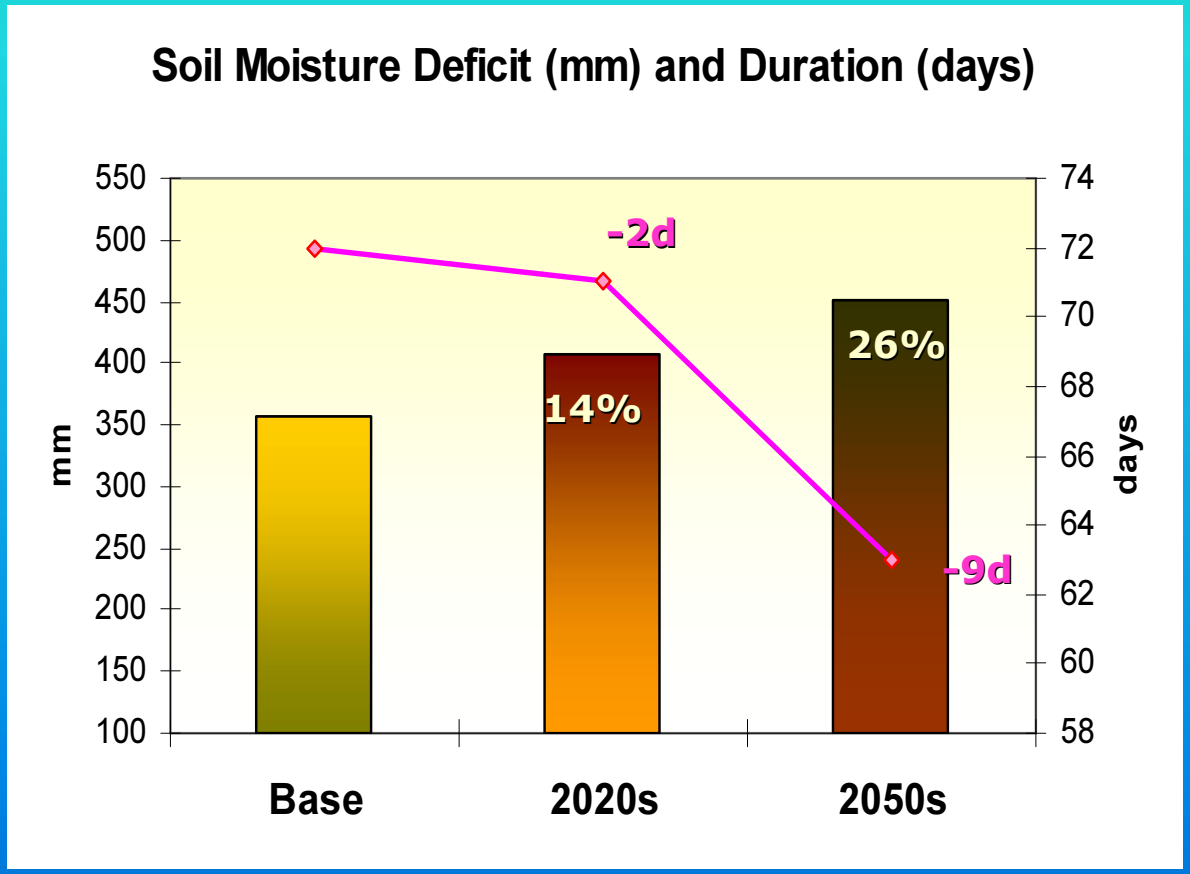
⇒ Daily ETc increases in the first phases by an average of 12% in 2020s and 16% in 2050s, and greatly decreases in the late season up to 36% in 2020s and up to 74% in 2050s;

Effects of climate change on growing season length of maize crop



Changes in the growing season length of rainfed maize crop under HadCM3 scenarios (decades 2020s and 2050s) as compared with the baseline period

Effects on soil moisture deficit

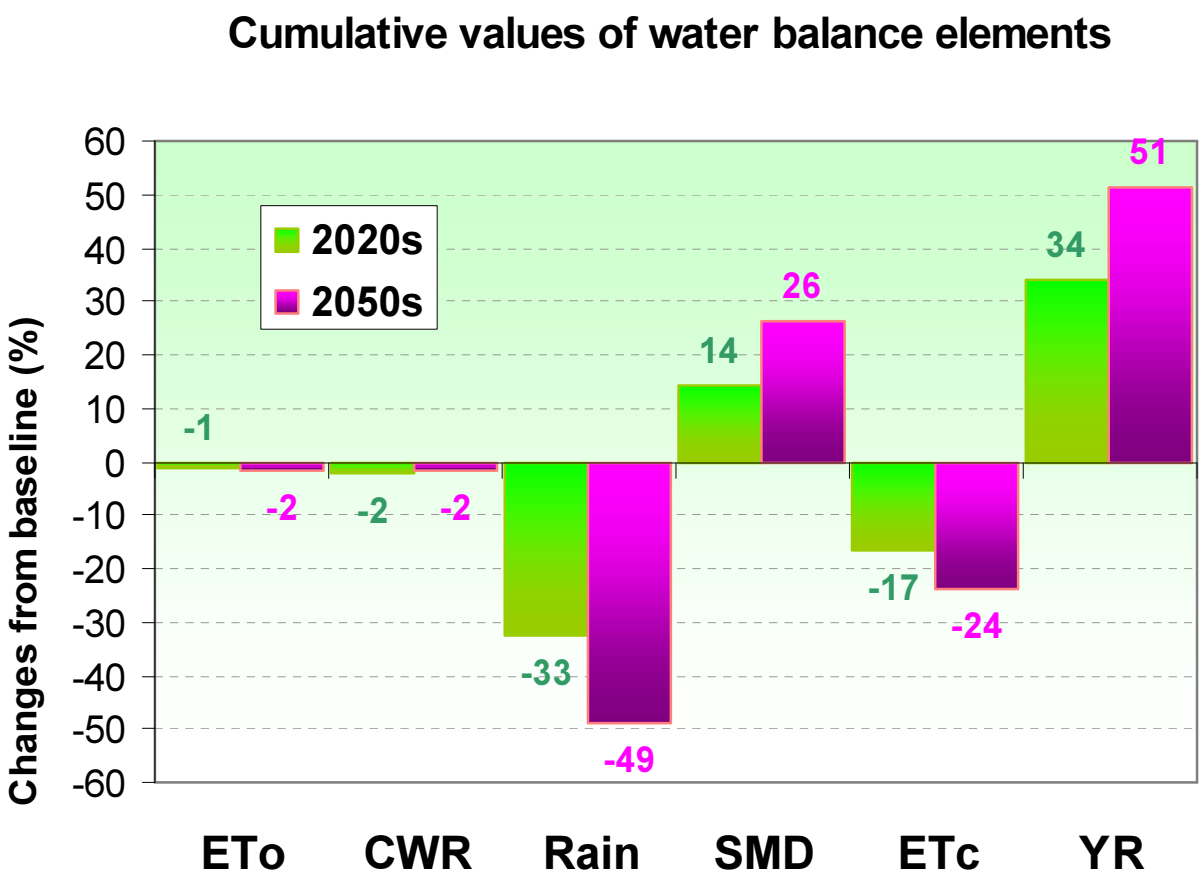


Comparison of the difference in amount (mm) and duration (days) of soil moisture deficit simulated with CROPWAT model in the baseline climate and the two decades predicted by HadCM3 model, at Calarasi station

Effects of climate change scenarios on estimated total yield reduction due to crop stress

Climate	Yield Reduction (%)	Changes from Base (%)
Current climate	39%	-
2020s	51%	+34%
2050s	58%	+51%

Effects on growing season water balance elements



Changes in the cumulative water balance elements during whole maize growing season under HadCM3 scenarios against the baseline period

Conclusions:

- Changes in climate, which are likely to occur during future decades may have significant negative effects on the main water balance elements and maize yield;

- The water availability for maize crop would decreases due to a combination of increase daily reference evapotranspiration, enhanced losses of soil moisture and decrease in rainfall relative to crop water requirements.