



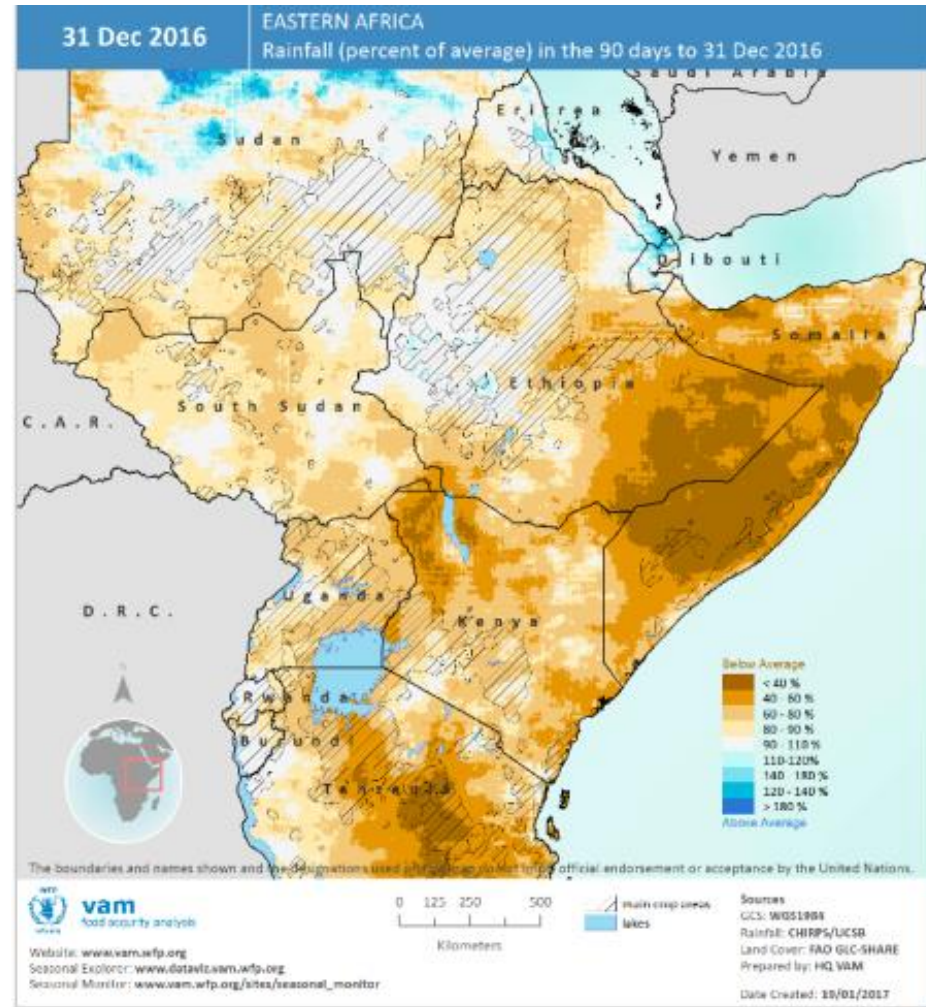
HYDRO-CLIMATIC RISKS TO THE TURKWEL RIVER BASIN

Feyera Hirpa, Ellen Dyer, Simon Dadson, Richard Washington & Rob Hope - University Of Oxford

March 28, 17:57

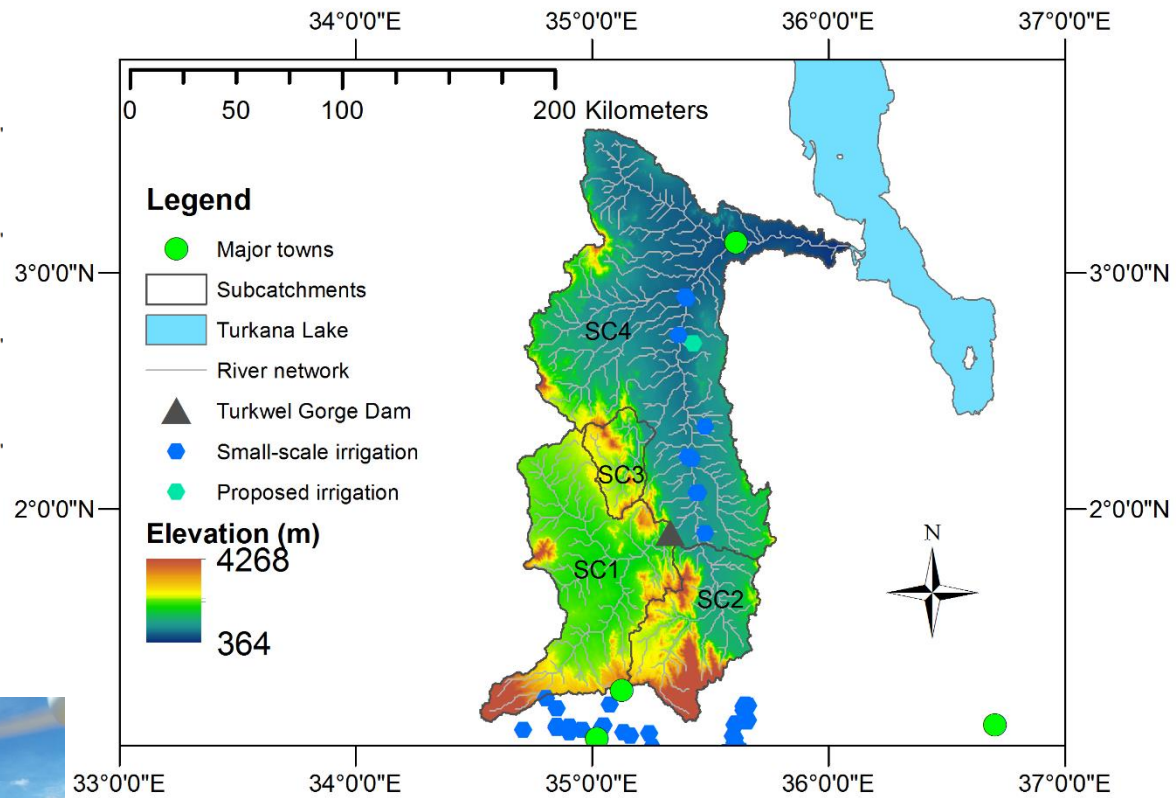
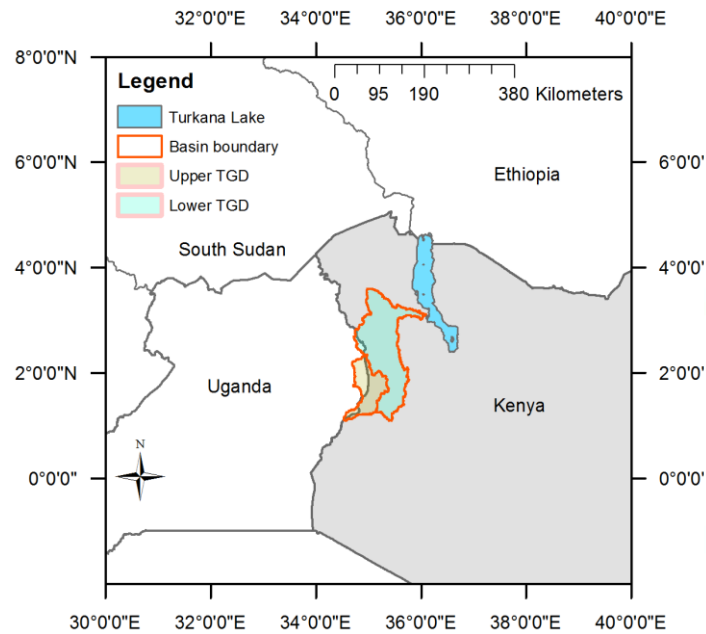


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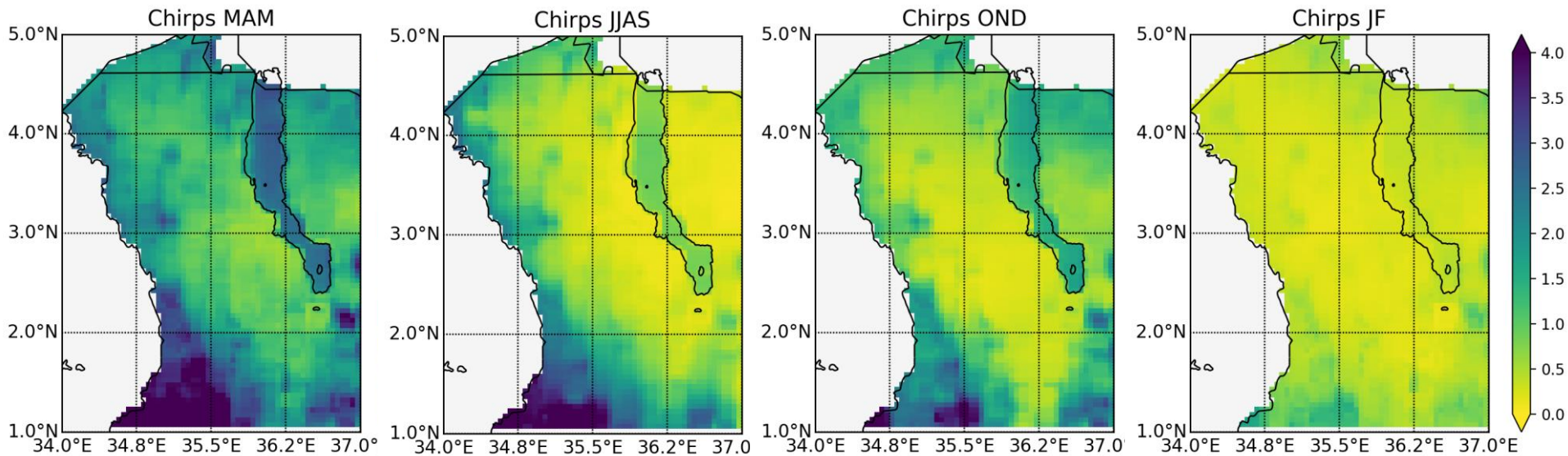


Climate Resilience, Water Services and Poverty in Kenya Turkana Stakeholder Workshop
Thursday 15 February, 2018

- Context: Turkana and Turkwel river basin
- Climate variability and risk from a climate perspective
- Decision scaling: risk from a hydrological and water allocation perspective
- Moving forward: the long rains - how can we better understand future projections and risk?



- Turkwel River Basin covers 23,740 km² from Uganda through West Pokot to Turkana
- One of the three rivers flowing into Lake Turkana
- Critical resources for livestock, HEP, agriculture, industry and municipal supply



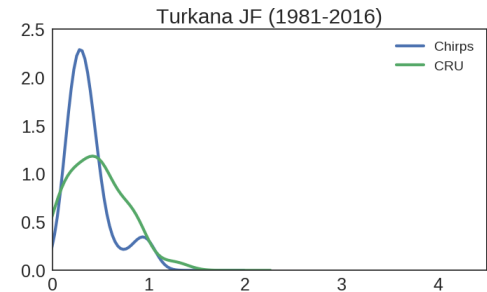
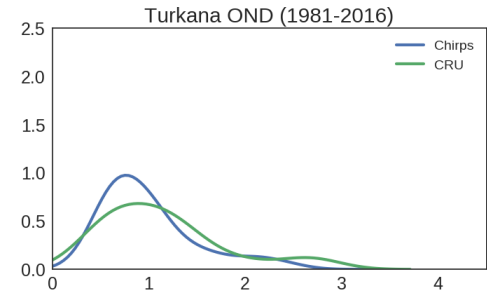
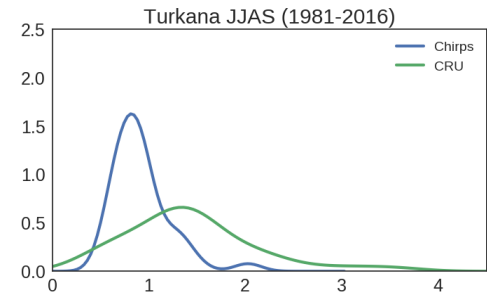
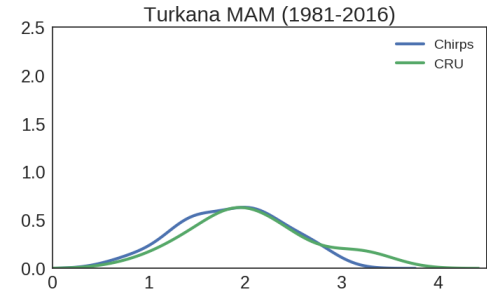
Data: CHIRPS v2.0
1981-2016
(mm/day)

- MAM (long rains) has the highest rain rates of all seasons
- Unlike other parts of Kenya, the rainfall climatology is not bimodal but peaks in MAM and decreases throughout the year
- Some areas of Turkana and the Turkwel river basin have near zero rain rates for most of the year outside of MAM

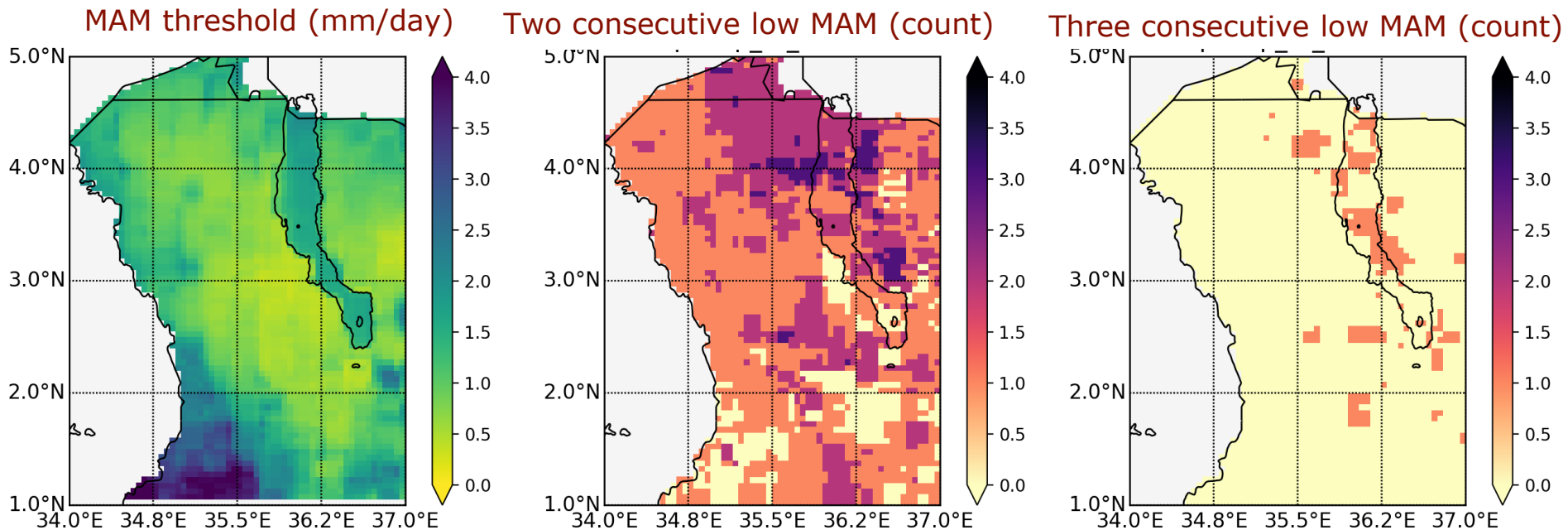


VARIABILITY

- MAM has higher rain rates (the mean is just below 2mm/day) but the distribution of rain rates can reach up to 4 mm/day
- The spread in JJAS is large for CRU but not for CHIRPS
 - Gauge data sparsity is an issue, CHIRPS is merged satellite-gauge product
- Agreement is better in OND and the rain rates are about half of MAM
- Low rain rates of 1 mm/day are common outside of the long rains season
- The range of extreme values is shown here but this does not show how these events are organised



CONSECUTIVE EVENTS

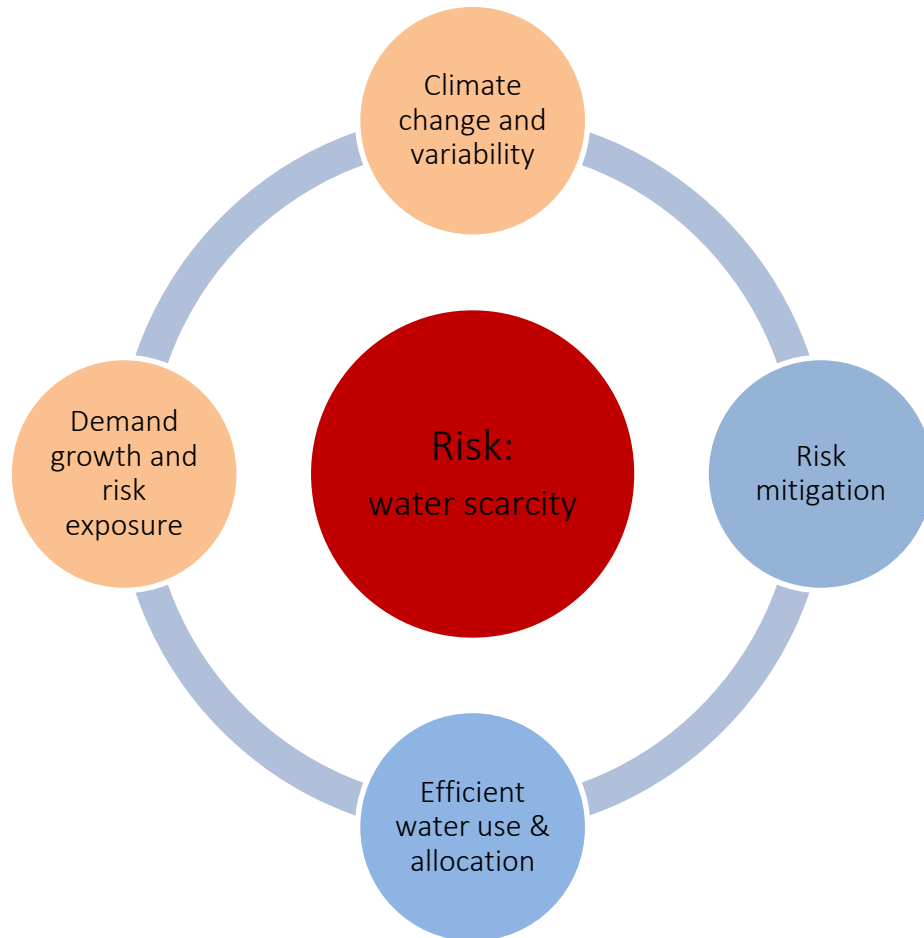


Data: CHIRPS v2.0

- How often do dry events occur consecutively? And what is the impact of these events?
- Example: setting a threshold of one standard deviation below the mean as a threshold, how often do two MAM seasons dip below this threshold one after the other, or three times in a row within 1981-2016?
- Are these successive, but not individually extreme events as, if not more, detrimental than contained extreme events?

RESEARCH QUESTIONS

- How do climate change and variability impact water scarcity in the basin?
- How much of the water demand is currently met? And how does future expansion affect the water demand satisfaction?
- What can be done to meet the rapidly growing water demand (efficient allocation and risk mitigation)?



METHODOLOGY: RISK SCALING

1. Identify water-related risk in the basin



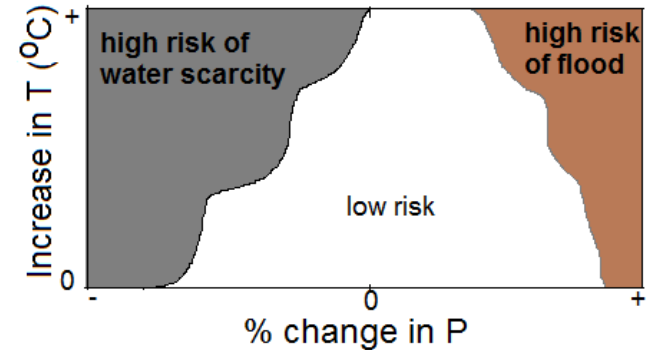
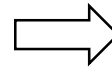
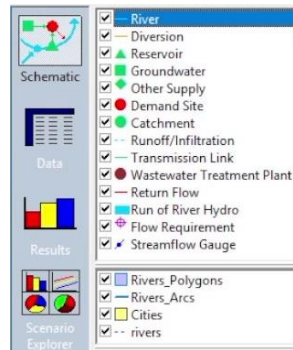
e.g., drought-driven water scarcity, food shortage, and demand growth

2. Define desirable threshold levels



e.g., minimum water requirement, maximum groundwater abstraction

3. Identify climate and demand conditions that may lead to the identified risk



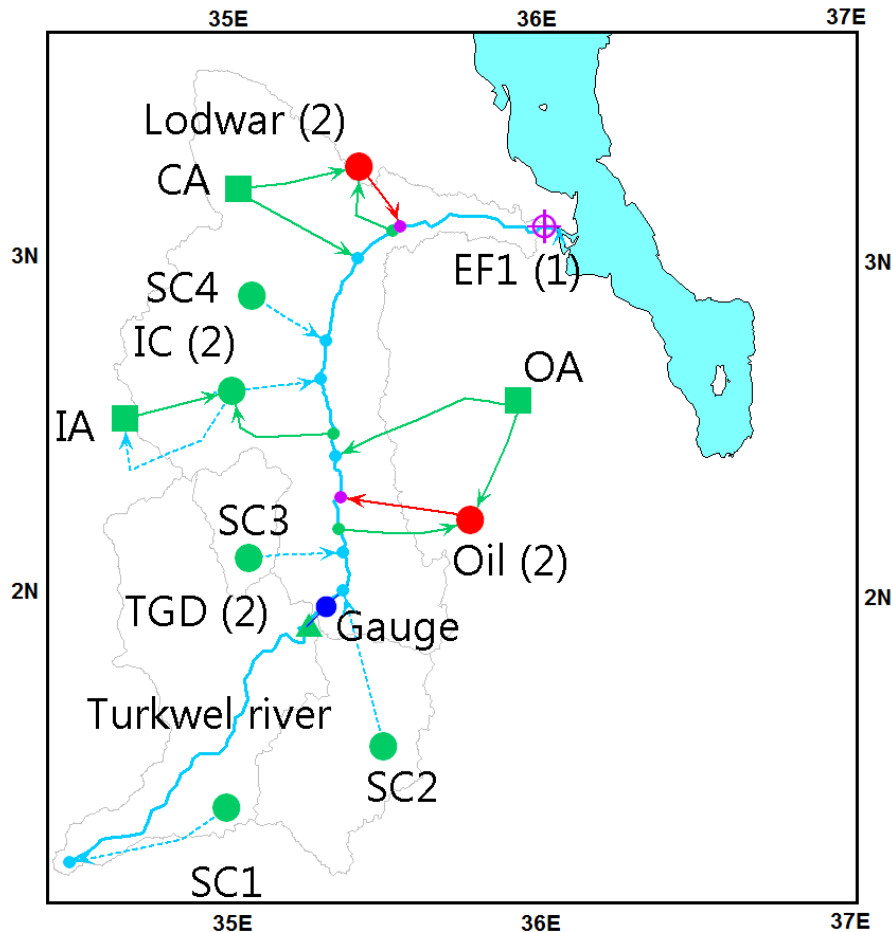
4. Inform decisions around risk mitigation



e.g., improved agricultural practices, water storage, reducing water loss



ANALYSIS: WEAP MODEL



Components:

- Four sub-catchments (SC)
- Irrigation catchment (IC)
- Reservoir: Turkwel Gorge Dam (TGD)
- Two demand sites: Lodwar town and industry
- Three alluvial aquifers: CA, IA and OA
- Environmental flow requirement (EF1)

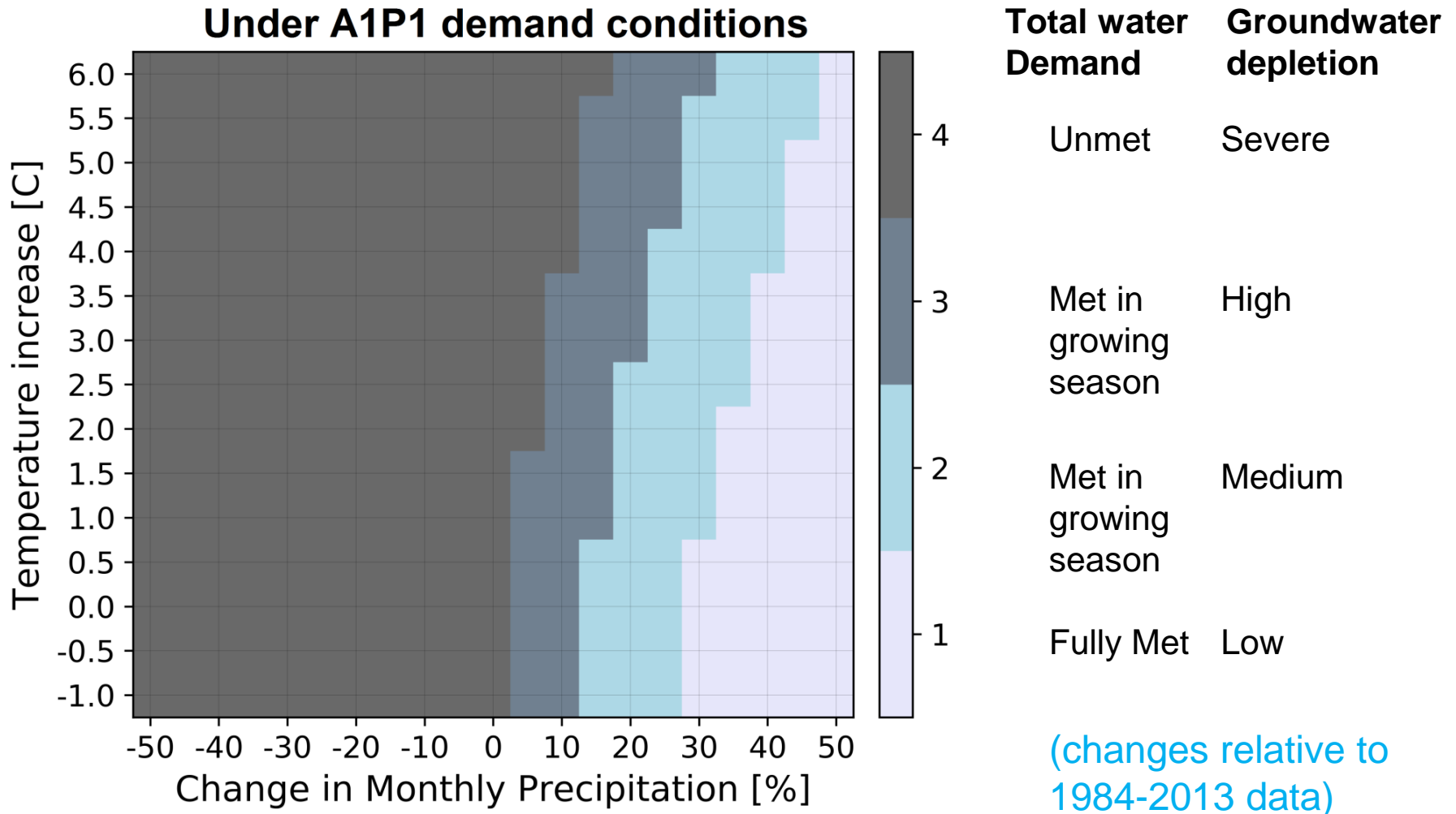


WATER DEMAND SCENARIOS

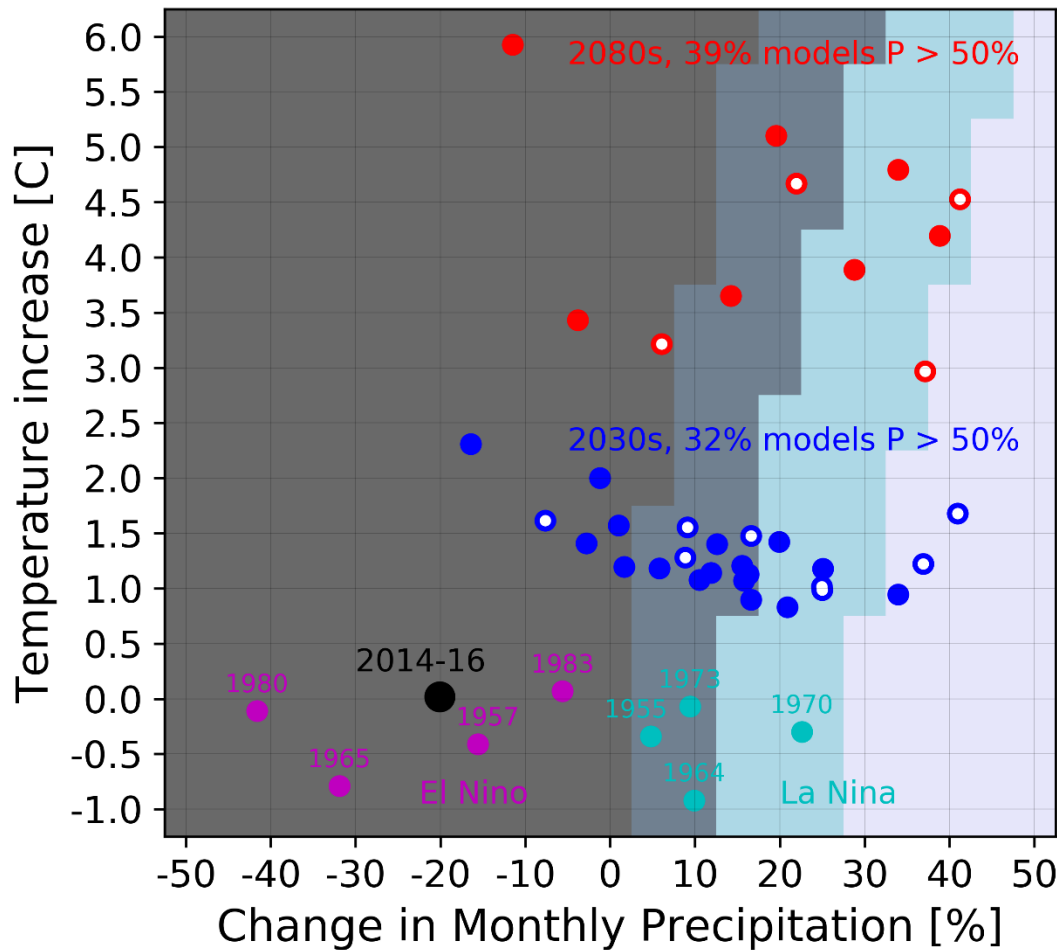
Demand type	Scenario	Description	Informed by
Irrigated agriculture	A1	18 km ² of irrigated cropland	FAO 2013 estimate [Maina et al., 2013]
	A2	100 km ² of irrigated cropland	FAO potential estimate [Maina et al., 2013]
	A3	250 km ² of irrigated cropland	Planned Turkwel Multipurpose Project [KVDA, 2013]
Lodwar town domestic consumption	P1	Growth rate of 2.7%	Kenyan national average [KNBS, 2012].
	P2	Growth rate of 6.0%	Turkana County's growth rate [Kenya County Fact Sheets, 2013]

CLIMATE RESPONSE SURFACE

The impact of change in rainfall and temperature on meeting water demand and groundwater depletion



IMPACT OF CLIMATE CHANGE & VARIABILITY



GCMs

16% in 2030s

16% in 2080s

30% in 2030s

17% in 2080s

11% in 2030s

28% in 2080s

43% in 2030s

39% in 2080s

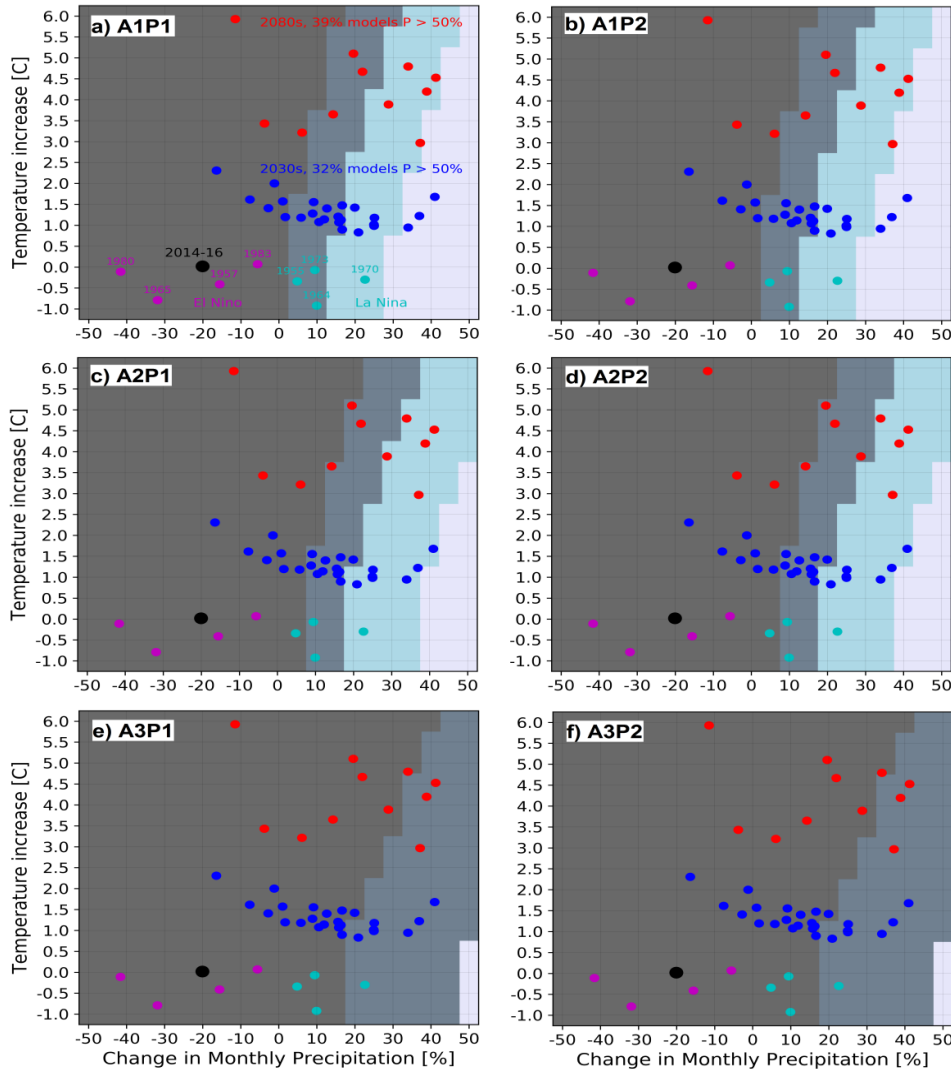
Historical data:

El Niño (1980, 1965, 1957 and 1993)

La Niña (1970, 1964, 1973 and 1955)



IMPACT OF AGRICULTURAL AND POPULATION GROWTH

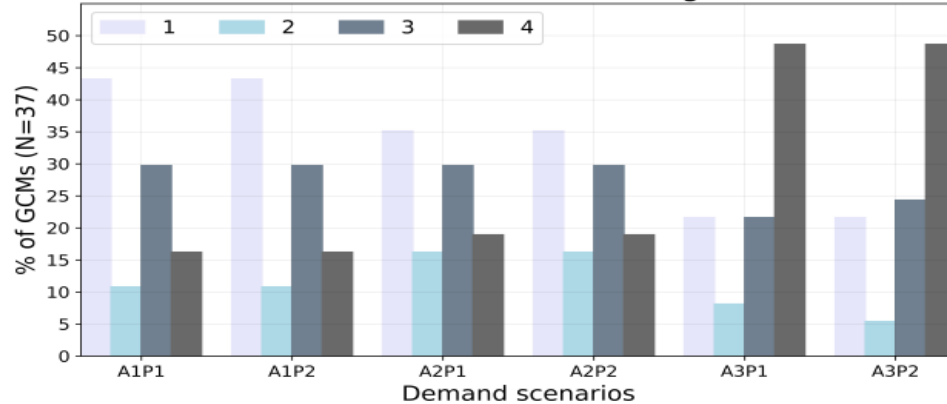


- Increasing irrigation puts additional stress on the water resources.
- Significant rainfall increase is needed to maintain low risk level

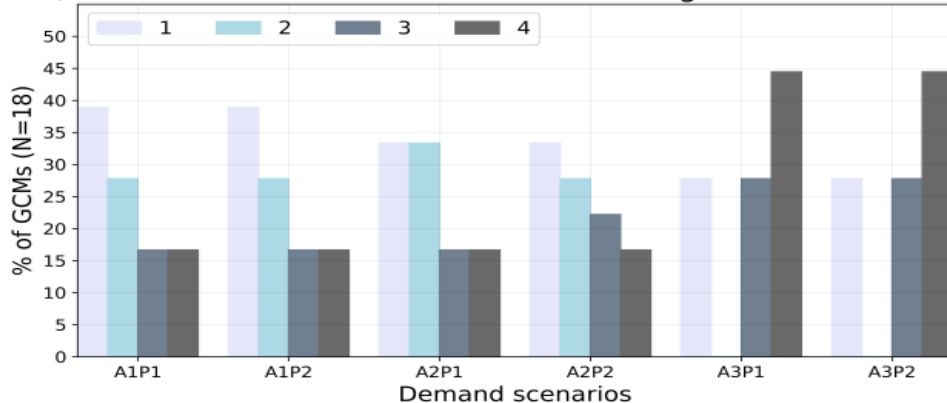


IMPACT OF AGRICULTURAL AND POPULATION GROWTH

a) 2030s climate risk variation with change in water demand



b) 2080s climate risk variation with change in water demand

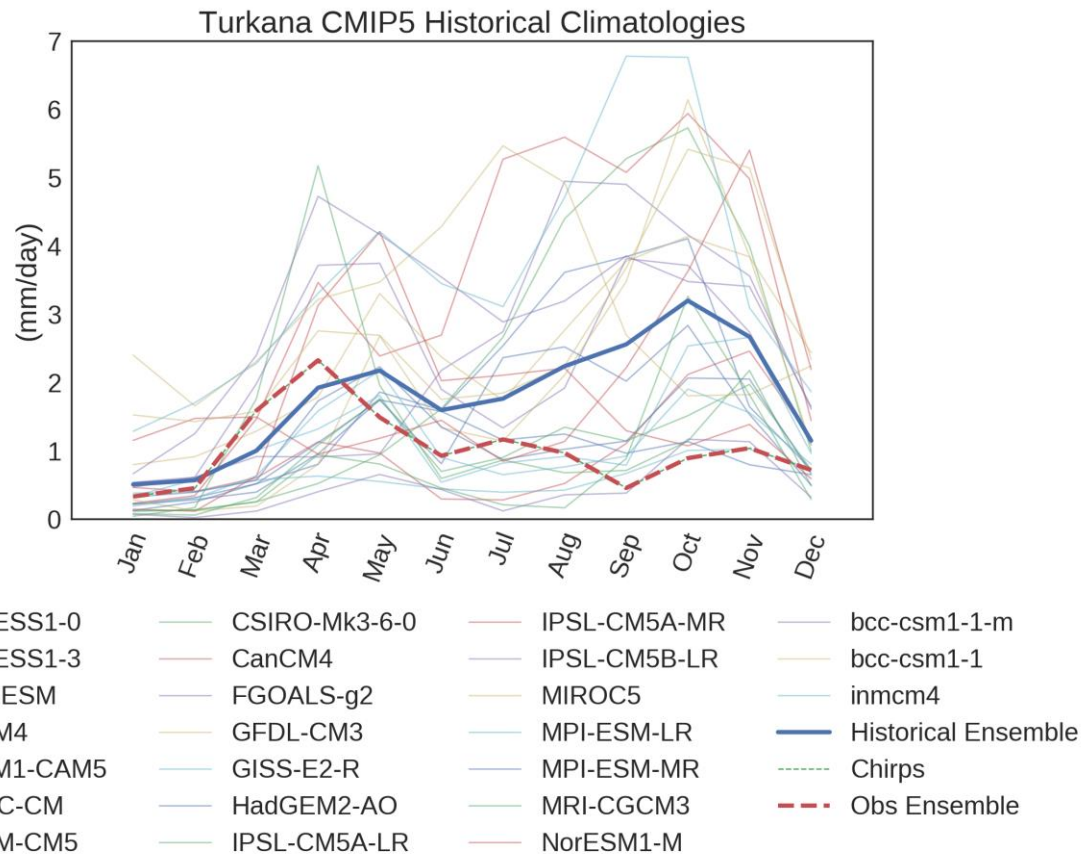


- Increasing irrigation puts additional stress on the water resources
- The severe risk (“category 4”) of future climate increases 3 times from A1P1 (16%) to A3P2 (48%)

IMPACT OF AGRICULTURAL AND POPULATION GROWTH

Results reveal that:

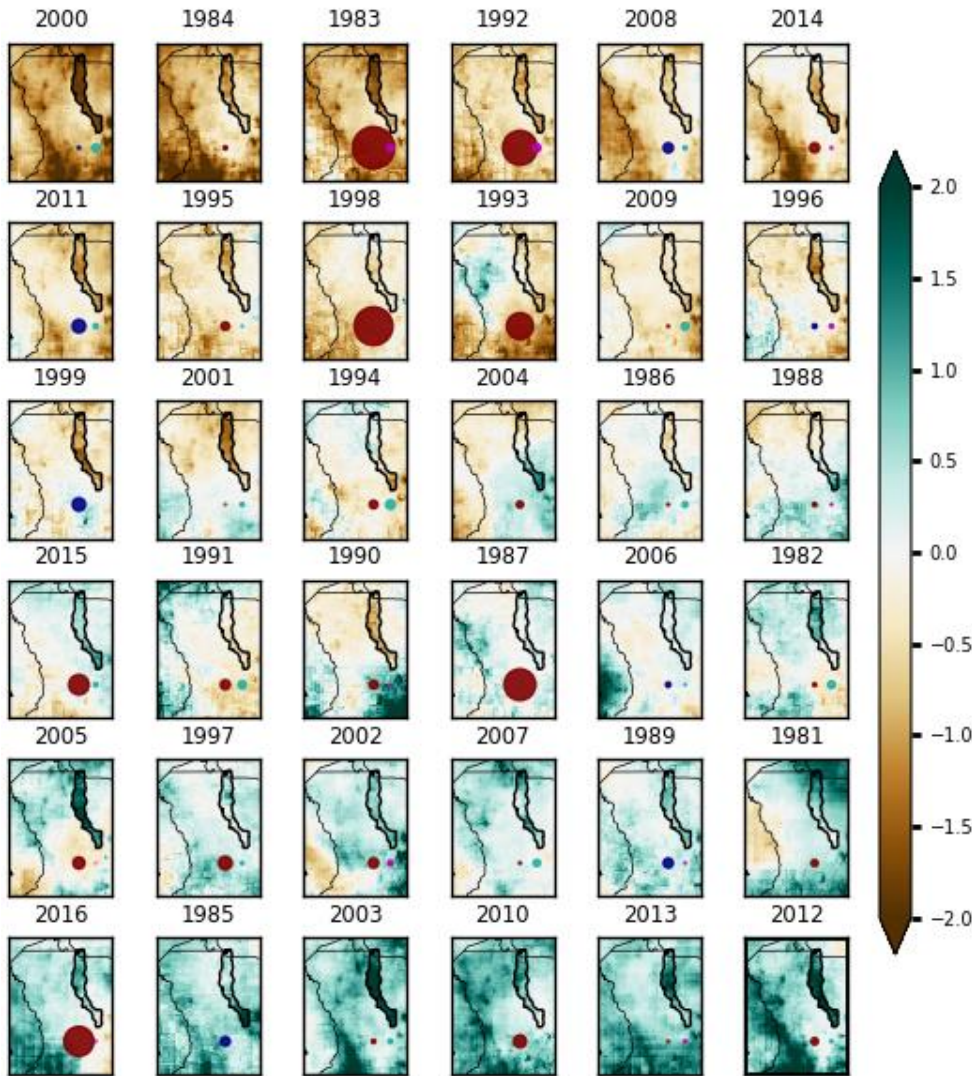
- The basin has been historically water-stressed
- Expanding irrigation and climate variability are the main drivers of water scarcity in the basin
- A potential increase in crop irrigation from 18 km² to 250 km² significantly increases the risk due to future climate change
- Decision scaling has shown that even though the ensemble of climate models shows more rain in the future that some development scenarios may still present risks



- Very few models are able to reproduce rainfall in Turkana, missing the climatology and showing increasing rather than decreasing long rain trends in the historical period
- This leads to low confidence in the predicted trends
- Challenge: understand why coupled models cannot capture long rains, and better constrain future projections

CLIMATE EXTREMES & TURKANA

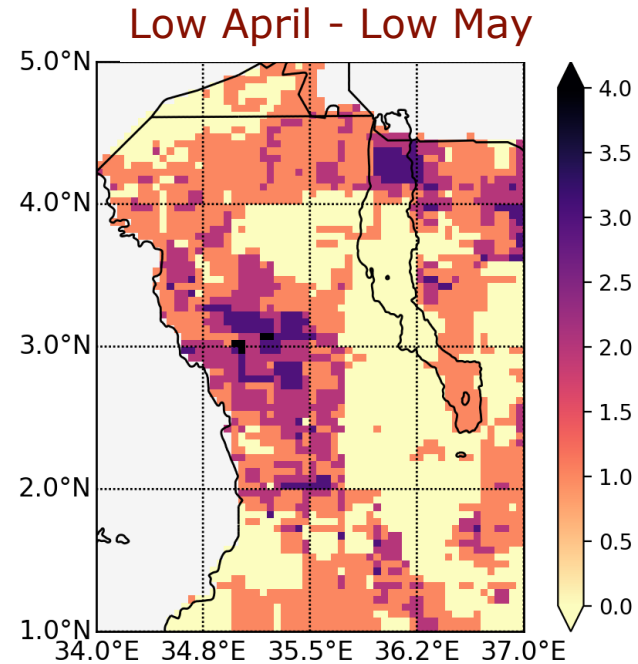
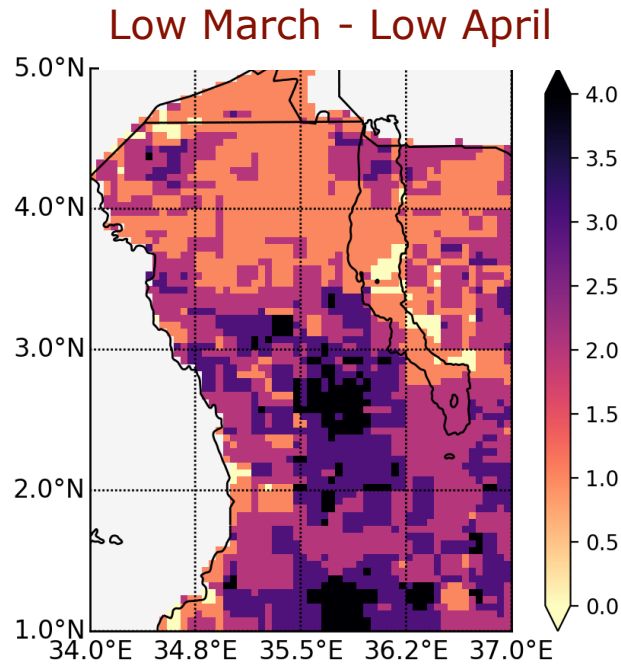
MAM anomalies (mm/day)



- Long rain anomalies have been ordered from driest to wettest years
- ENSO and Indian Ocean dipole (IOD) indices have been overlaid
- Applying these indices in MAM is not as helpful in diagnosing wet and dry years as it is in OND
- Understanding MAM variability is not as straightforward as OND variability, but this season is the most important source of rainfall for Turkana

Red is El Nino
 Green is + IOD
 Blue is La Nina
 Purple is - IOD

^ UNDERSTANDING THE LONG RAINS: BREAKING UP THE SEASONS



Data:
CHIRPS
v2.0

- What does a short long rains season look like?
 - How often is a dry March followed by a dry April vs a dry April followed by a dry May
- Long rains are predominantly short because they start late
 - What large scale climate drivers cause this?
 - Understanding subseasonal variability will lead to a better characterisation of rainfall and a better understanding of what climate drivers affect rainfall in Turkana

- Risk mitigation may consider demand (irrigation, environmental flow regulations) and supply responses (new water resources)
- Without investing in improved hydro-climatic monitoring policy choices will continue to face significant scientific uncertainty
- Lodwar's future expansion and growth will depend on a robust and effective water resource management strategy
- Existing challenges include limited *in situ* data and large uncertainty in the future hydro-climatic trajectories (the “East African climate paradox”)
- Currently trying to understand drivers of long rain variability by looking at the sub-seasonal scale and applying these findings to available global climate models

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