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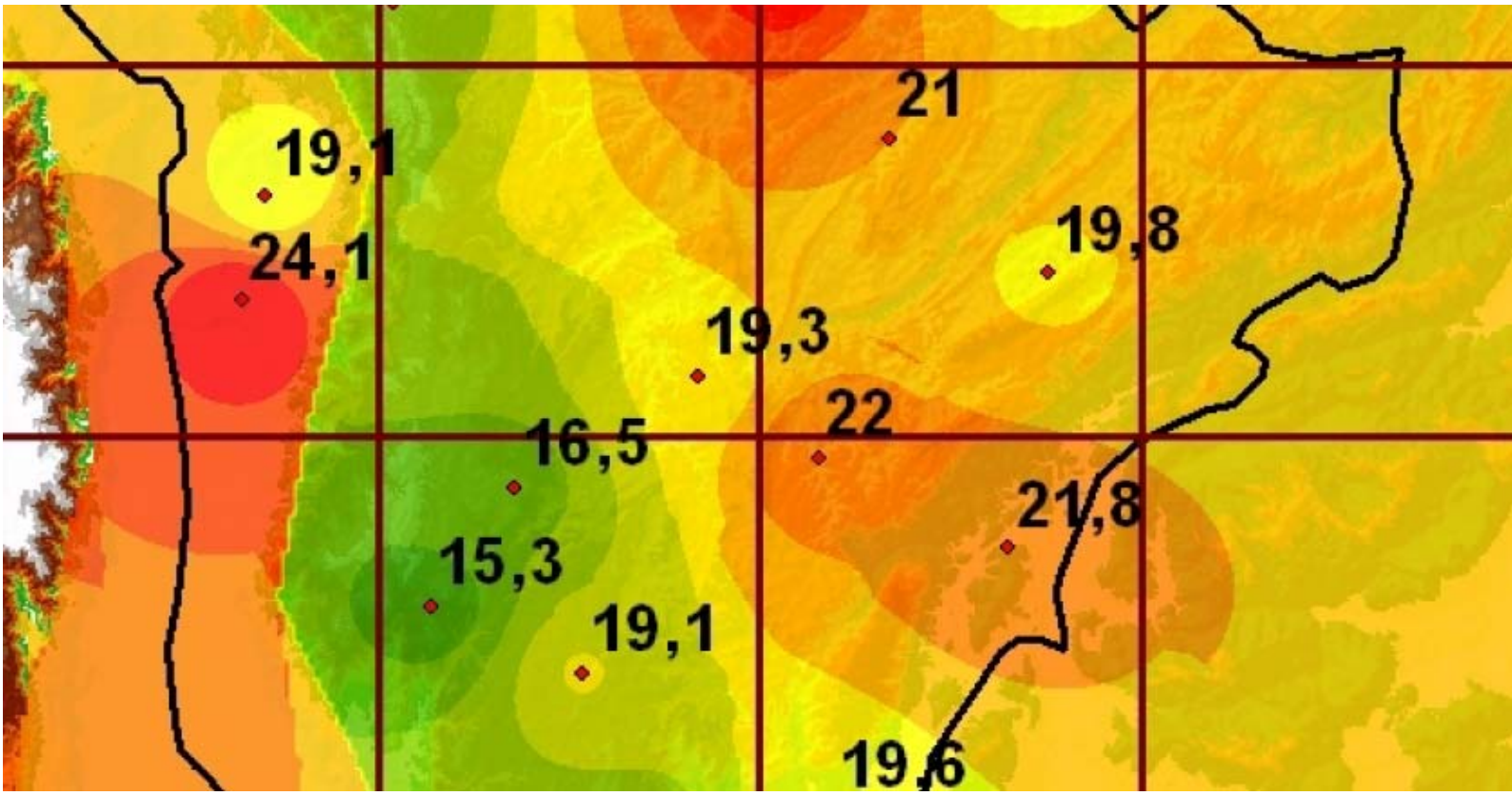

Climate Change Projections for Burundi

A Summary for Policy Makers

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April 2014

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1 Introduction

Water and soil resources are essential for Burundi's economic and social development. Already today, these resources are under high stress from population growth, land use pressure and rising natural resource demand. Climate change and increasing climate variability might add to these trends and further degrade the availability and quality of water and arable land.

In order to better understand the effects of climate change, a study on climate change projections for Burundi was conducted within the framework of the GIZ project "Adaptation au changement climatique pour la protection des ressources en eau et sol au Burundi" (ACCES). The study draws on the latest Regional Climate Models (RCMs) available for Burundi and two different emission scenarios (Representative Concentration Pathways 4.5 and 8.5). Taking the years between 1970 and 1999 as reference, the study analysed changes in annual as well as seasonal precipitation and temperature for the future periods of 2031-2060 and 2071-2099. [1]

This summary highlights the key findings from the study as well as potential socio-economic implications of climate change in Burundi, which are in brief:

- **Precipitation for Burundi is projected to generally increase** with the eastern and southern parts of the country as well as the central plateau receiving more rainfall.
- While **rainfall will increase during the rainy season**, the months before the onset of the rainy season (August/September) might become drier.
- A **likely prolongation of the dry season** is projected by some of the models used.
- There is high probability that annual average **air temperatures will steadily increase** in Burundi over the 21st century.
- Air temperature will particularly **increase in the dry season.**
- The future surplus of water could **likely increase the risk of extreme rainfalls**.
- The changes in precipitation patterns and quantity as well as temperature may have **significant implications for agricultural production**, in particular crop cultivation.

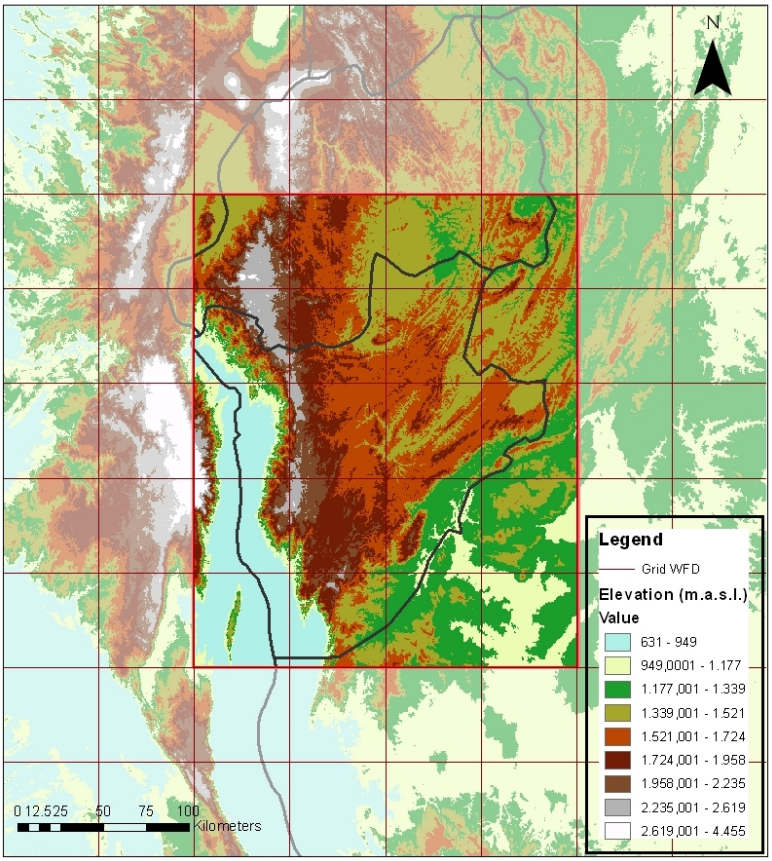
The following sections outline briefly the methodology for the climate change projections as well as the key findings of this study.

[1] The two periods were selected to provide climate change information for the near and far future, thus, supporting decision making processes at different planning horizons in the short to mid-term and long-term.

2 Methodological Approach

The climate change projections for this study were conducted in an area of 20 grid cells with a spatial resolution of approximately 50km/0,5° covering all of Burundi, Ruanda, eastern parts of Congo and the West of Tanzania (Figure 1).

Figure 1: Grid cells representing the study area (red rectangle)



Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

In order to develop future climate change projections for Burundi, the most recent Regional Climate Models (RCMs) provided by the **CO**ordinated **R**egional **D**ownscaling **EX**periment (CORDEX) Africa[2] were analysed. They comprise ten model combinations as shown in Table 1.

[2] For more information, please see: http://start.org/cordex-africa/.

These models were run using different emission scenarios, so-called **R**epresentative **C**oncentration **P**athways (RCPs) which provide different assumptions of greenhouse gas emission pathways. Two RCPs were selected in this study to cover a wide range from a medium-low (RCP 4.5) to high (RCP 8.5) global anthropogenic radiative forcing (Meinshausen et al., 2011; Moss et al., 2010).

Table 1: RCM and ESM model combinations used

RCM	Driving Earth System Model (ESM)
SMHI-RCA4 (RCA4)	CanESM2, CNRM-CM5, EC-EARTH, GFDL-ESM2-M, MIROC5, MPI-ESM-LR, NorESM1
CanRCM4 (RCM4)	CanESM2
KNMI-RACMO22T (RACMO)	EC-EARTH
DMI-HIRHAM5 (DMI)	EC-EARTH

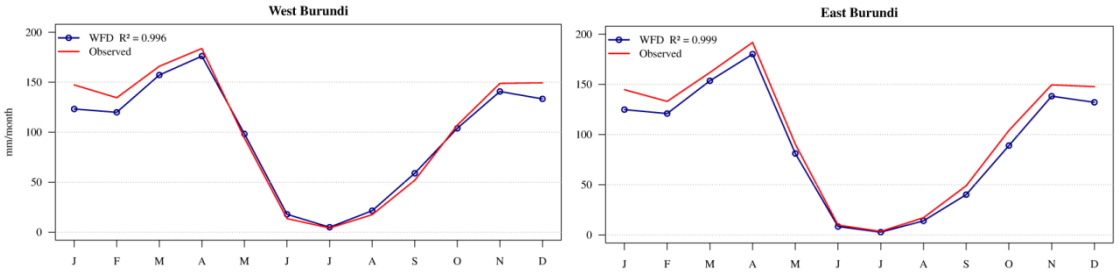
Please note: RCA4 was driven by seven ESMs. Instead of showing every single model combination, a multi-model mean for RCA4 was calculated and is used in this study.

Using the above mentioned models and scenarios, future projections were developed for two time periods, 2031-2060 and 2071-2100, and compared to the historical period 1970-1999. The two future periods were selected to provide climate change information for the near and far future, thus, supporting decision making processes at different planning horizons in the short to mid-term and long-term.

As a basis for comparison and performance analyses of the climate models, WATCH forcing data (WFD) [3] (Weedon et al., 2011) was used as an alternative to observed precipitation and temperature data as these were not available for the study. WFD is a global sub-daily meteorological forcing dataset provided for scientific use with land surface- and hydrological-models. The high correlation between the later available observed data and the WFD justifies the usage of WFD as reference dataset (see Figure 2).

[3] WFD is a global sub-daily meteorological forcing dataset provided for scientific use with landsurface- and hydrological- models. For more information on the Water and Global Change EU FP6 project (WATCH), please see: http://www.eu-watch.org/.

Figure 2: Correlation of rainfall seasonality in west and east Burundi. WFD and observed data averaged over the period 1970-1999.



Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

To evaluate the performance in representing rainfall in Burundi, all climate models were compared with WFD in the reference period (1970-1999) at the monthly time step. This comparison revealed that the model mean overestimated precipitation for the rainy months while a slightly underestimation of precipitation was observed for April and May.

However, one cannot expect that RCMs represent observed climate data perfectly. The climate system is very complex and the regional climate is influenced by large-scale (global) circulations. Dynamical RCMs are driven by global models and thus inherit in a way the uncertainties related to these boundary conditions.

The RCMs used in this study nonetheless show that they are able to represent the patterns of rainfall seasonality although with different skills. However, even if the quantities of monthly rainfall do not perfectly match observations, climate change studies focus on relative medium to long-term changes of those quantities.

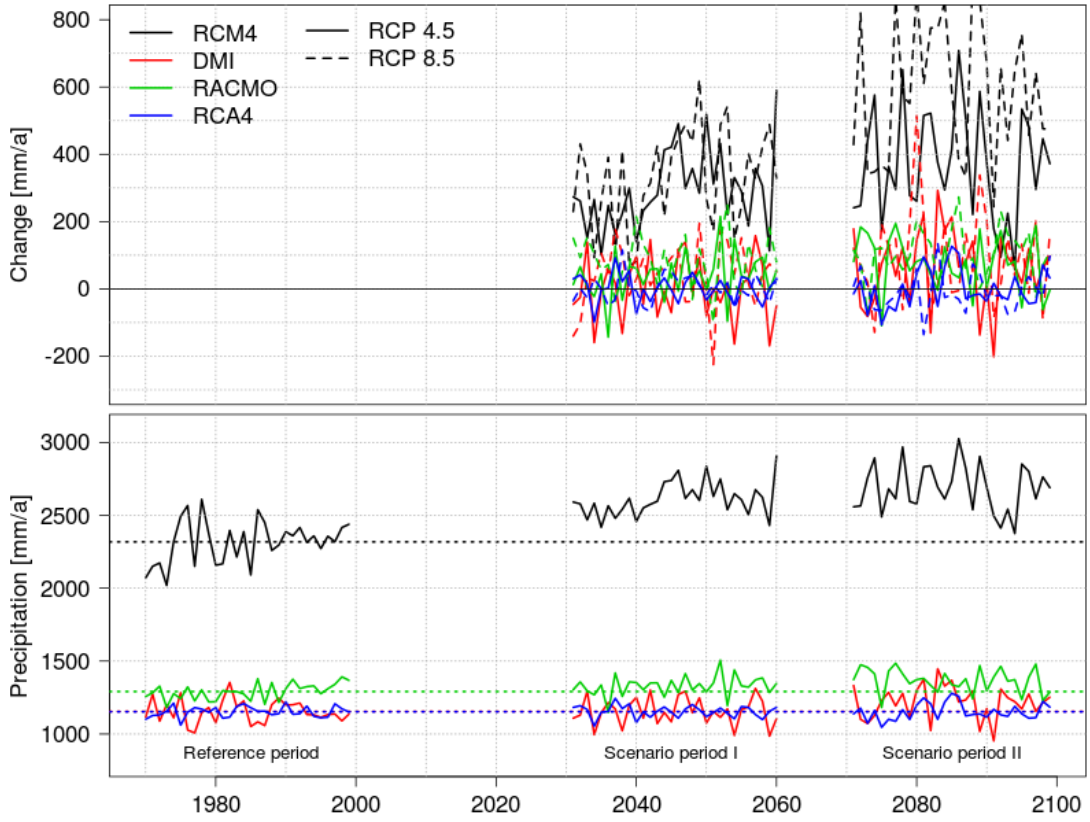
Hence, the aim of this study is to investigate the relative change signals of model projections and the models used in this study are considered to be adequate for this purpose.

3 Changes in Annual Precipitation

The study of climate change projections in Burundi shows the following future trends in annual precipitation:

- Compared to the reference period (1970-1999), average annual precipitation is projected to increase in entire Burundi with different extent in the future (Figure 3).

Figure 3: Projections of annual precipitation for Burundi using 4 RCMs



Source: Liersch/PIK 2014.

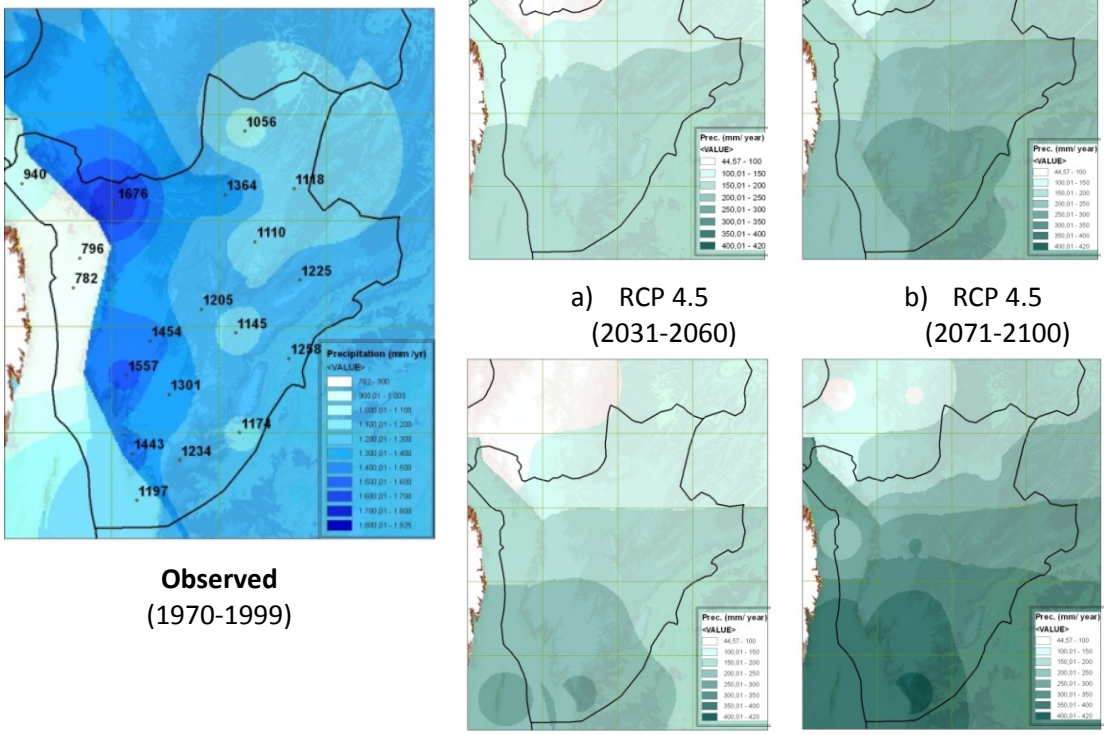
- Average annual precipitation in Burundi increases by approximately 84mm to 113.6mm or 5.7% to 7.7% in 2031-2060 and by 127mm to 196mm or 8.6% to 13.2% in 2071-2100 (Table 2).

Table 2: Changes in average annual rainfall (multi-model mean)

	1970-1999	2031-2060			2071-2100		
	mm	Ave. [mm]	%	mm	Ave. [mm]	%	mm
RCP 4.5	1479	1563	5.7	84.1	1607	8.6	127.4
RCP 8.5	1479	1593	7.7	113.6	1675	13.2	195.9

- The gradient of the projected change in precipitation grows from the North to the South of Burundi, varying from 44mm of rainfall in the northern part over the period 2031-2060 and the RCP4.5 scenario (Figure 4a) to 420mm in the south of Burundi over the period 2071-2099 according to the RCP8.5 (Figure 4d).
- The projected change of rainfall is particularly pronounced in the Congo-Nile highlands, the central plateau and the depression in the east (see Figure 4).

Figure 4: Projected precipitation changes in [mm]



Observed
(1970-1999)

a) RCP 4.5 (2031-2060)

b) RCP 4.5 (2071-2100)

c) RCP 8.5 (2031-2060)

d) RCP 8.5 (2071-2100)

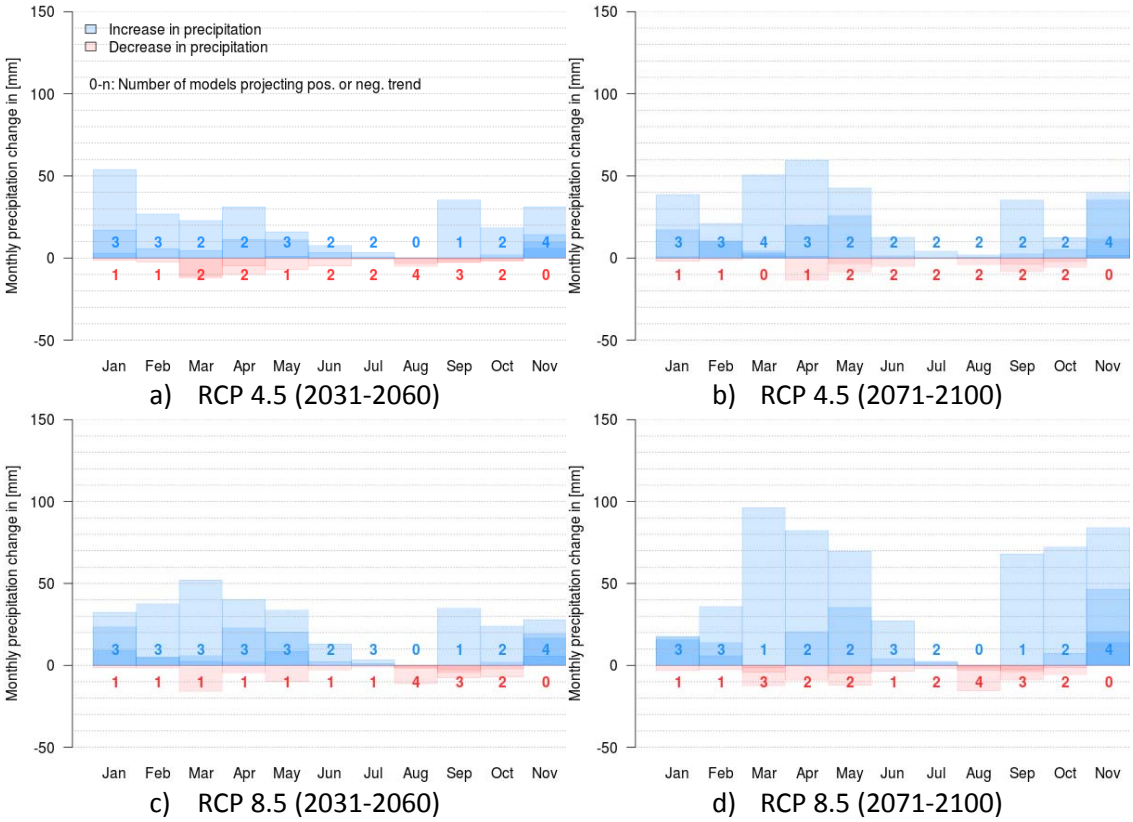
Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

4 Shifting Seasonal Precipitation Patterns

In regard to seasonal patterns of precipitation, the climate change projection study provided the following results:

- Most RCMs agree on increasing precipitation during the core rainy season (November to February).
- All RCMs in all periods and scenarios agree on a clearly positive precipitation trend in the months November and December (Figure 5).

Figure 5: Monthly precipitation changes compared to reference period 1970-1999

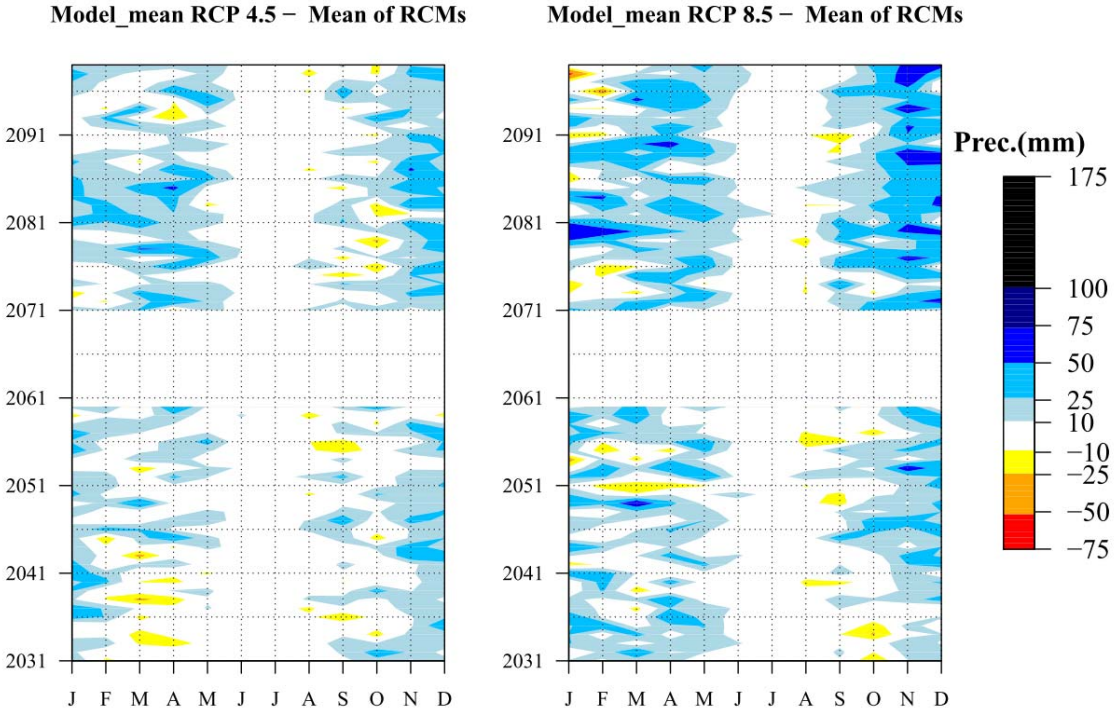


Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

Explanation for Figure 5: Every model is represented by one semi-transparent colour band for increasing (blue) and decreasing (red) trends. The darker the colour the more models agree on the same trend.

- In the transition time between rainy and dry season and vice versa, the models project different trends and the results are thus more uncertain.
- The RCMs agree on the general trend that the month before the onset of the rainy season will be drier. Depending on the model it affects the months August to October.
- Although the multi-model mean does not show a significant drying trend at the beginning of the rainy season (Figure 6), one should keep in mind that this was projected by three of four RCMs. Since the RCM4 model shows significant precipitation changes it plays a dominant role in the averaging process.
- Two RCMs (DMI and RCA4) project a prolongation of the dry season.

Figure 6: Multi-model mean of monthly rainfall anomaly projections for Burundi



Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

5 Changes in Annual Air Temperatures

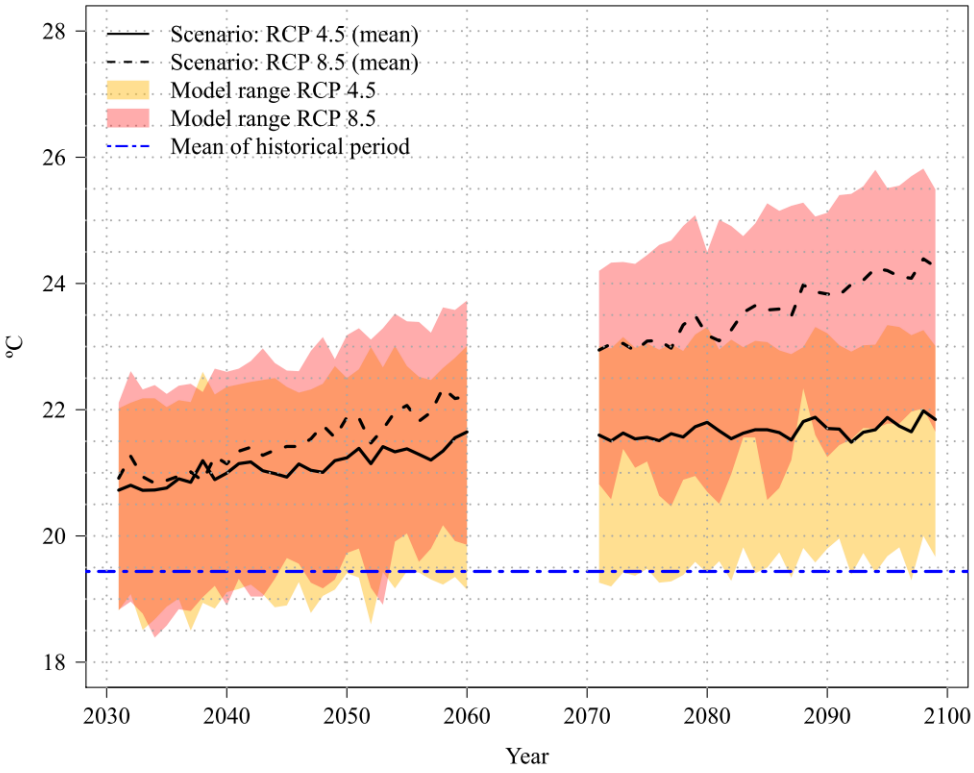
The applied data for the study indicated, that for the reference period (1970-1999) air temperature had already significantly increased. The 1990s were with an average annual air temperature of 20.2°C about 0.6°C warmer than the 1970s with 19.6°C. With regard to future trends in temperature, the study concluded the following:

- All RCMs agree that annual average air temperatures are projected to steadily increase over the 21st century in Burundi (Table 3 and Figure 7).

Table 3: Changes in air temperature (multi-model mean)

	1970-1999	2031-2060		2071-2100	
	°C	Ave. [°C]	K	Ave. [°C]	K
RCP 4.5	19.4	21.1	1.7	21.7	2.2
RCP 8.5	19.4	21.5	2.1	23.6	4.2

Figure 7: Multi-model mean of annual air temperature projections for Burundi



Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

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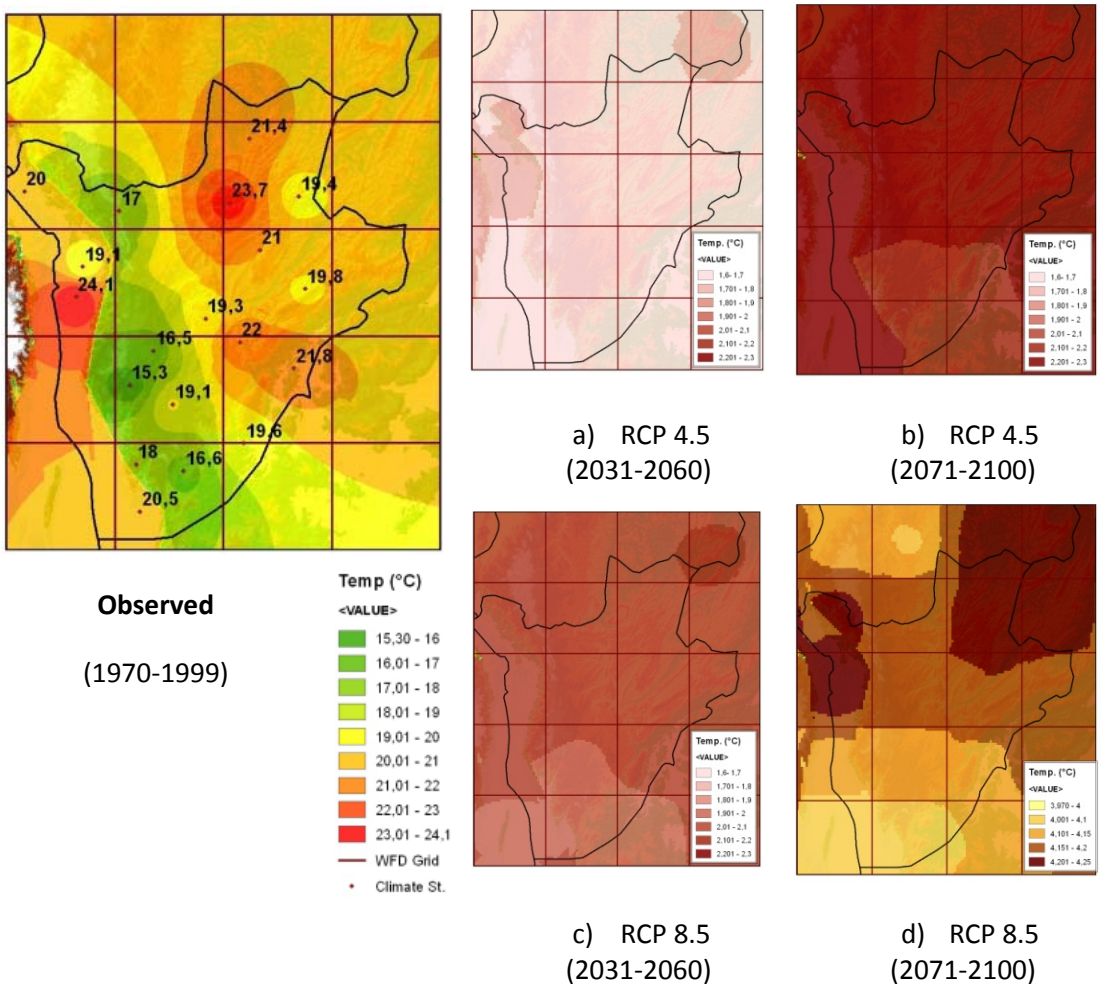
- The projected increase in average annual air temperature for RCP4.5 (all models) ranges between 1.4 and 2.0K in the period 2031-2060 and between 1.9 and 2.6K in 2071-2100.
- The projected increase in average annual air temperature for RCP8.5 (all models) ranges between 1.7 and 2.9K in the period 2031-2060 and between 3.6 and 4.7K in 2071-2100.
- It should be emphasised that projections for the near future period (2031-2060) show a much lower range across the two scenarios than during the period at the end of the 21st century.

Figure 8: Projected temperature changes in K (Kelvin) 1K=1°C



Observed

(1970-1999)

a) RCP 4.5 (2031-2060)

b) RCP 4.5 (2071-2100)

c) RCP 8.5 (2031-2060)

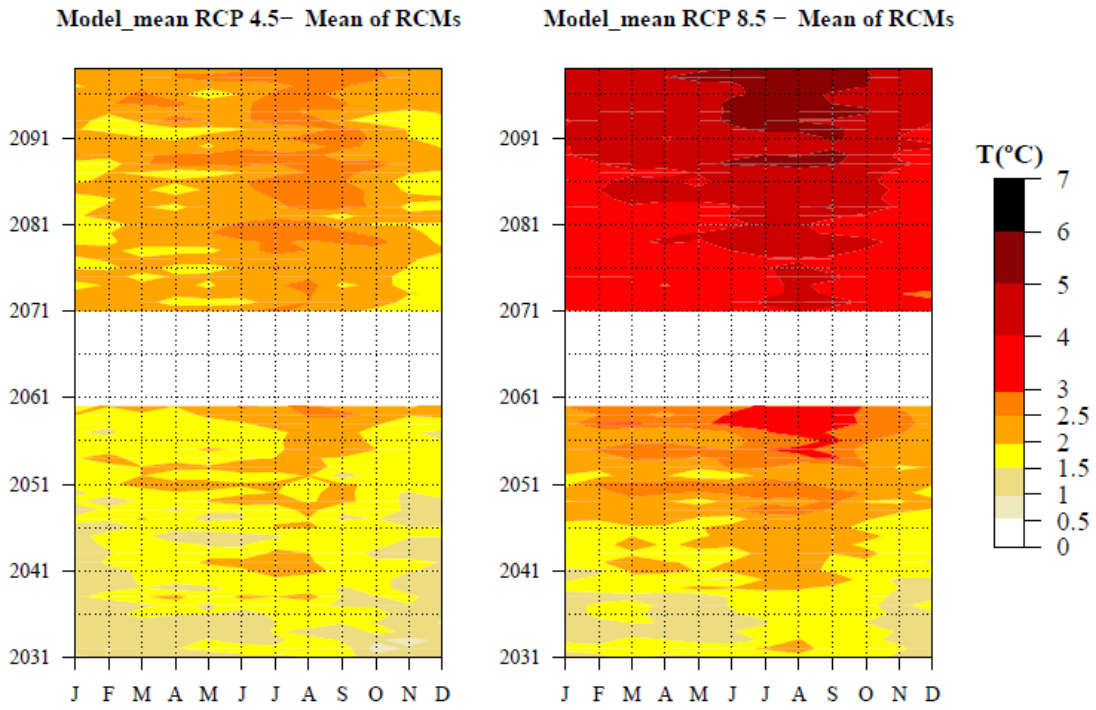
d) RCP 8.5 (2071-2100)

Source: Climate Change Report for Burundi, Liersch, Rivas 2014.

In regards to seasonal changes in temperature, this climate change projection study concluded:

- Average monthly air temperature is projected by all RCMs to increase in each month and year in both RCP4.5 and 8.5 (Figure 9).
- The highest increase of air temperature is projected to occur in the dry season and is increasing over the scenario periods.

Figure 9: Projected monthly air temperature anomalies to 1970-1999



Source: Climate Change Report for Burundi, PIK 2014.

6 Potential Implications of Climate Change for Burundi

The climate change projections conducted for this study showed that precipitation and temperature will both increase in Burundi in the future. Furthermore, the usual patterns of rainy and dry season might be altered due to climate change: the months November to February in the rainy season are projected to become wetter whereas a drying trend is projected for August and September. Besides, the dry season in Burundi will likely become hotter and longer in future. This trend will be most severe in the last third of the 21st century.

These climatic changes will have significant implications for the agricultural sector and people's livelihoods in Burundi:

- Future climate conditions may no longer be optimal growing conditions for the crops currently cultivated in the different regions of Burundi. Agricultural practices and crop types would therefore need to be adapted to rising temperatures and changing rainfall patterns and amounts.
- Higher temperatures and a prolongation of the dry season may further decrease water availability in regions already prone to seasonal water scarcity. This particularly applies to the northern part of Burundi as well as the area around Bujumbura.
- The surplus of water from rainfall might not be effective and simply get lost as surface runoff. This could further increase soil erosion in Burundi and decrease the already scarce arable land resources.
- This study did not address the risk of extreme rainfalls due to climate change. However, increased precipitation could take the form of extreme rainfalls which converging with soil erosion may lead to a higher risk and frequency of land and mud slides.

In order to cope with these adverse effects of climate change, such trends in precipitation and temperature should be considered in adaptation strategies and development plans of relevant vulnerable sectors as well as in land use planning.

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