CLIMATE | WATER | ADAPTATION

Climate related projections on future water resources and human adaptation in the Great Ruaha River Basin in Tanzania



Key messages

Temperatures will likely increase by 1-2 degrees by the middle of the century and 3-4 degrees by the end of the century.

A likely overall increase in precipitation and larger seasonal variation might lead to water related stress during a prolonged dry season and flood risks during the wet season.

The overall climate related effect on water resources is a status quo.

Increased rainy season rainfall offers opportunities for rain fed agriculture and water storage for hydropower and irrigation. Likewise groundwater resources should be included in integrated management.

Local governments (LG) are already effectively dealing with these climate related impacts. Assigning more responsibilities and capacities to LG can unlock great potential for adequately delivering locally diversified climate change adaptation.

Output from CLIVET: a DANIDA funded research and capacity building project

Global climate models predict increased temperatures and precipitation for East Africa towards the end of the century. The CLIVET research and capacity building project, a joint collaboration between research institutions in Tanzania, South-Africa and Denmark, further investigated these predictions. It utilized regional climate models for the Great Ruaha River Basin (GRRB) in Tanzania and linked these to potential impacts on regional water resources, to adaptation strategies within the agricultural sector and to national policies.

The Great Ruaha River Basin

The 84,000 km^2 Great Ruaha River Basin is located in central Tanzania. It comprises the catchment area of the Great Ruaha river, and it's main tributaries, amongst them the Little Ruaha. The basin is vital for the Tanzanian economy due to the large agricultural production, hydropower generation and national parks. Approximately 1.2 million people live in the catchment, most of them to various extents dependent on the local natural resources.

In the past decades a drop in dry season river flow has been observed (Kashaigili, 2008), leading to major concerns regarding sustainable water resources management. One of the likely causes for the diminishing water availability during the dry season is over exploitation for irrigation purposes combined with climate induced change or variability.

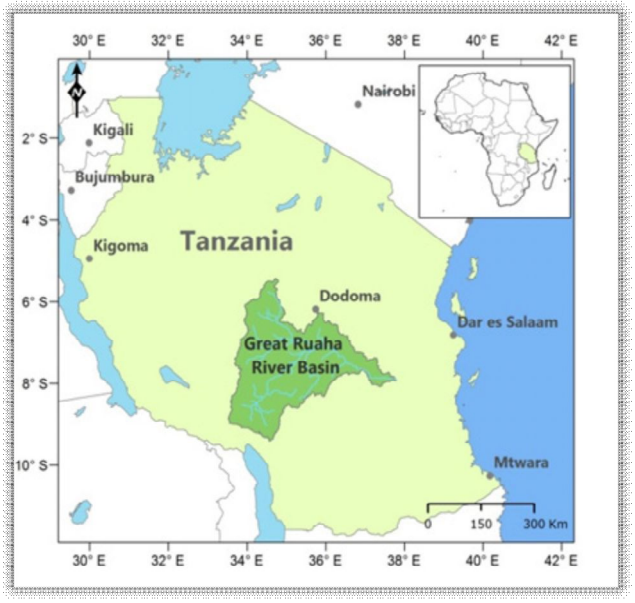


Fig 1. The Great Ruaha River Basin

Predicting future climate conditions in GRRB

Likely future climate conditions in the GRRB were explored using state-of-the-art regional climate models (RCM's). These were obtained by dynamically downscaling global climate models, making them better suited for describing local and regional climate conditions. To deal with inherent uncertainties connected to future climate predictions, the RCM's were combined with different greenhouse gas (GHG) emission scenarios (Fig. 2). The input data for the climate prediction analyses originated from the CORDEX database (COordinated Regional climate Downscaling Experiment). Overall, 12 different regional models combined with two different GHG emission scenarios, RCP4.5 and RCP8.5, were available for the African continent. Emission scenario RCP8.5 is the business as usual scenario and is currently regarded as the most realistic, since recent developments in GHG emissions closely follow this scenario.

One of the first detailed ensemble climate prediction and hydrological impact analysis in East Africa.

Climate predictions for temperature and precipitation from these 12 RCM's were analyzed by comparing the reference period 1976-2005 with two future time slices in respectively the near future (2031-2060), and the far future (2071-2100). Results were analyzed as monthly mean values for each 30 year period in order to get robust climate signals.

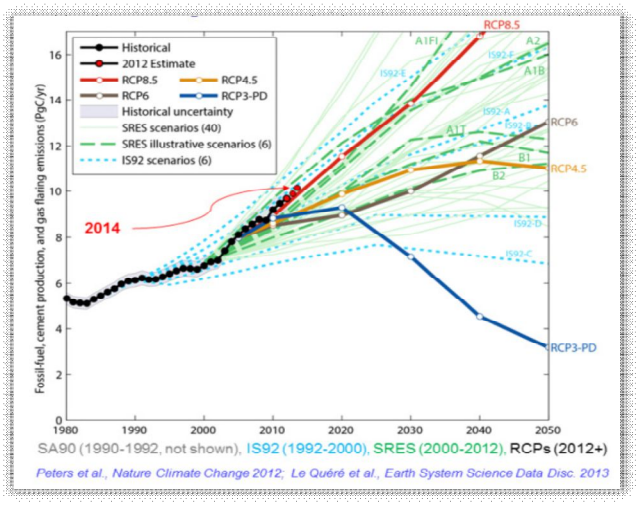


Fig 2. Greenhouse gas emission scenarios

Predicting future hydrological impacts in GRRB

Based on the projected future changes in temperature and precipitation, a water resources impact assessment was undertaken using a hydrological model, set up and calibrated specifically for the GRRB (Stisen & Tumbo, 2015).

The impact assessment evaluated the likely future flows in the Great Ruaha River basin based on the future climate predictions. It only considers the changes in water resources related to climate while assuming all other model components, such as consumption and land use, to remain unchanged. While such a scenario is not necessarily realistic, it gives a good idea of climate driven impacts.

What can we expect in the future for GRRB?

Temperature

The RCMs show clear tendencies regarding future temperature changes in the GRRB (Fig. 3). Temperatures are predicted to increase

- by 1-2 degrees by the middle of the century (3a)
- by 3-4 degrees towards the end of the century (3b)

Although the individual models predict a range of actual temperature change, they all project the same trend towards increasing overall future temperatures in the region. Especially temperatures are expected to increase during the dry season.

Precipitation

Regarding future precipitation, results are also relatively clear across the 12 RCMs (Fig. 4):

- Precipitation increases in the wet season
- Precipitation decreases in the dry season
- This trend is amplified towards the end of the century (4b)

Since the GRRB precipitation pattern is strongly seasonal, changes in the wet season influence annual precipitation the most (Fig. 5). Overall, a general increase in the total annual precipitation over the GRRB is projected to

- 6% by the middle of the century (5a)
- 10% by the end of the century (5b)

Water resources

The combined effect of increased temperatures and increased precipitation is illustrated through the hydrological impact model. The results in figure 6 illustrate how the two climatic changes tend to even out as the increase in precipitation is compensated for by a temperature driven increase in evaporation. Results in figure 6 are shown for the Little Ruaha river at Iringa.

- Average monthly river flow is projected to remain approximately at the historic level within the Great Ruaha River basin
- Increased floods during the wet season and prolonged drought during dry season can be expected

Temperature

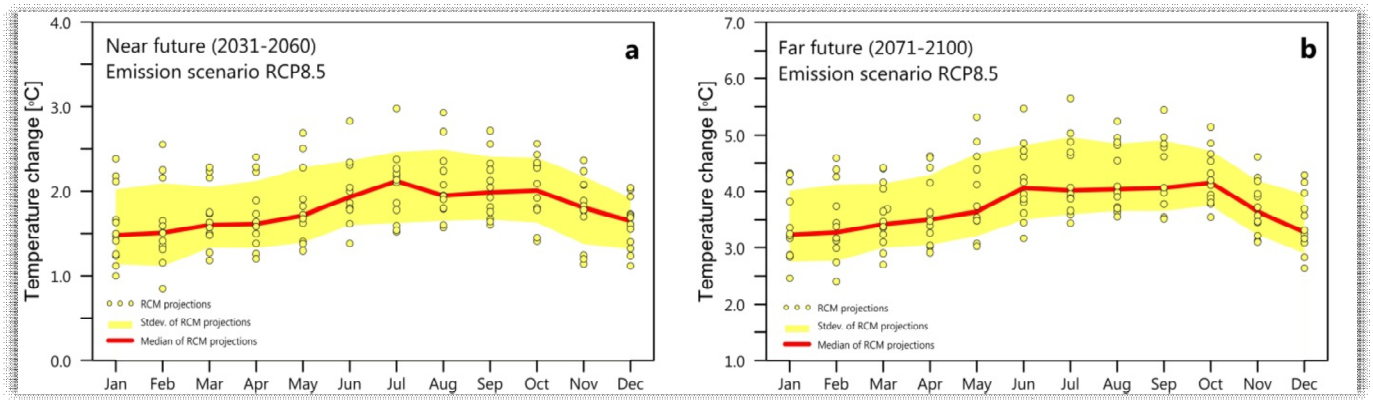


Fig 3. Projected changes in annual temperature patterns for the GRRB. Values reflect the increase in monthly mean temperature for the future.

Precipitation

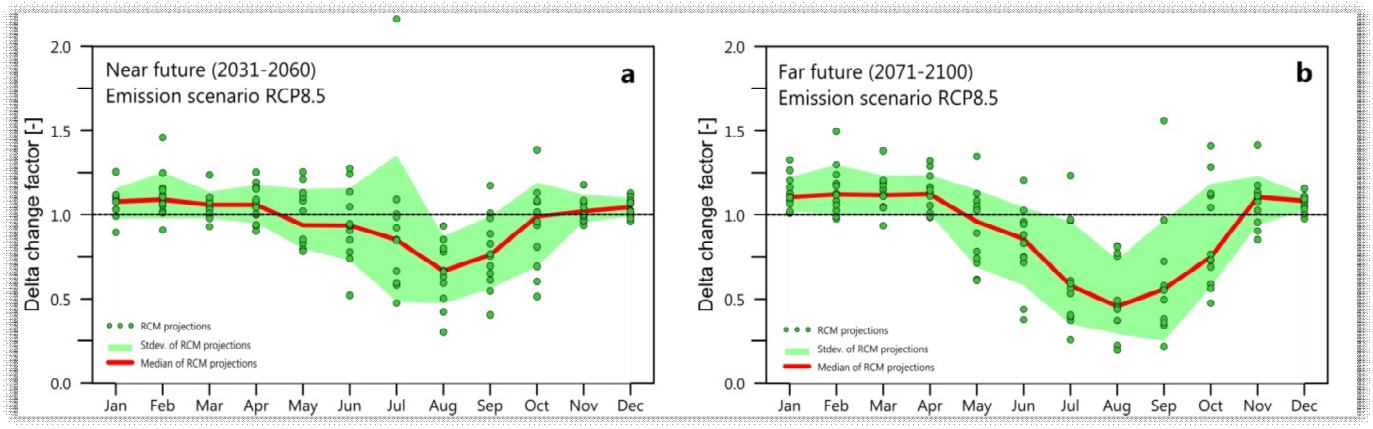


Fig 4. Projected changes in annual precipitation patterns for the GRRB. Values above one indicate a wetter future and below one a drier future.

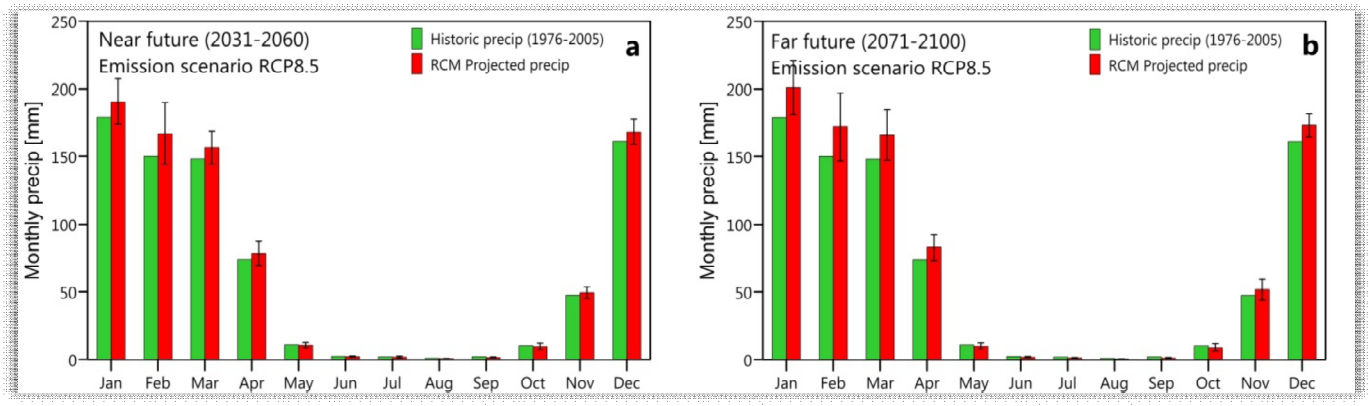


Fig 5. Projected changes in average monthly precipitation for the GRRB. Red bars represent the average of 12 RCM projections and the error bars the stdev. among the RCM's.

River flow

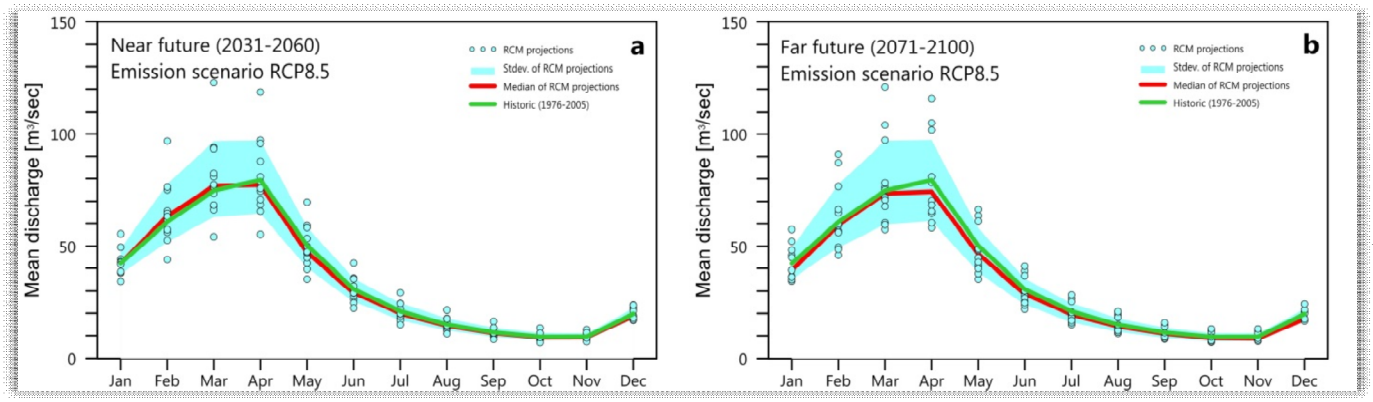


Fig 6. Projected changes in average monthly discharge at Iringa on the Little Ruaha River.

Contemporary local livelihoods and climate

The inhabitants of the GRRB have since long learned to deal with rainfall variability and have developed a range of appropriate adaptation strategies. As predictions reveal that future climatic conditions might become more extreme, these adaptation strategies might be challenged. CLIVET researchers investigated local perceptions on climate change issues within agriculture and explored existing and potential future adaptation strategies at the farm and village level.
Results from detailed house and field surveys in Iringa district indicated that:

- Subsistence farming practices turn to intercropping during dry seasons
- Cash crops such as tomatoes and onions play an increasingly important role for local livelihoods but are found more susceptible to pests when climate conditions are extremer
- Irrigated plots are on the rise, and provide wealth increasing opportunities to those with access
- Emerging urban centers provide a plethora of income opportunities alternative to agriculture

The policy perspective and government strategies

CLIVET researchers found that promising strategies were in place at national level (e.g. National Climate Change Strategy and accompanying communication, monitoring and evaluation frameworks, GOT, 2012 & 2013) , but that the actual assignment of mandates for delivery of adaptation on the ground was still in a very early phase. Targeted climate change adaptation funding was lacking and predominating sectoral policies challenged an integrated agenda on adaptation issues at all levels.
No prominent climate change impact narratives existed at the district level governments (LGA) in the GRRB area, but climate related issues such as dry areas and recurrent food shortages, river water use and crop pests were clearly on the local agenda. District officers also talked about the need to support livelihood diversification in the area, about forest resources and about infrastructural projects related to water, such as the construction of rainwater harvesting dams or the construction of irrigation infrastructure.

Conclusion and Recommendation

The climate in the GRRB will likely be **warmer and wetter** and with increasing seasonal variation and extremes towards the end of the century. This brings along **potential challenges for agricultural livelihoods** in the form of increased pest incidence and flooding, but it also provides **opportunities for water storage** for hydropower generation and irrigated agriculture. In addition, an **increased focus on groundwater resources** should be a valuable addition to the current water management (Villholth et al, 2013). **National policies are in place but effective climate change adaptation delivery lags behind**. In order to maximize the opportunities presented by the predicted climate impacts and to minimize potential adverse impacts on livelihoods, clear assignments of budgets and mandates to lower levels of government are needed. **District level governments hold the potential to play a pivotal role** in effectively delivering Tanzania's Climate Change Adaptation Strategy.

References

Government of Tanzania (GoT), 2012. /National Climate Change Strategy. / Monitoring and evaluation framework for climate change adaptation in Tanzania. /Guidelines for integrating climate change adaptation into national sectoral policies, plans and programmes of Tanzania, Dar es Salaam.

GoT, 2013. Climate change adaptation information toolkit for farming communities in Tanzania, Dar es Salaam.

Kashaigili JJ (2008) Impacts of land-use and land-cover changes on flow regimes of the Usangu wetland and the Great Ruaha River, Tanzania, Physics and Chemistry of the Earth, 33 (640-647)

Stisen S, Tumbo MH (2015) Interpolation of rain gauge data for hydrological modelling in data sparse regions using pattern information from satellite data. Hydrological Sciences Journal.

Villholth et al. (2013) Smallholder groundwater irrigation in sub-Saharan Africa: an interdisciplinary framework applied to the Usangu plains, Tanzania. Hydrogeology Journal, 21(1481-1495)

CORDEX website (http://start.org/cordex-africa/about/)

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