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Modelling impacts of climate change and water use in the Zambezi basin

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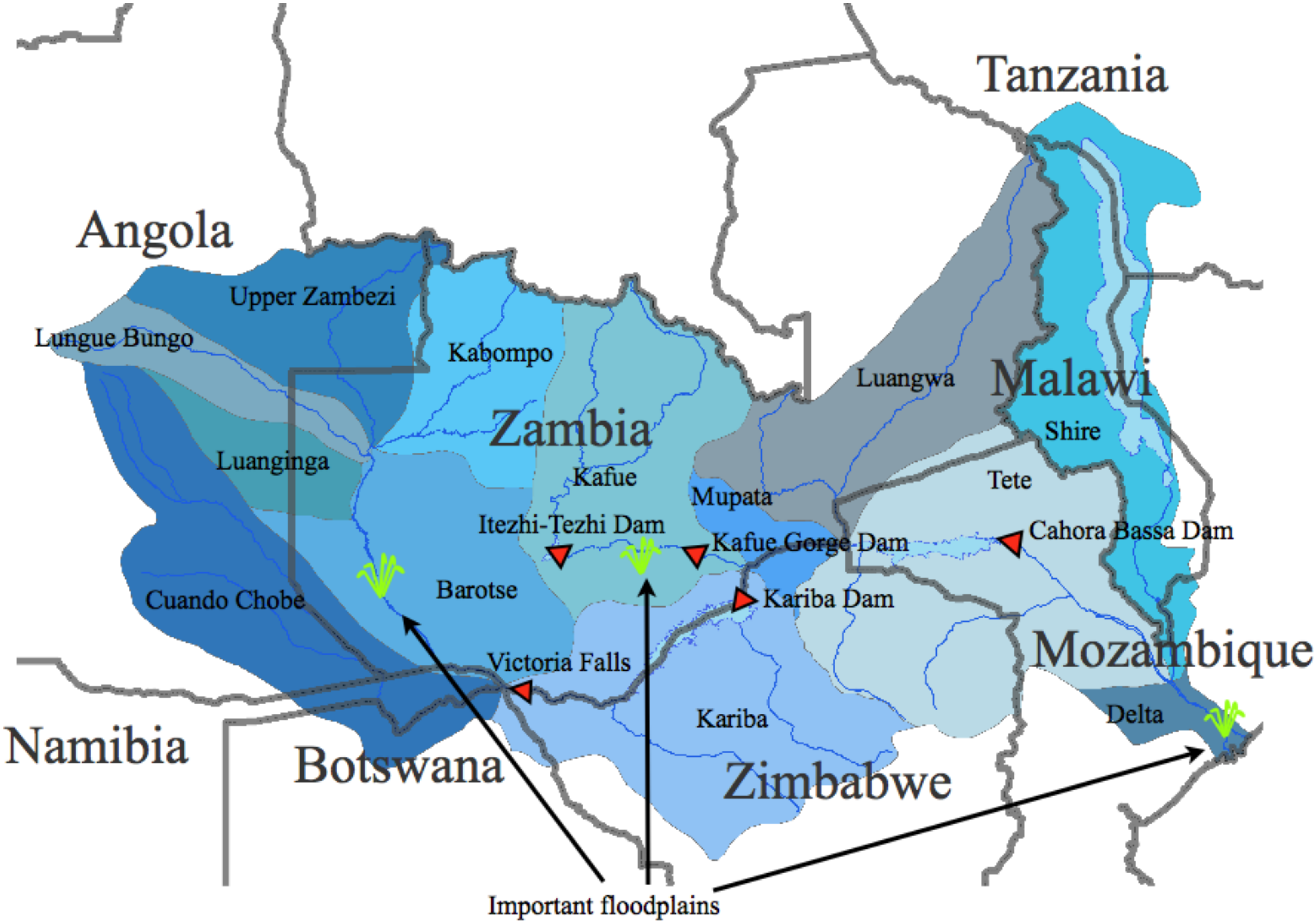
Main Questions

1) What is the impact of climate and environmental change
   -> Scenarios for water demand and supply in the Zambezi River Basin (ZRB) in the future
   -> Simulations for hydrology, climate, demand

2) Power and conflict in international river basins
   -> Power distribution in the Zambezi River Basin (ZRB)
   -> Game Theoretic Models

Zambezi River Basin (ZRB) Overview



Water Demand and Supply in the ZRB

Eight riparian countries (Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe)

Water abundant basin across all countries. Currently approx 15 % of water used.

High projected growth in agriculture leading to externalities in other countries.

Construction of 30 new dams mainly as RoR power plants.

Environmental change

⇒ Analysis and results are established by means of a coupled dynamic water demand – supply simulation model.

Country Level Scenarios Overview

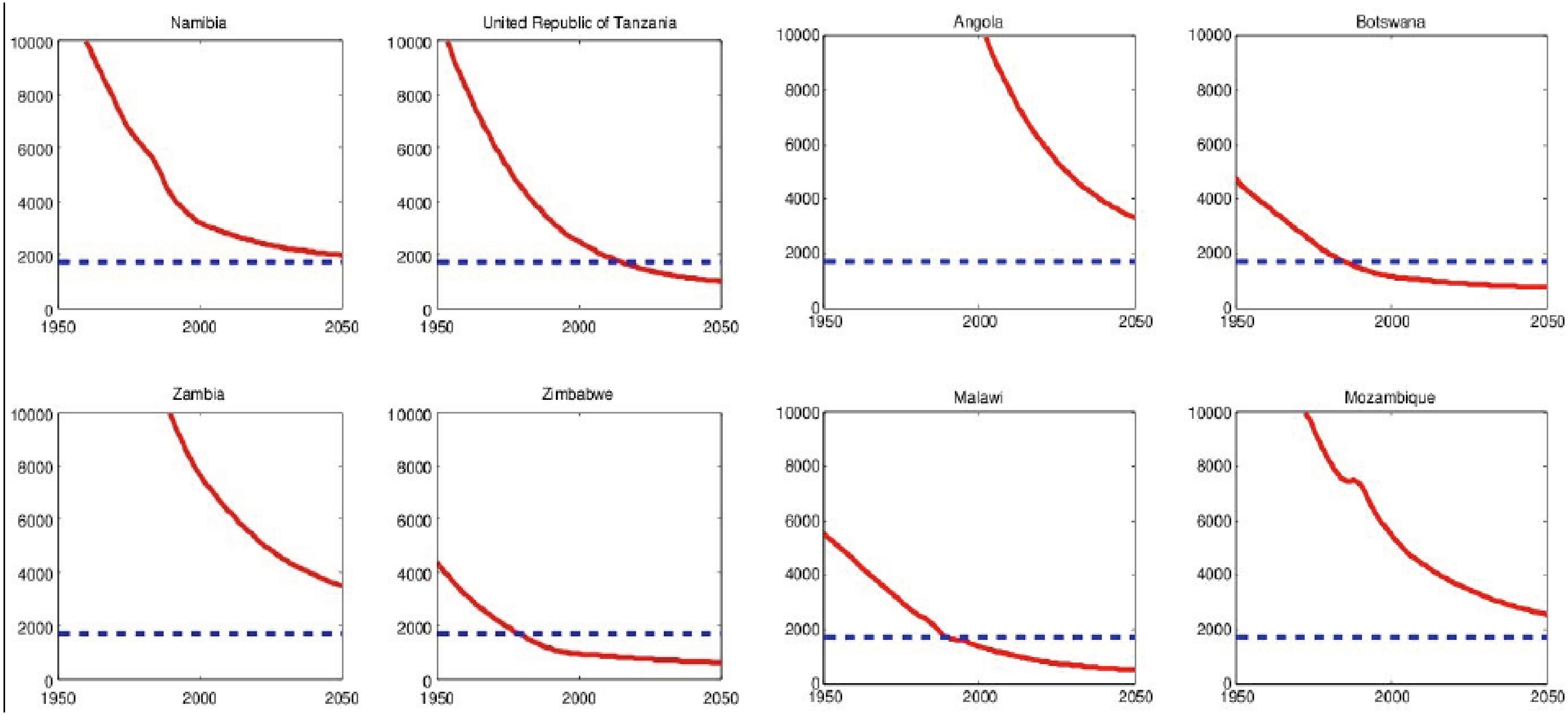


Figure: Per capita water availability [m³/year] in the eight ZRB countries (not only ZRB).

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The blue line marks a threshold of 1700 m3/year, which is commonly regarded as a threshold for water scarcity.

Simulation Model Assumptions

Hydrological (rainfall-runoff) model of the ZRB, calibrated on the best available runoff data => water supply by nature

Changes in water demand until 2050

- Agriculture (irrigation)
- New reservoirs/dams (evaporation)
- Household demand
- Industrial demand

Climate scenarios (IPCC 2007) -> worst case

Implications studied at different scales and locations

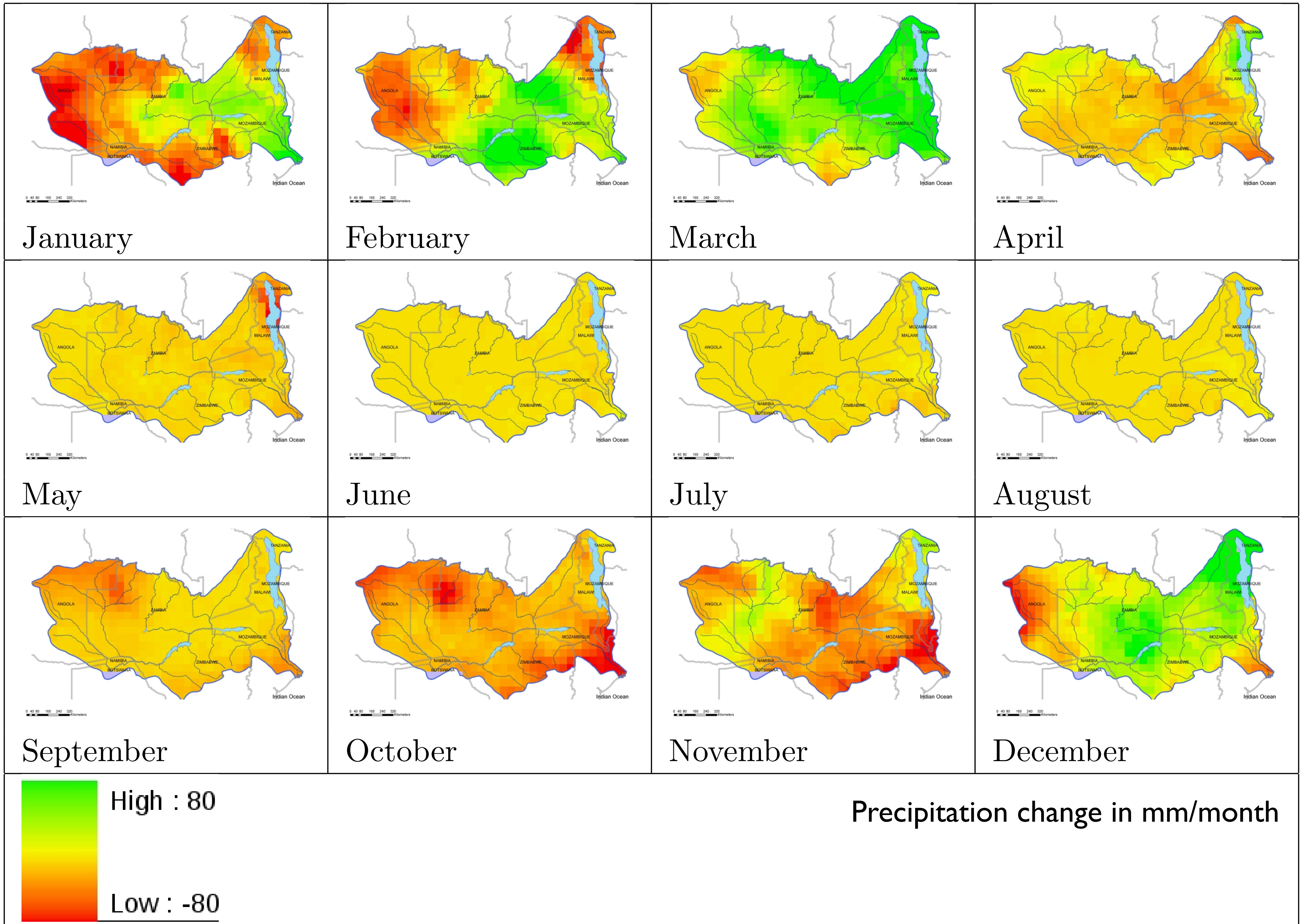
- Subbasin
- Specific locations
- Country level

Results tell us how sensitive the ZRB is, at specific locations, to particular changes in climate and water demand

Scenarios

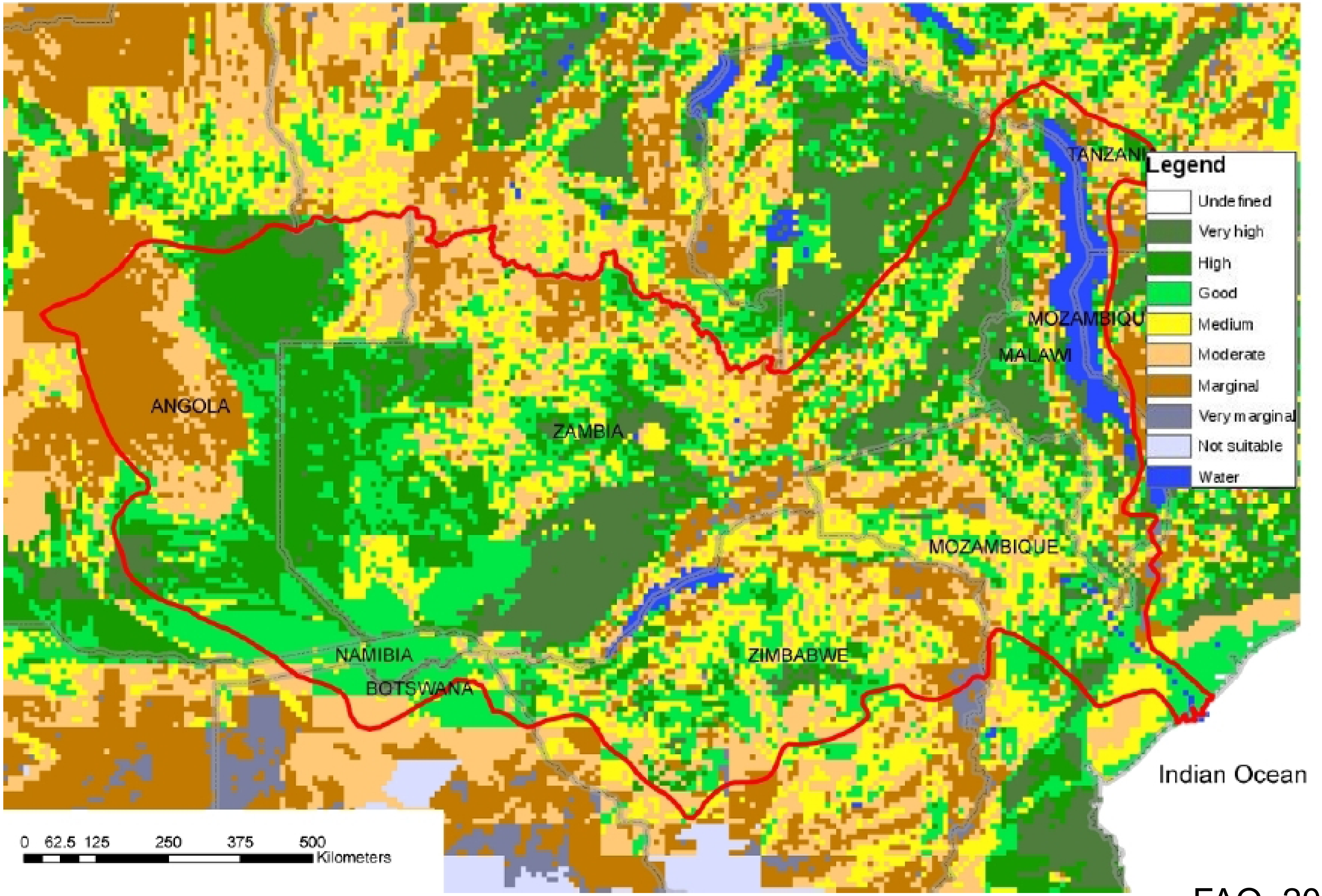
- Scenario (1): Status quo
  - Minor population growth and urbanization
  - No expansion of irrigated agriculture
  - No new hydro-power dams
  - No water transfer projects
  - No climate change
- Scenario (2): Moderate
  - Moderate population growth and urbanization
  - 3% of arable land irrigated
  - Some new dams built
  - Some minor water transfer projects implemented
  - Moderate changes in climate
- Scenario (3): Strong
  - High population growth and urbanization
  - 8% of arable land irrigated
  - All hydro-power dams implemented
  - All water transfer projects implemented
  - Strong change in climate

Precipitation Change until 2050



IPCC, 2007

Scenarios - Agriculture



FAO, 2005

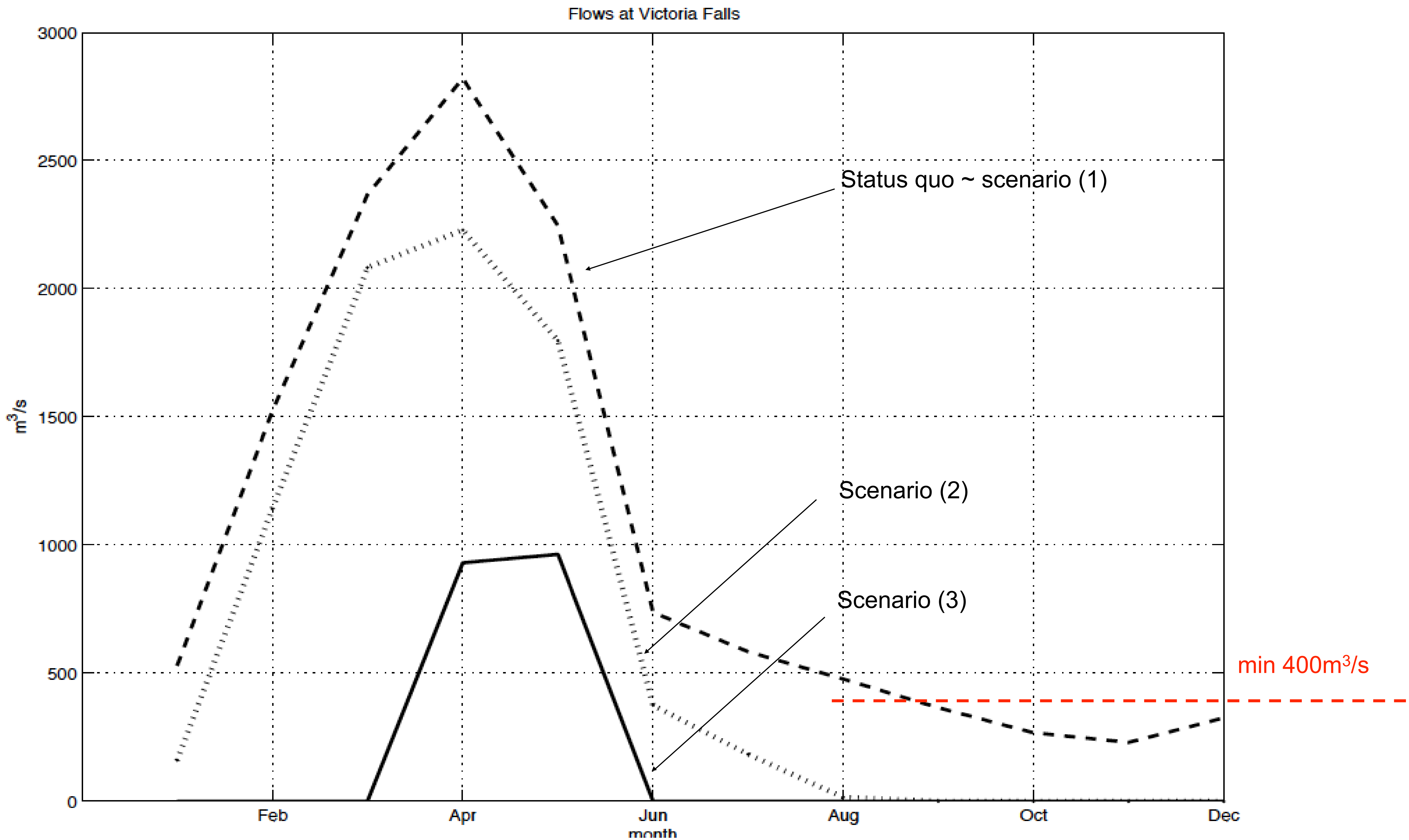
Model Results I - Subbasins

Sub–basin	Year 2000	scenario (1)	scenario (2)	scenario (3)
1. Delta	2126	1964	1542	462
2. Tete	1457	1397	1069	105
3. Shire	279	181	110	0
4. Mupata	996	873	514	0
5. Luangwa	87	82	0	0
6. Kariba	748	687	405	0
7. Kafue	159	131	61	30
8. Cuando Chobe	26	24	0	0
9. Barotse	204	198	0	0
10. Luanginga	15	14	0	0
11. Lungue Bungo	124	123	84	28
12. Upper	34	33	0	0
13. Kabompo	3	2	0	0

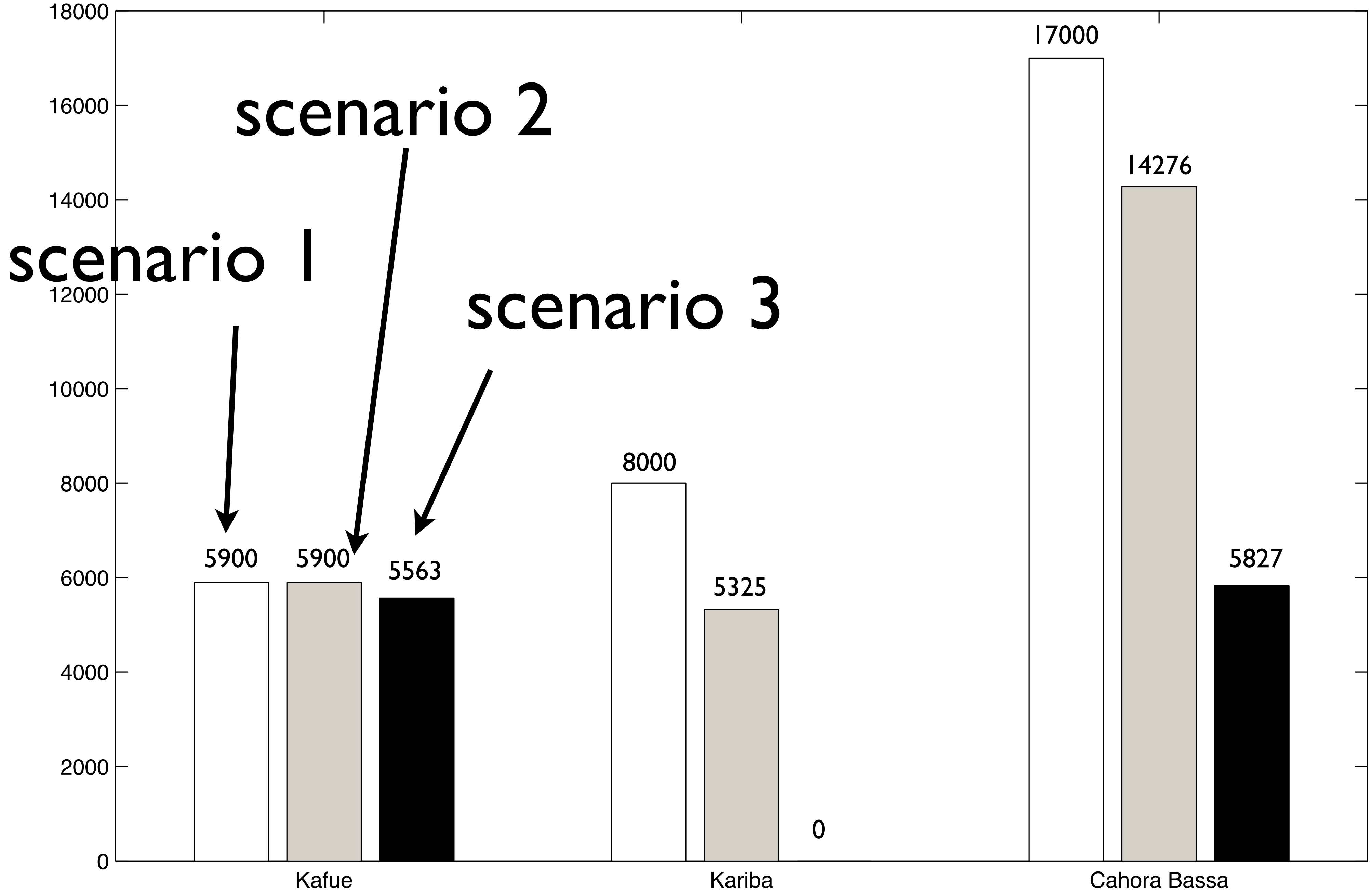
Mean minimum flows [m^3/s] in the dry season, projected for 2050 (October).

Source: Beck, Bernauer 2011

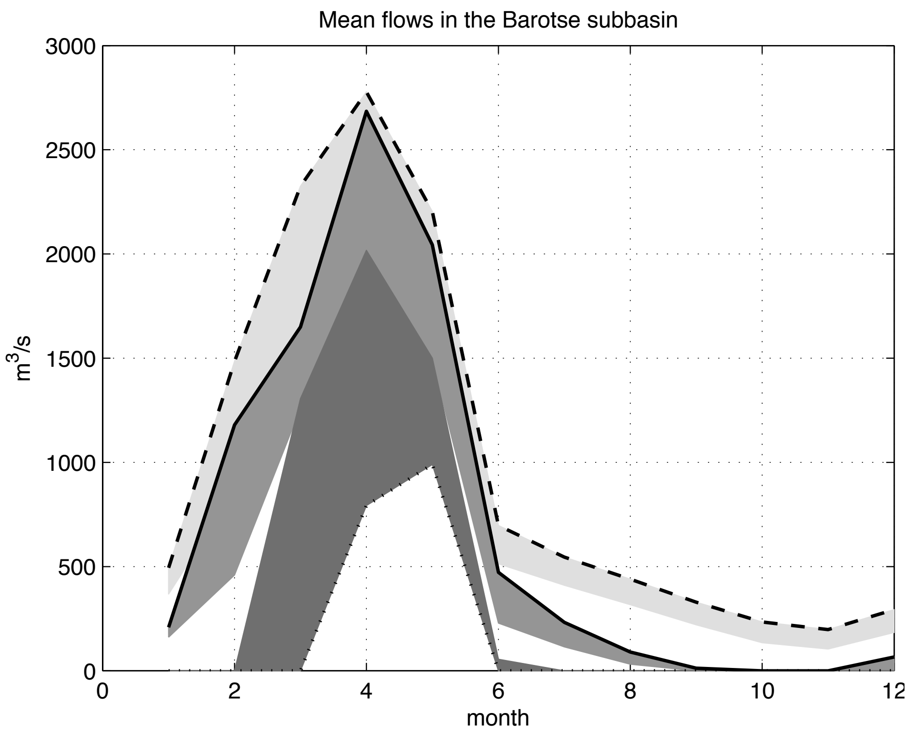
Water Availability at Victoria Falls in 2050

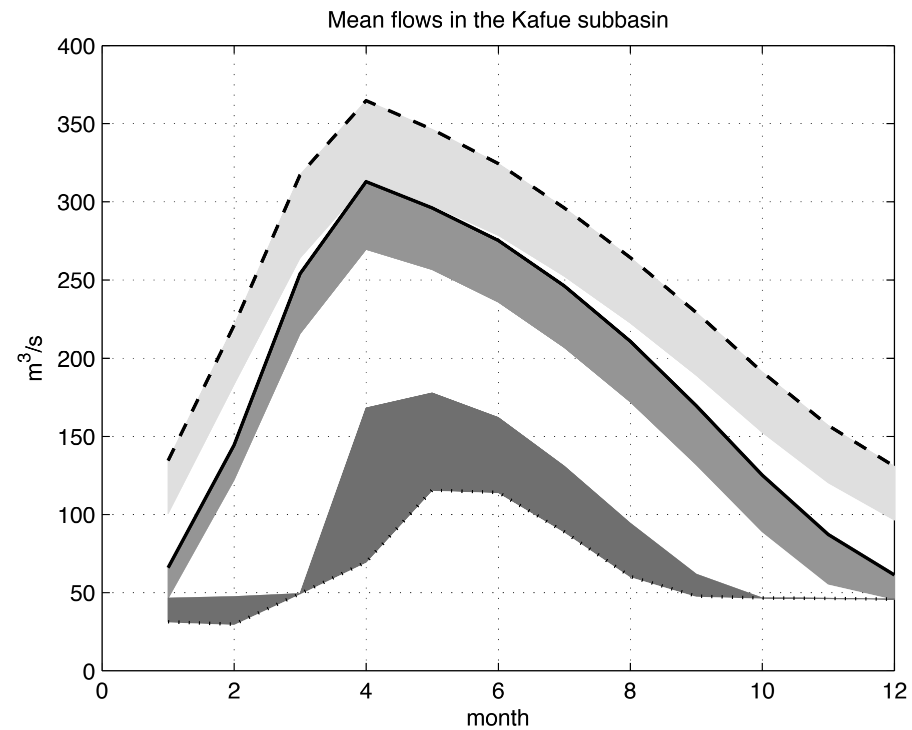


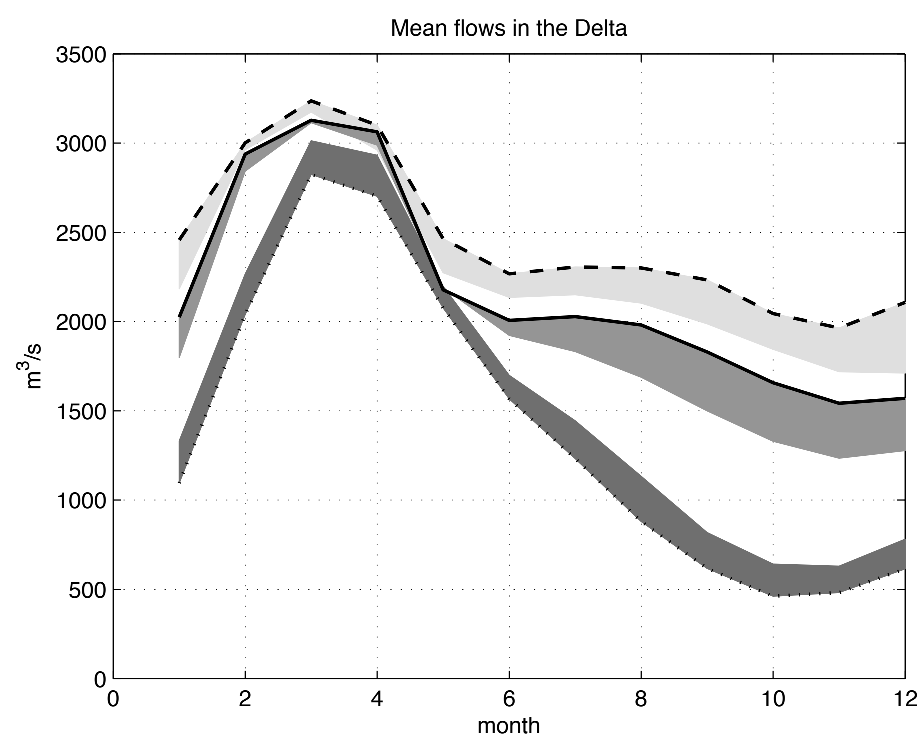
Impact on Hydro Power Production



Impact of Climate Change



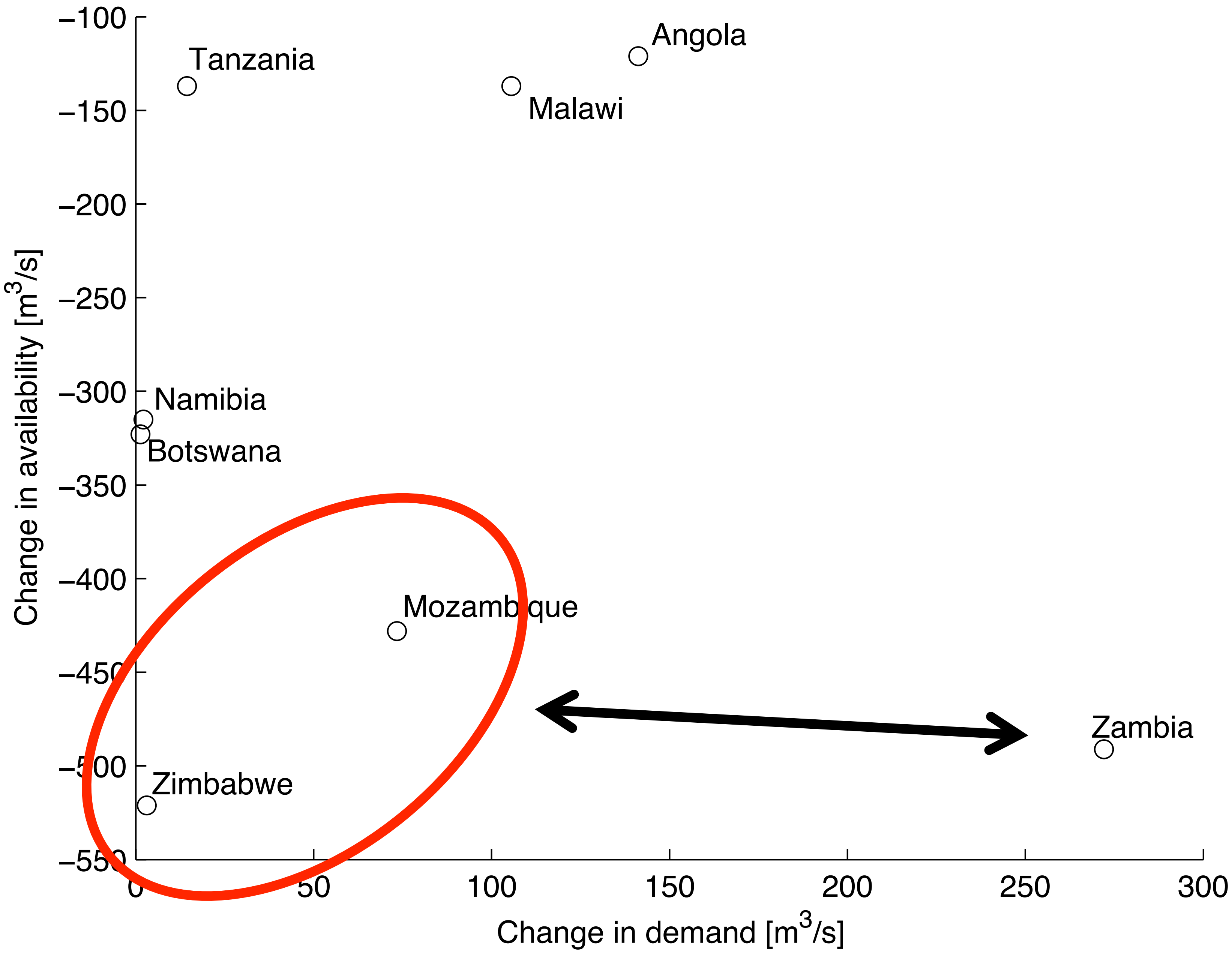




Anthropogenic impact: biggest expected change.

Climate: less impact than might be expected.

Externalities in water use could trigger conflict - Comparison of water availability 2000-2050.



So what?

- Even in a “middle-of-the-road” scenario (2) severe water shortages at least in some parts of the ZRB are likely.
- Our scenarios are for “average years”, water shortages in low-precipitation years could be much worse.
- Strong changes in *relative* water demand and availability of ZRB countries could become a source of international conflict.
- In absence of effective international cooperation on water allocation issues, very important transboundary impacts are very likely in future
- Allocation rules should be set up within the next few years before serious international conflicts over sharing the Zambezi waters arise.
- Climate impact much less important than demand scenarios