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Federal Ministry Republic of Austria Sustainability and Tourism

Directorate of Water Resources Management Ministry of Water and Environment Uganda

EAST AFRICAN COMMUNITY LAKE VICTORIA BASIN COMMISSION

One people, One Destiny

# East Africa Scenario RESULTS

*Peter Burek, Robert Burtscher, Taher Kahil, Sylvia Tramberend*

water futures and solutions

Towards Innovative Solutions through Integrative Water Futures Analysis

WFaS Workshop, Entebbe, 4-6 Dec 2018

# *What can models tell us?*

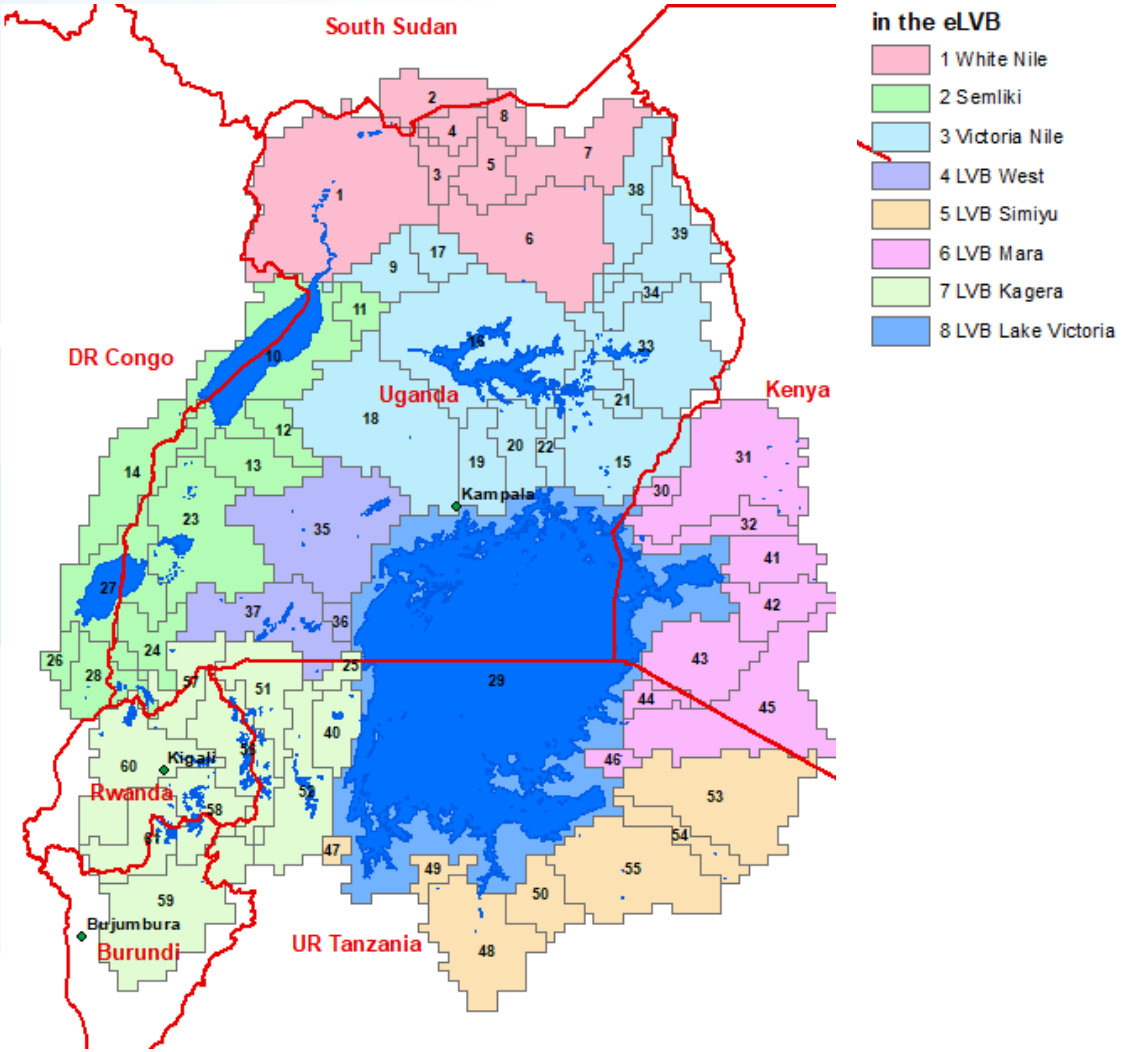
- The extended Lake Victoria Basin

- Biophysical drivers of hydrology
- Human water demand
- Socio-ecological water system characteristics
- Costs

# The extended Lake Victoria Basin (eLVB)

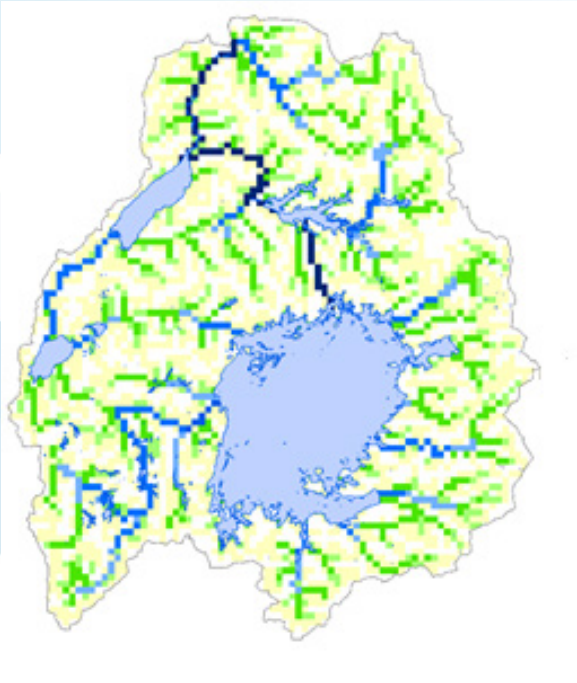
# The extended Lake Victoria Basin (eLVB)

The 61 sub-basins of the eLVB and their aggregation to 8 major basin regions

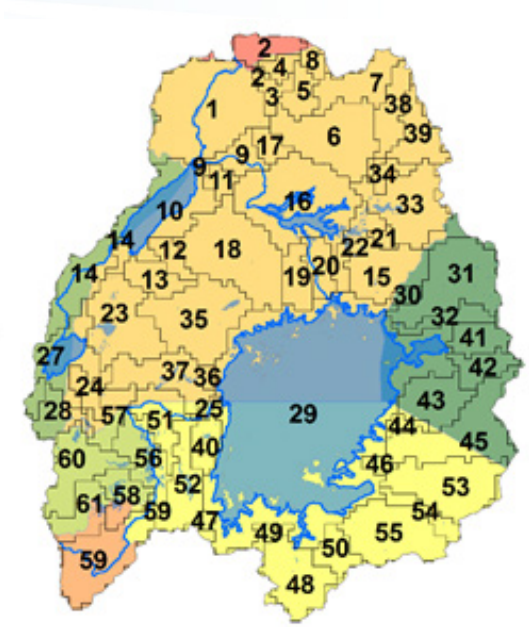


# The extended Lake Victoria Basin (eLVB)

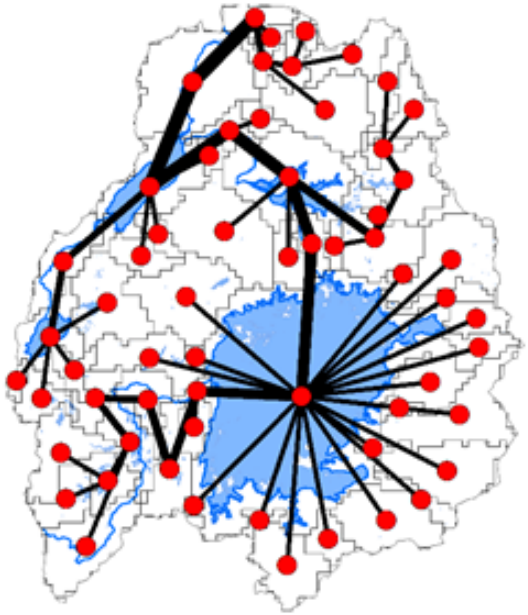
River network



61 sub-basins

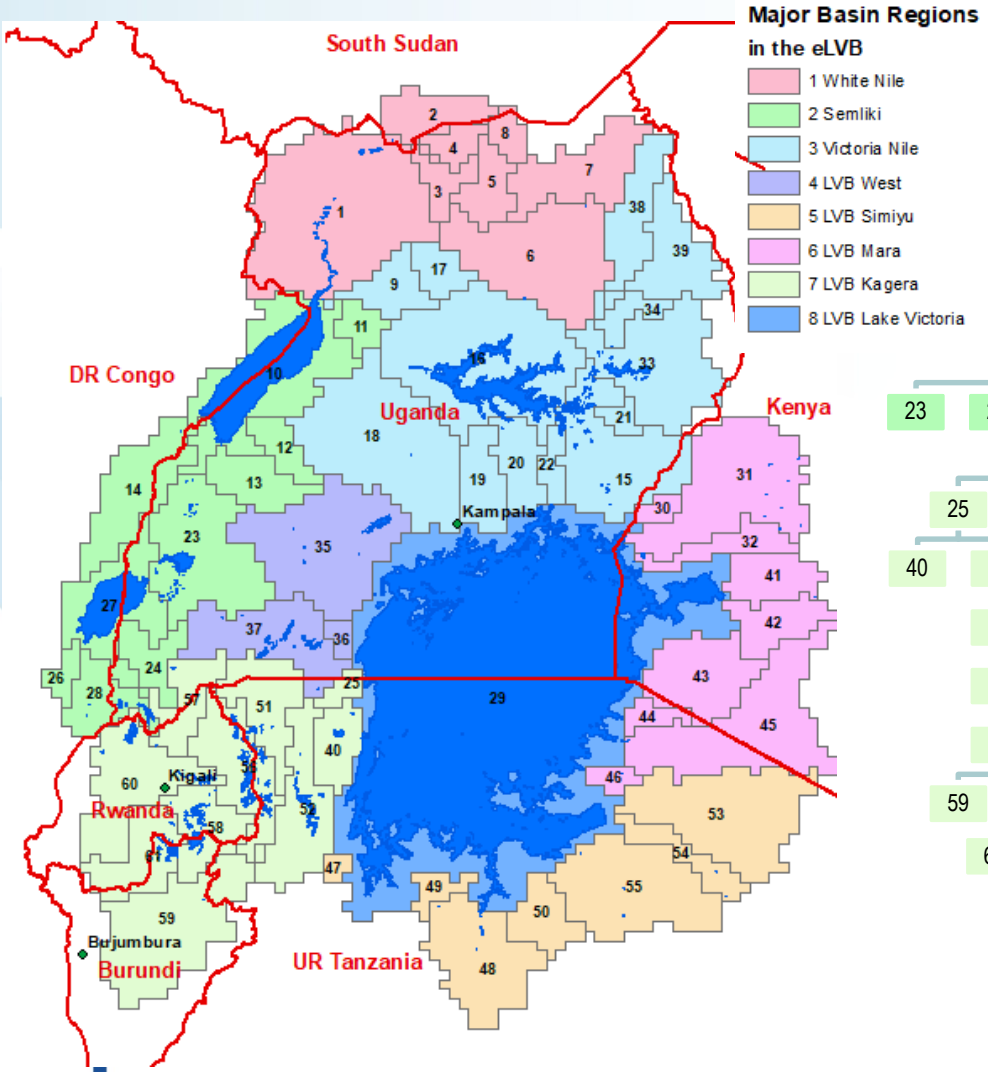


Sub-basin connection

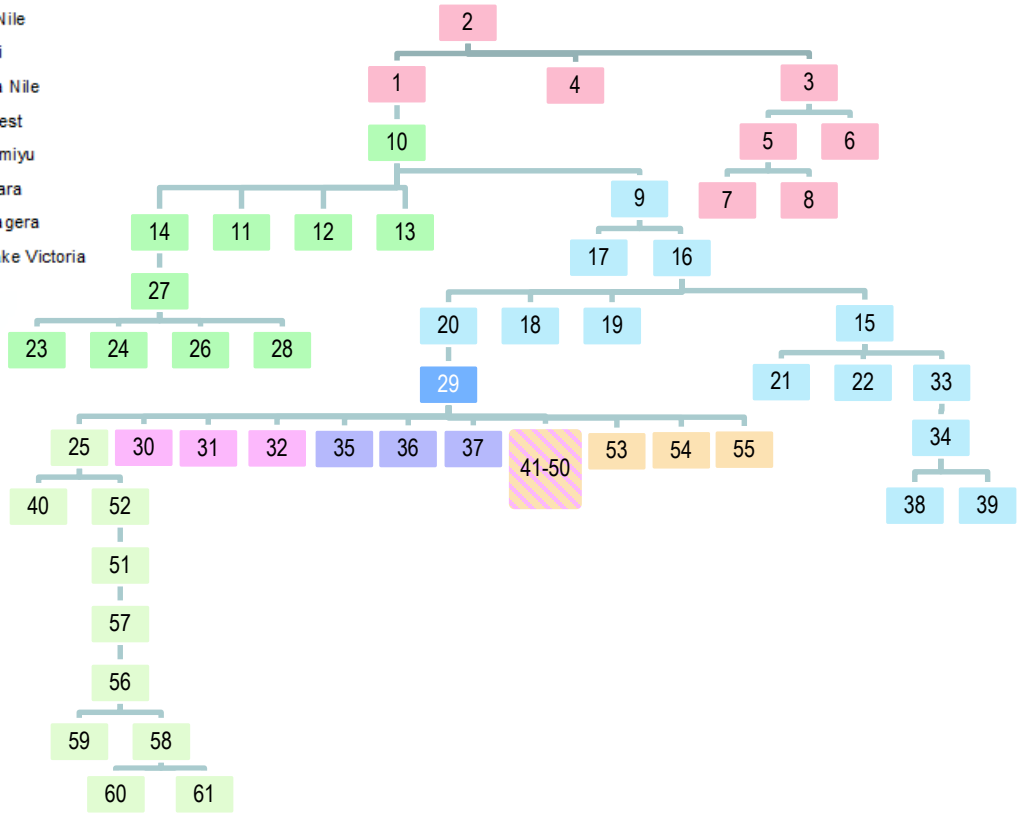


# The extended Lake Victoria Basin (eLVB)

The 61 sub-basins of the eLVB and their aggregation to 8 major basin regions

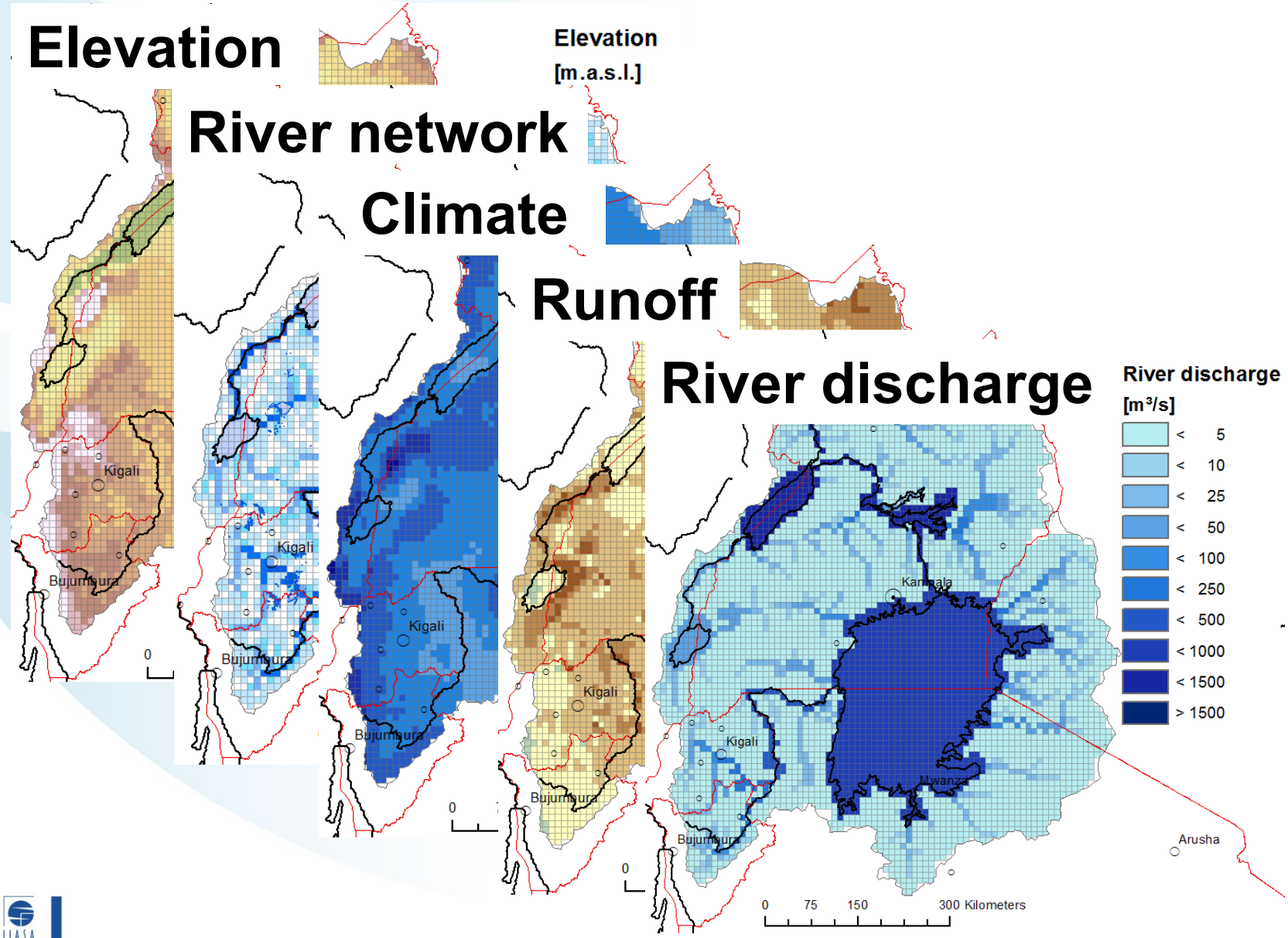



Schematic sub-basin connection map



# BIOPHYSICAL DRIVERS OF HYDROLOGY

# Biophysical drivers of hydrology

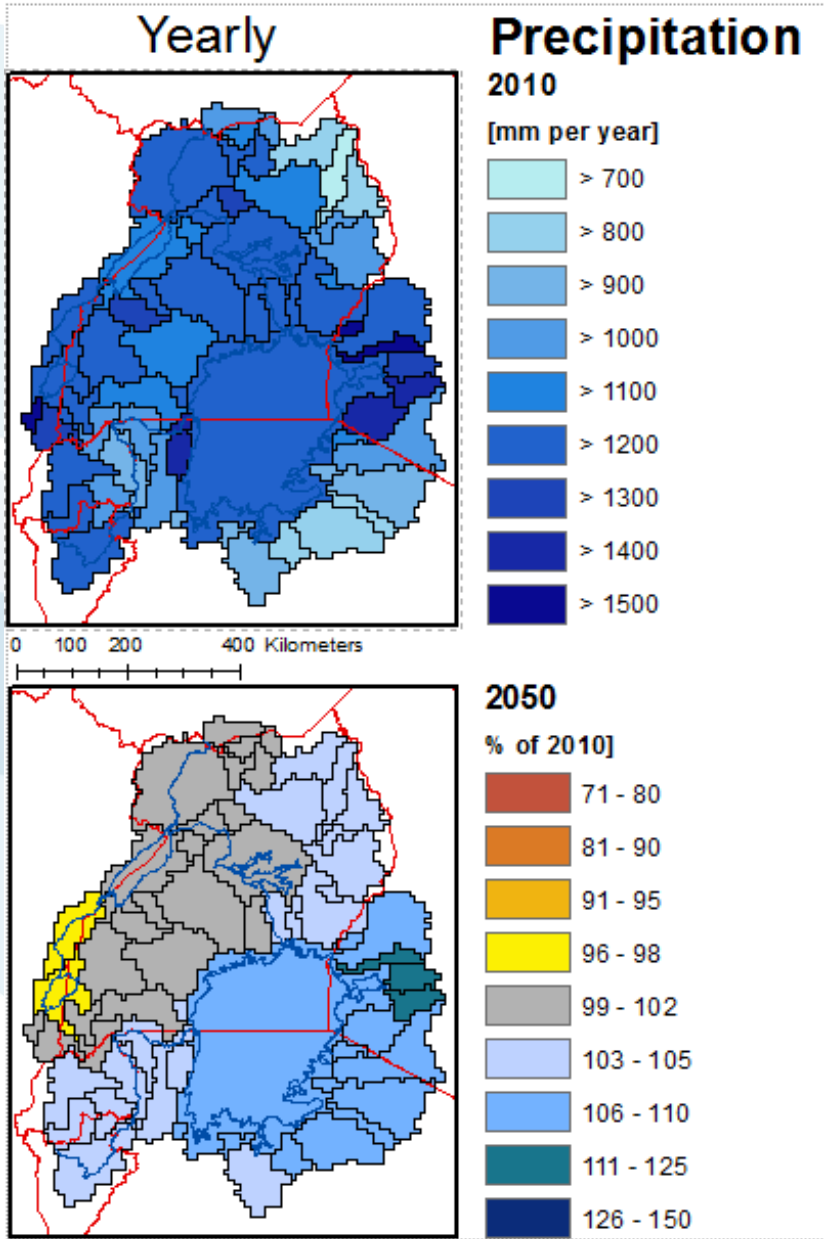


# Climate change

**1st Story (of 2)**

Climate Change and rainfall, runoff, river discharge

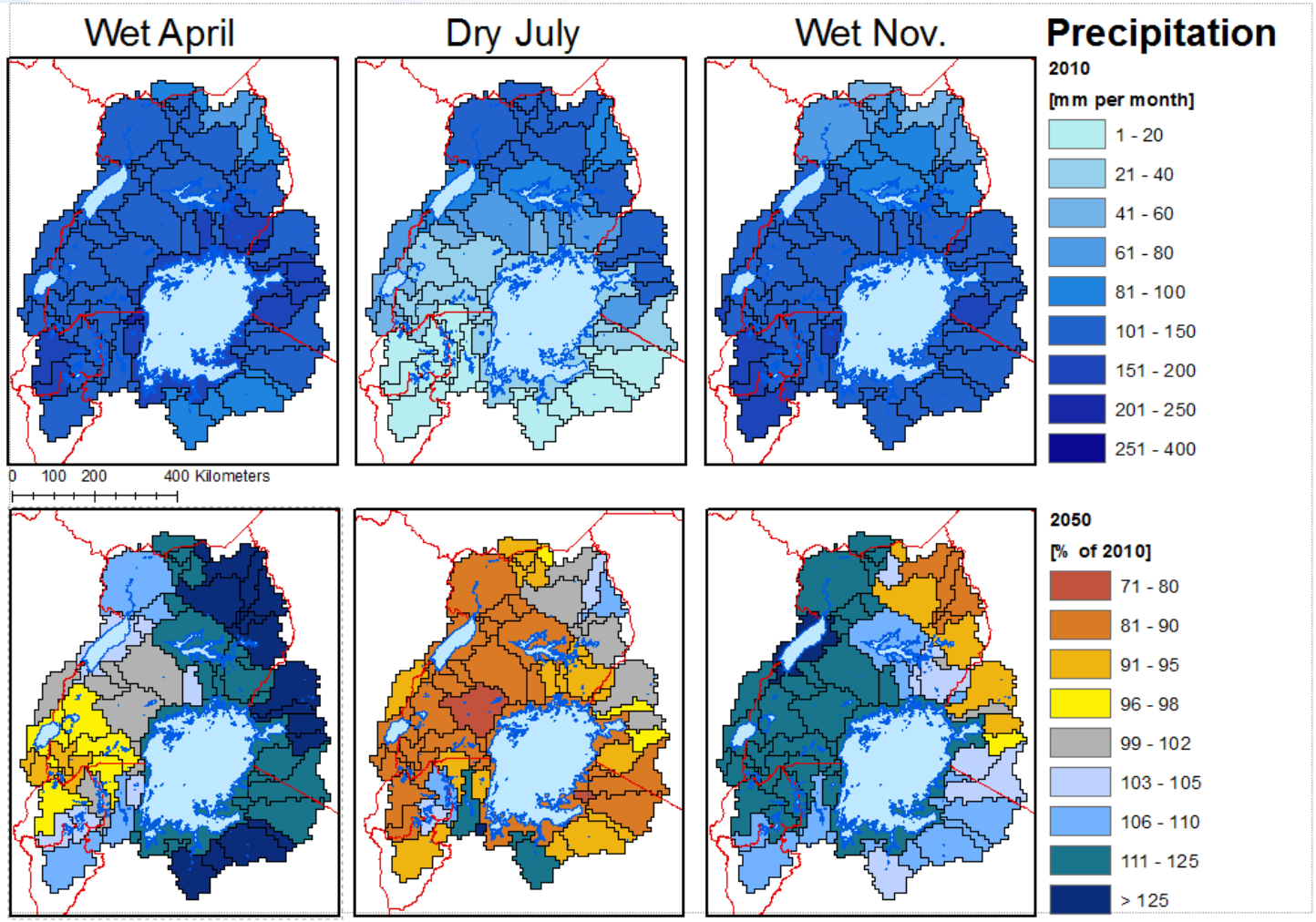
# Precipitation change till 2050




Precipitation change based on:

- RCP 6.0
- Two Global Circulation Models:
    - HadGEM2-ES
    - MIROC5
- Hydro model: CWatM
- Periods of 10 years
    - 2006-2015 -> 2010
    - 2046-2055 -> 2050

# Precipitation change till 2050

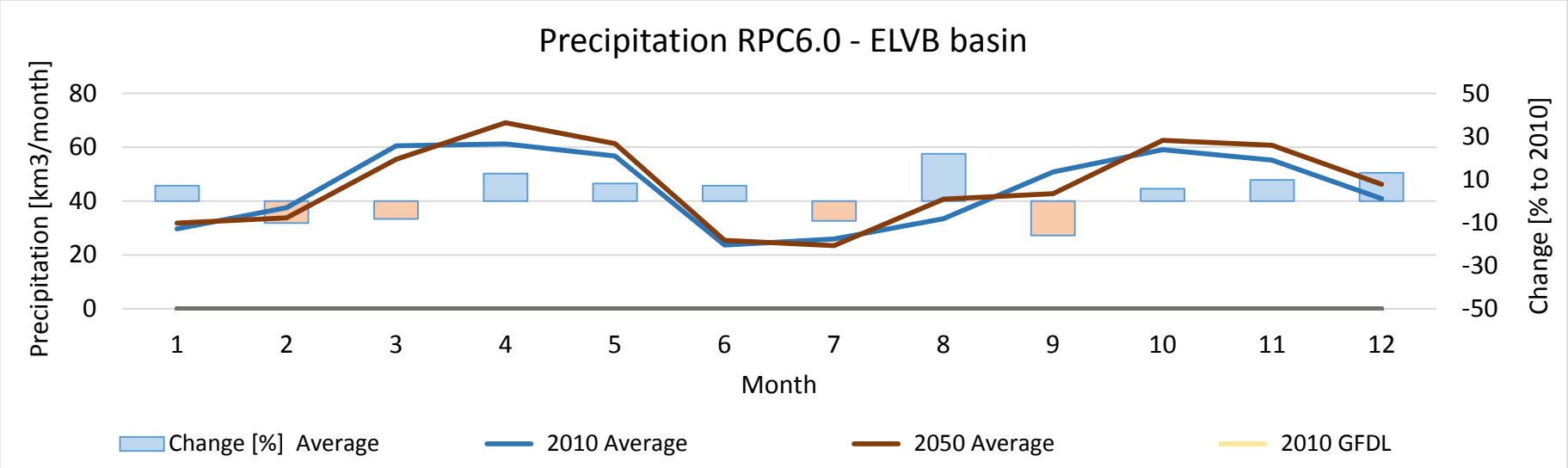



In general (but regionally different):

- Wetter rainy seasons
- Dryer dry season

# Precipitation change

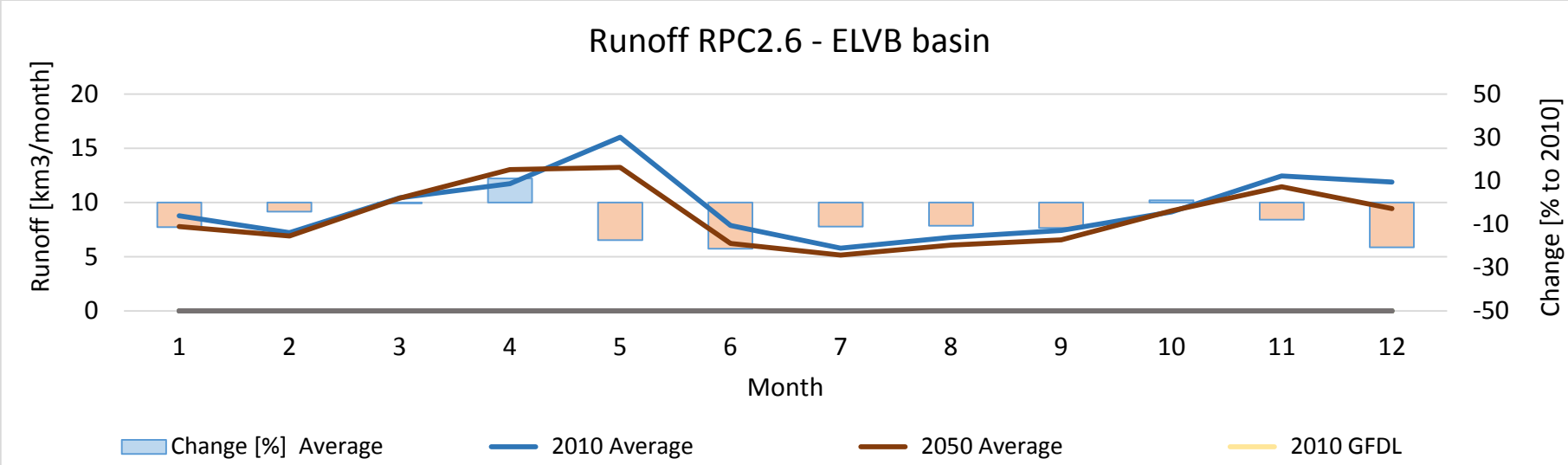
Total eLVB at Laropi (Northern Uganda):

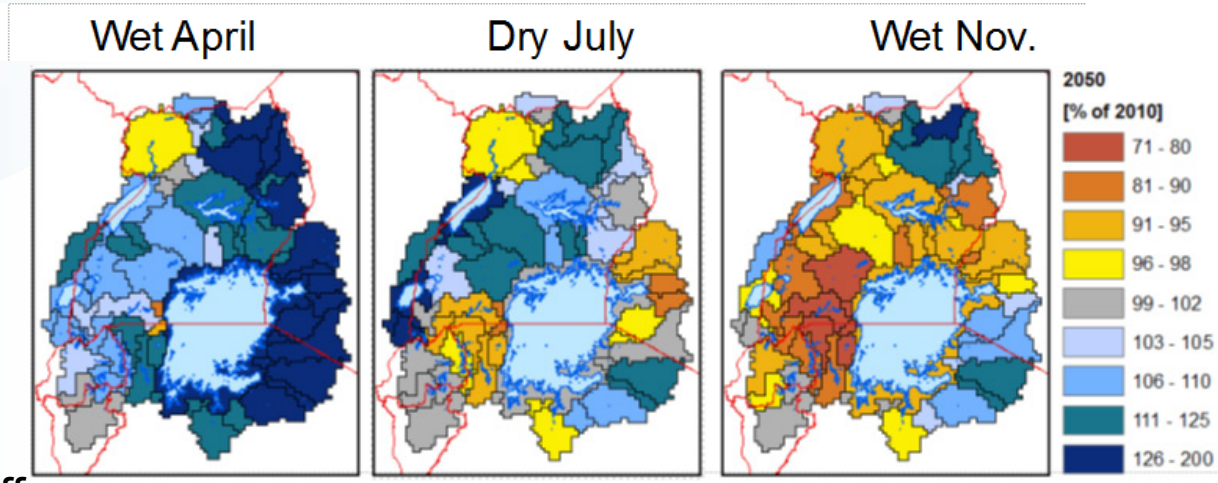



In general (but regionally different):

- Wetter rainy seasons
- Dryer dry season
- Shift of the rainy seasons

# Runoff change

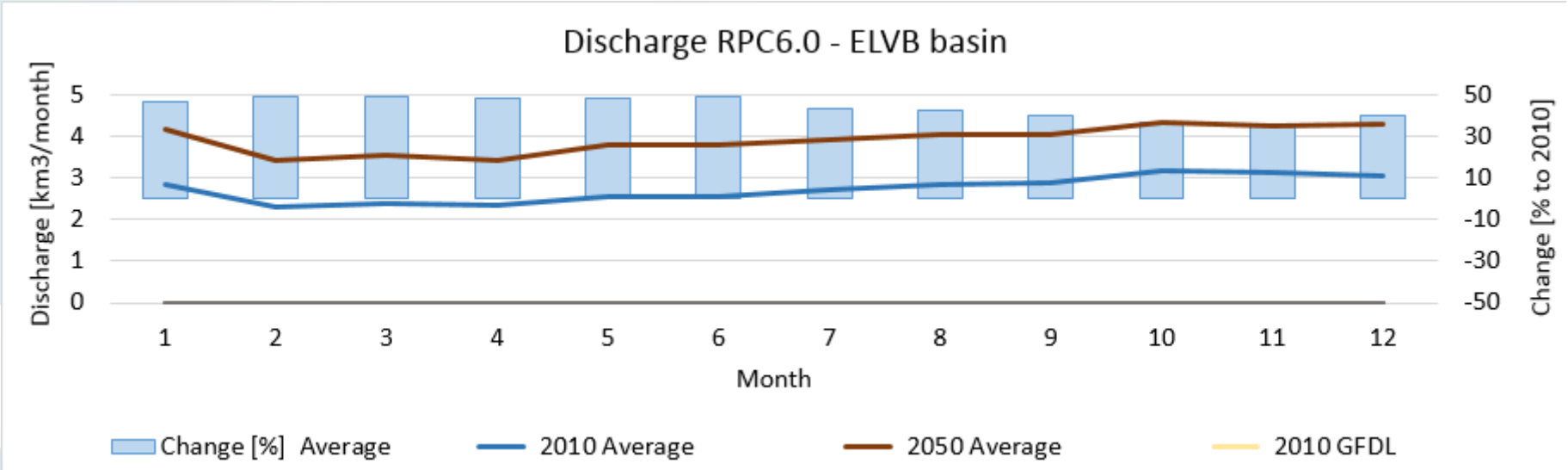


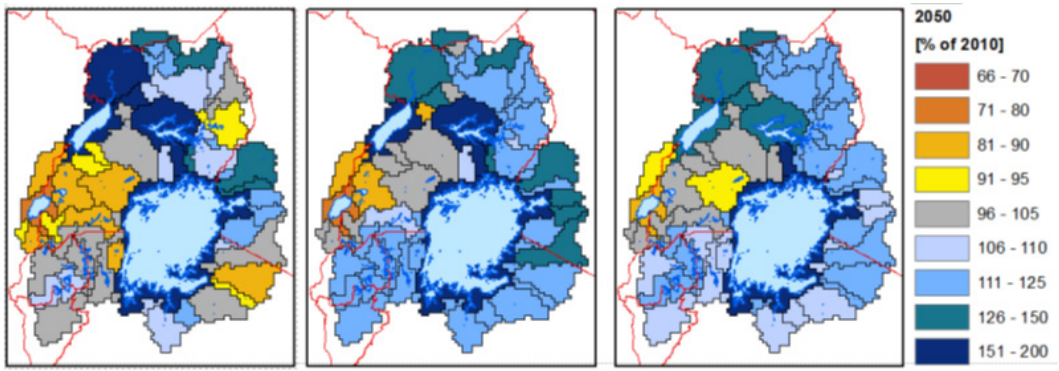




In general (but regionally different):

- Slightly more runoff in April

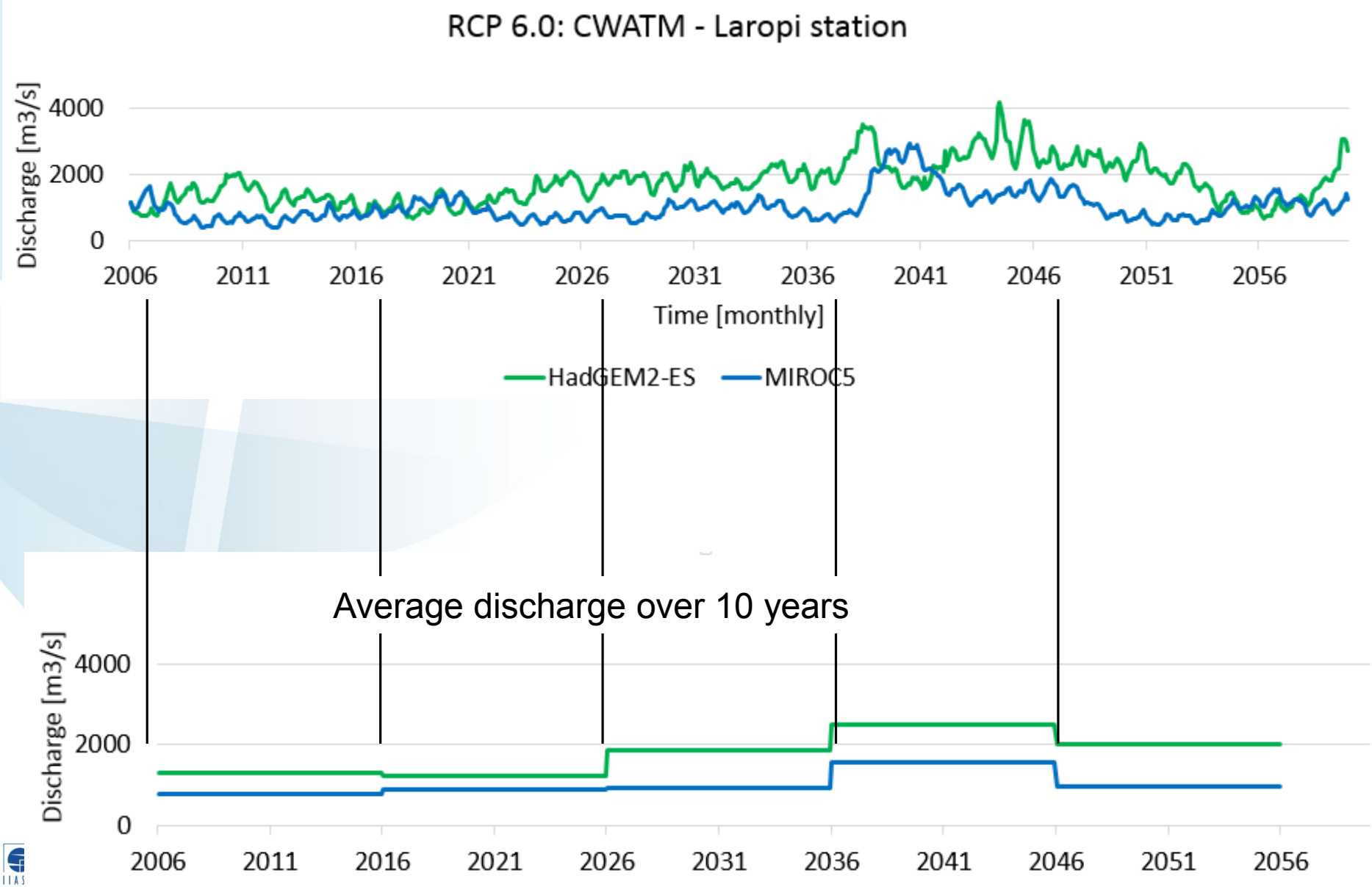
# Discharge change




Much higher in 2050 than in 2010! Why?

# Discharge change



# Climate change

## 1st Story (of 2)

Climate Change and rainfall, runoff, river discharge

- Important to look at monthly time scale
- Wetter rainy seasons
- Dryer dry season
- Shift of the rainy seasons
- Higher rainfall can nevertheless lead to lower runoff (due higher evapotranspiration)
- Less runoff but higher river discharge (storage of water in the lakes)
- High inter- and intra-annual variability

# Land use – water use change

**2nd Story (of 2)**

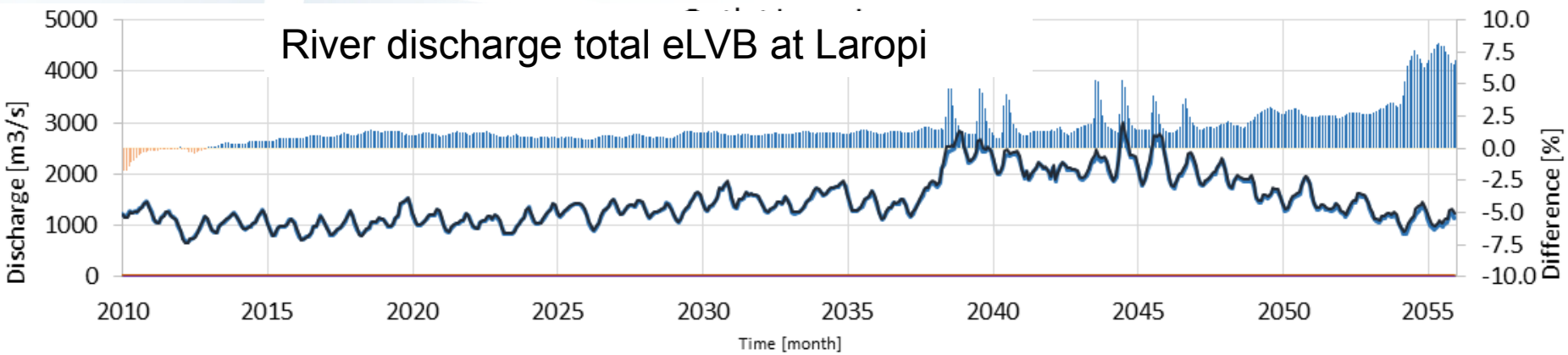
Land use and water use change
and river discharge

# Discharge – land use & climate change

Climate change: RCP 6.0 – average of two GCM – dynamic
Land use: kept constant at year 2010
Water use: non

Vs. scenario 2

Land use: dynamic change from 2010-2050 - EA-RVS scenario




River discharge total eLVB at Laropi

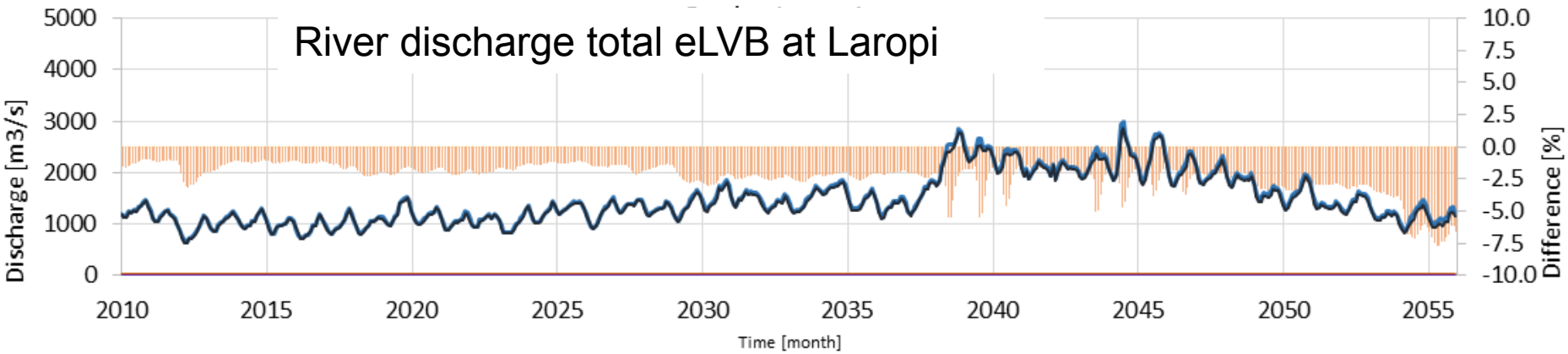
Change in % from scenario 1 to 2

# Discharge – land use & climate change

Climate change: RCP 6.0 – average of two GCM – dynamic
Land use: dynamic change from 2010-2050 - EA-RVS scenario
Water use: non

Vs.

Water use: dynamic change from 2010-2050 - EA-RVS scenario



# Discharge – land use & climate change

Climate change: RCP 6.0 – average of two GCM – dynamic
Land use: kept constant at year 2010
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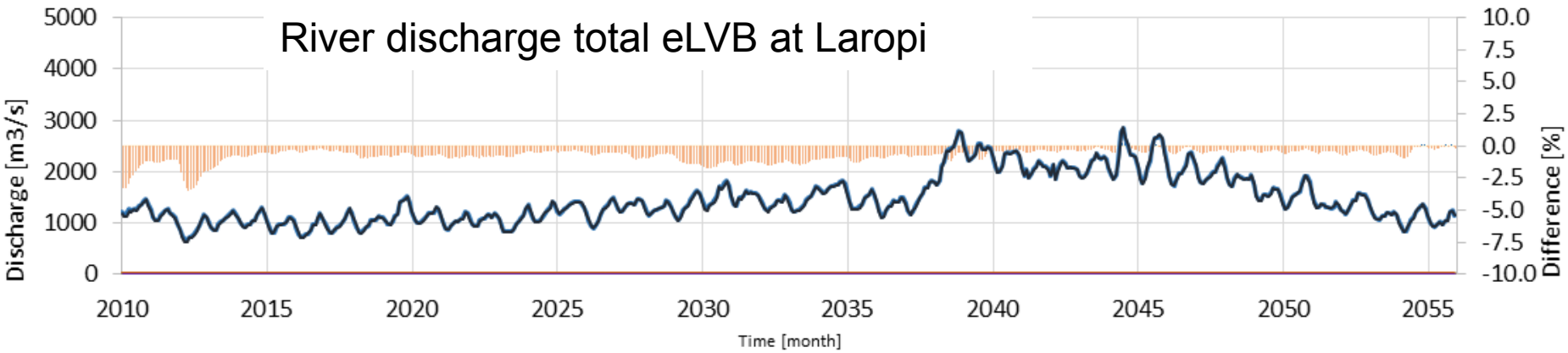
Vs.
Land use: dynamic change from 2010-2050 - EA-RVS scenario
Water use: dynamic change from 2010-2050 - EA-RVS scenario



# Land use – water use change

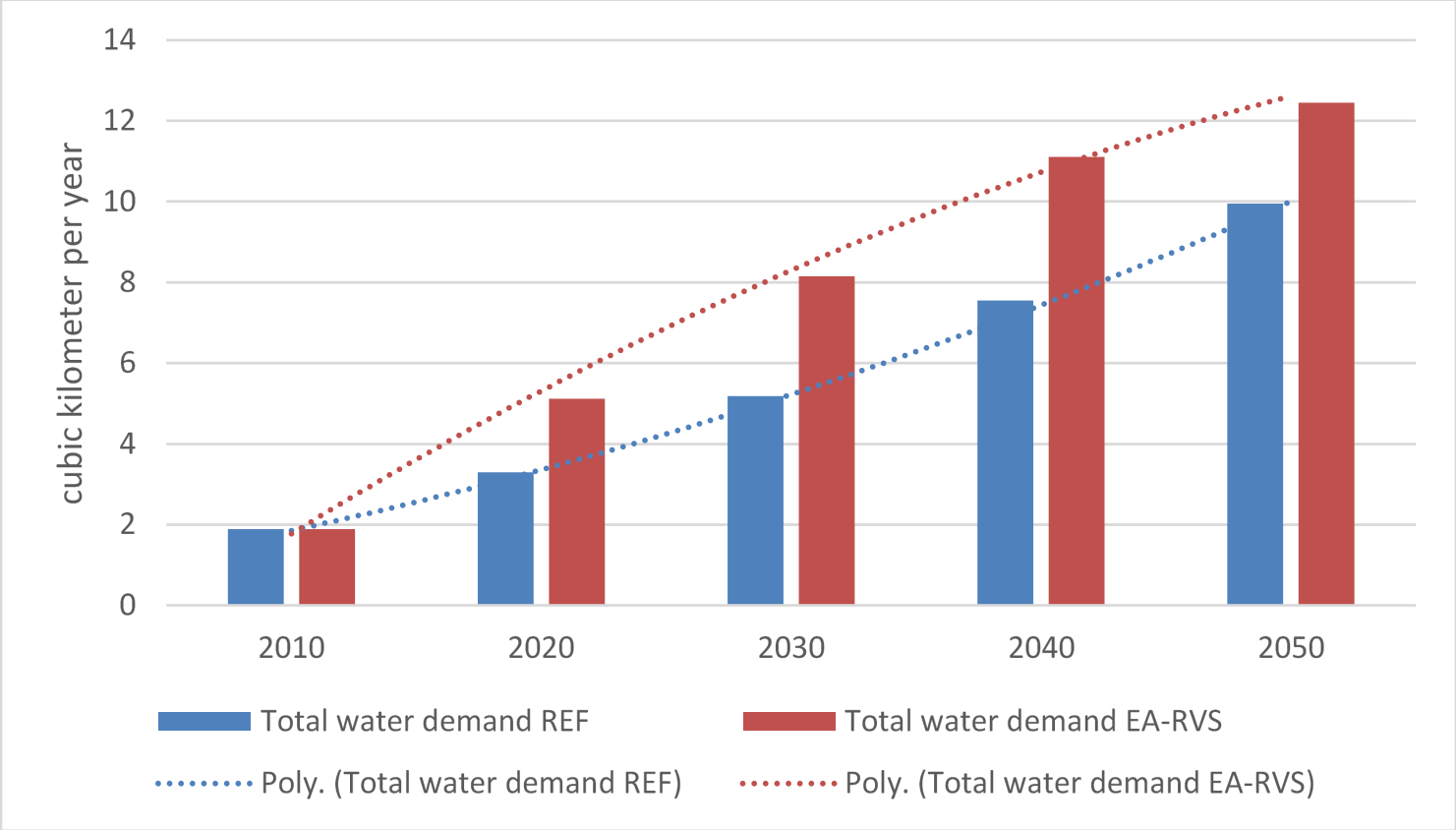
**2nd Story (of 2)**

Land use and water use change
and river discharge

- Change in land use can lead to more discharge
  (due to less forest, more sealed area)
- Change in water use can lead to less discharge
  (more water consumption)
- Looking at land use and water use change at the same time
  Land use change may counter act water use change

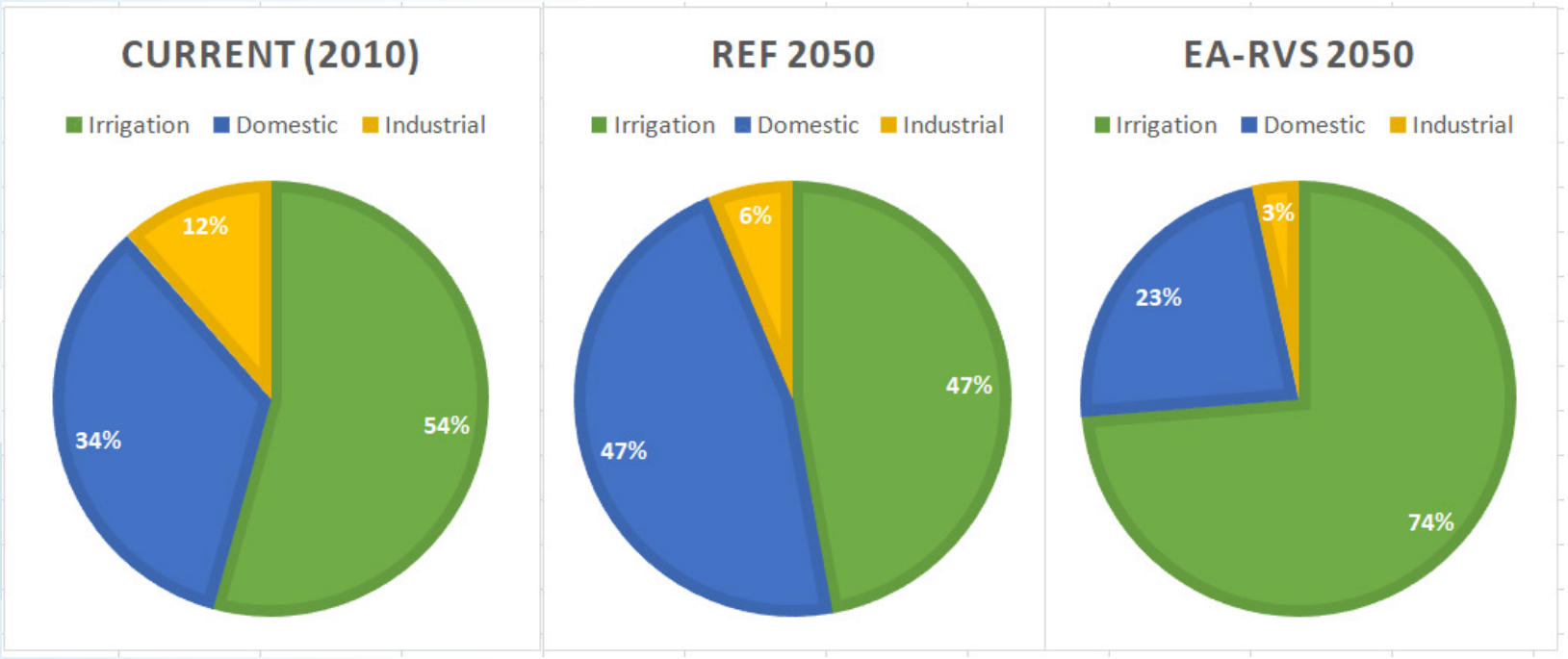
# HUMAN WATER DEMAND

# Human water withdrawal in eLVB 2010 to 2050




*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

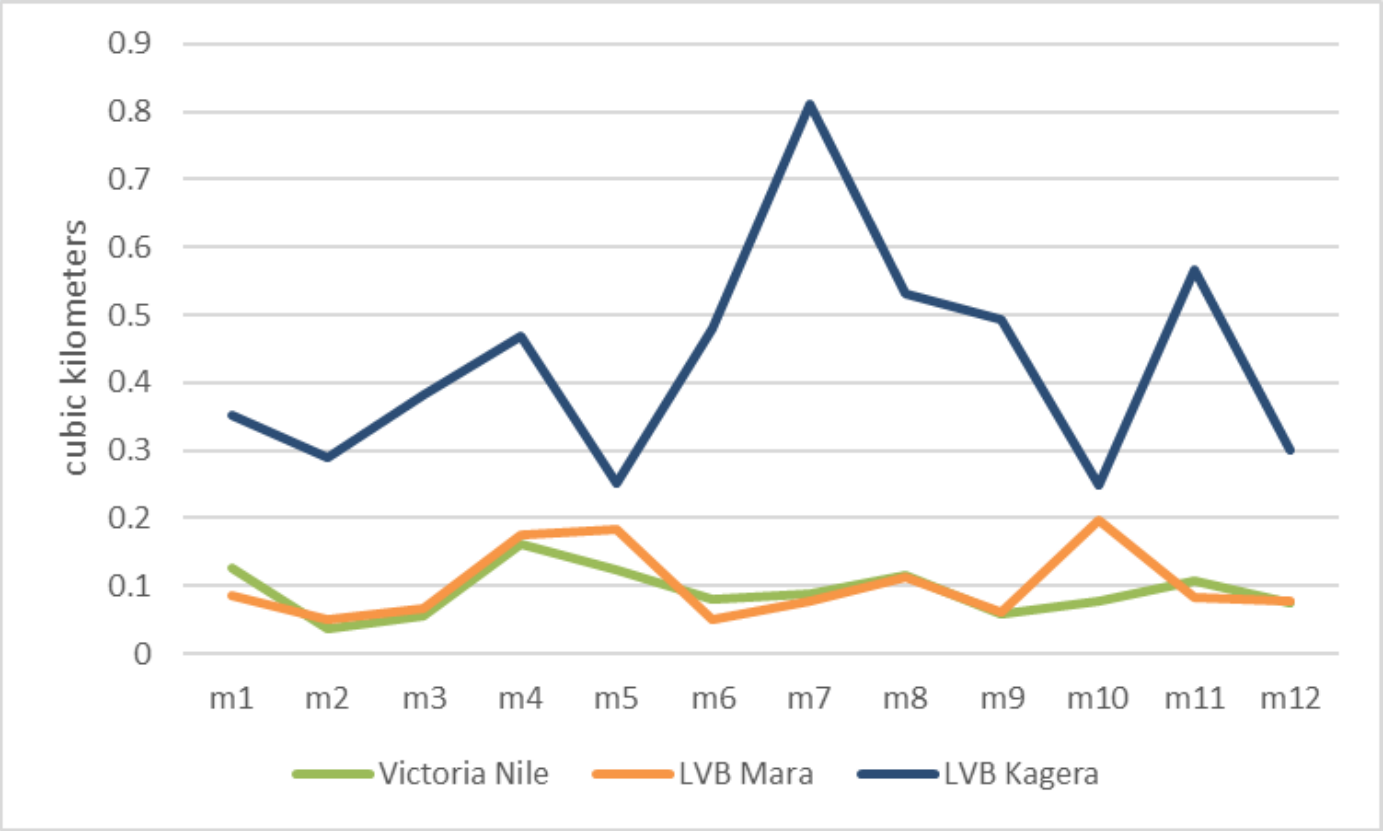
# Distribution of human water withdrawal by sector




*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

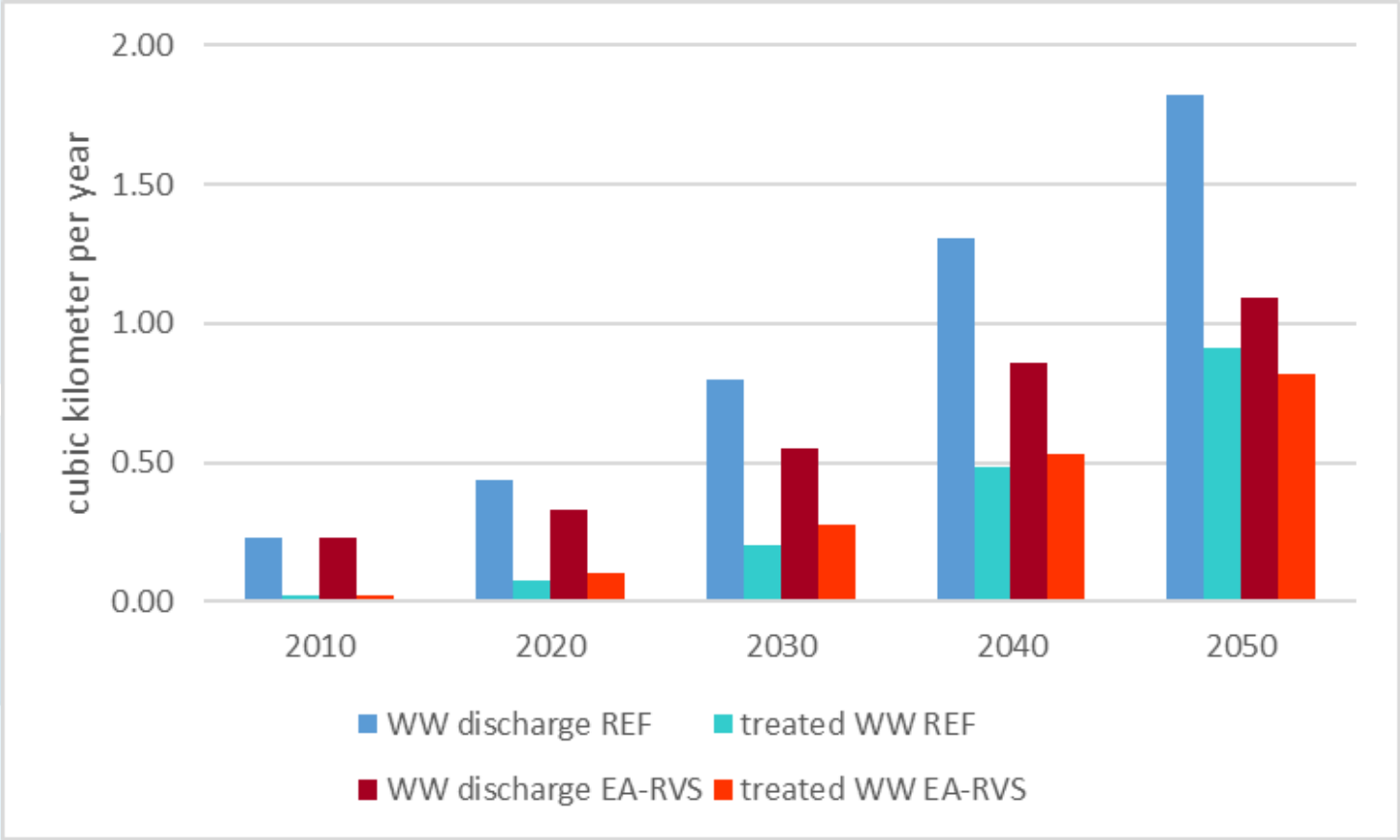
- REF: High water demand for domestic to cover high population growth
- EA-RVS: Higher share for agriculture to cover higher irrigation ambitions
- Industrial water demand remains quite low with declining share

# Monthly irrigation water withdrawal for selected major sub-basins in 2050




*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

# Wastewater: discharge and treated

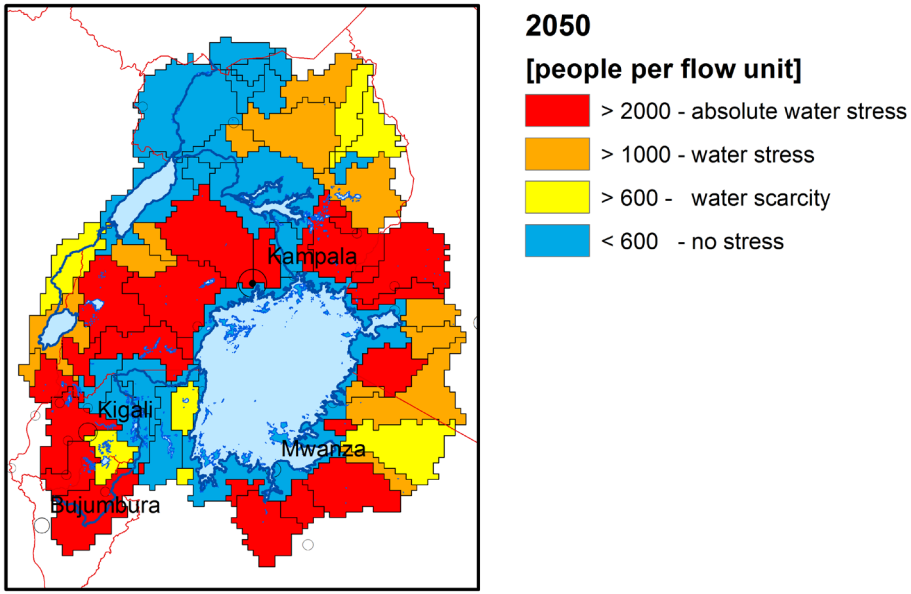



*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

- REF: More wastewater with less treated (only 50% by 2050)
- EA-RVS: Less wastewater with more treated (75% by 2050)

# Water scarcity:
# Water shortage based on WCI index

## Water crowding index (WCI), Falkenmark index

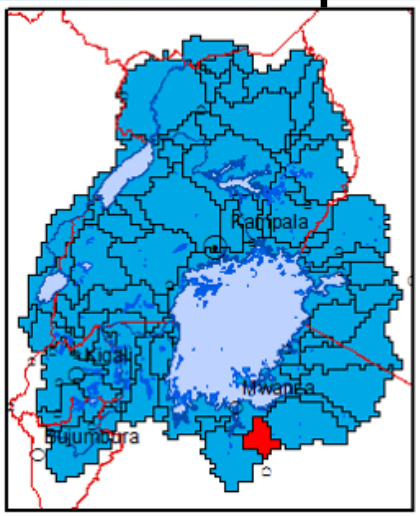



*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

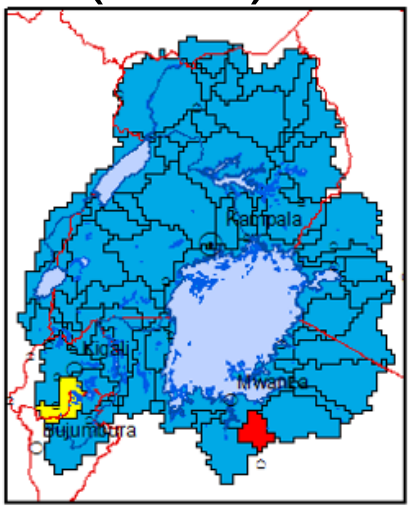
| Category | m³ per capita per year | People per 1 million m³ |
|---|---|---|
| no stress | > 1700 | > ~ 600 (588) |
| Stress | > 1000-1700 | > 1000 - ~600 (588) |
| Scarcity | > 500 - 1000 | > 2000 - 1000 |
| absolute scarcity | <= 500 | <= 2000 |

# Water scarcity: Water stress based on WEI index

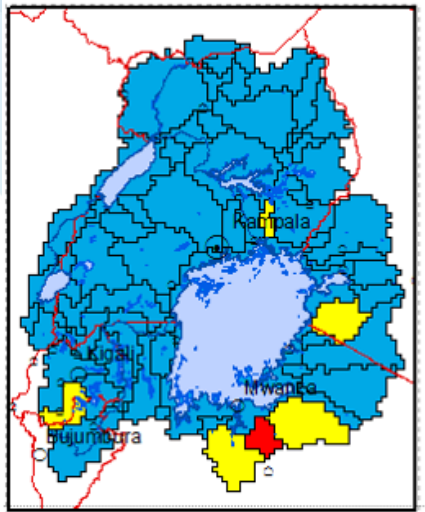
## Water exploitation index (WEI)



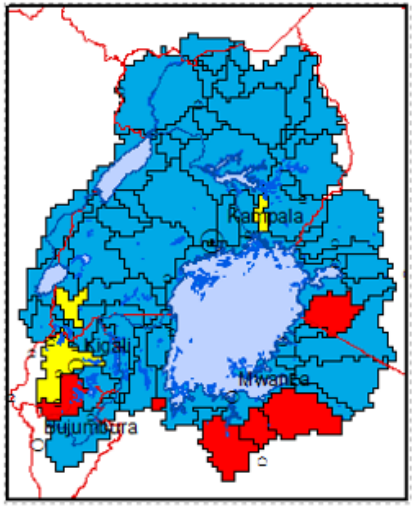

**2010**
**[% demand / availability]**
< 20
> 20
> 40




**July 2010**
**[% demand / availability]**
< 20
> 20
> 40




**2050**
**[% demand / availability]**
< 20
> 20
> 40




**July 2050**
**[% demand / availability]**
< 20
> 20
> 40

# Water scarcity indicators in comparison

## Water crowding Index (Falkenmark)

- Based on globally unified “water demand entitlements” ($m^3$/person/year)
- High water scarcity signal for the eLVB basin as a whole and for many sub-basins

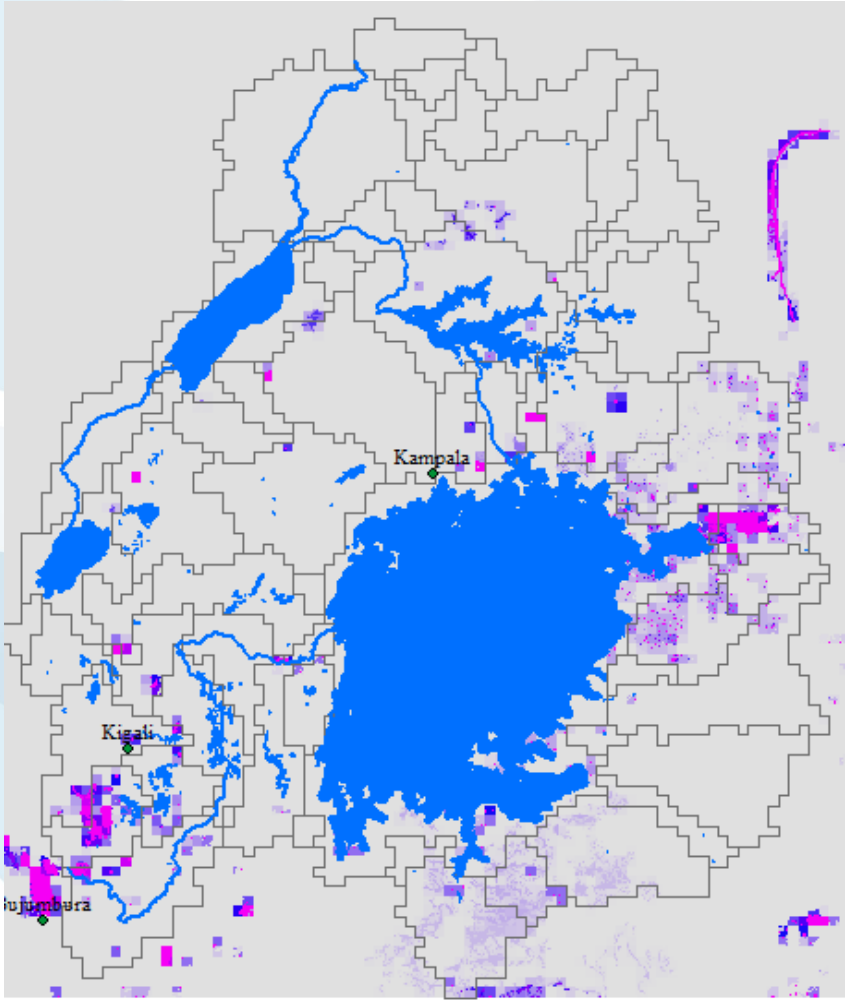
## Water Exploitation Index

- In situ situation of potential water demand / water availability
- Rather low signal of water scarcity for eLVB and some sub-basins with sever scarcity

Expression for “economic water scarcity”?

- simulated **potential** water demands remain below global averages of per capita consumption
- much of the available water may not be accessed: actual water demand may be considerably lower than potential water demand by 2050

# Potential further analysis




The map shows current irrigated areas.

IRRIGATION is the largest water user in the EA-RVS scenario.

*Where does irrigation development matter most?*

# *What can models tell us?*

- The extended Lake Victoria Basin

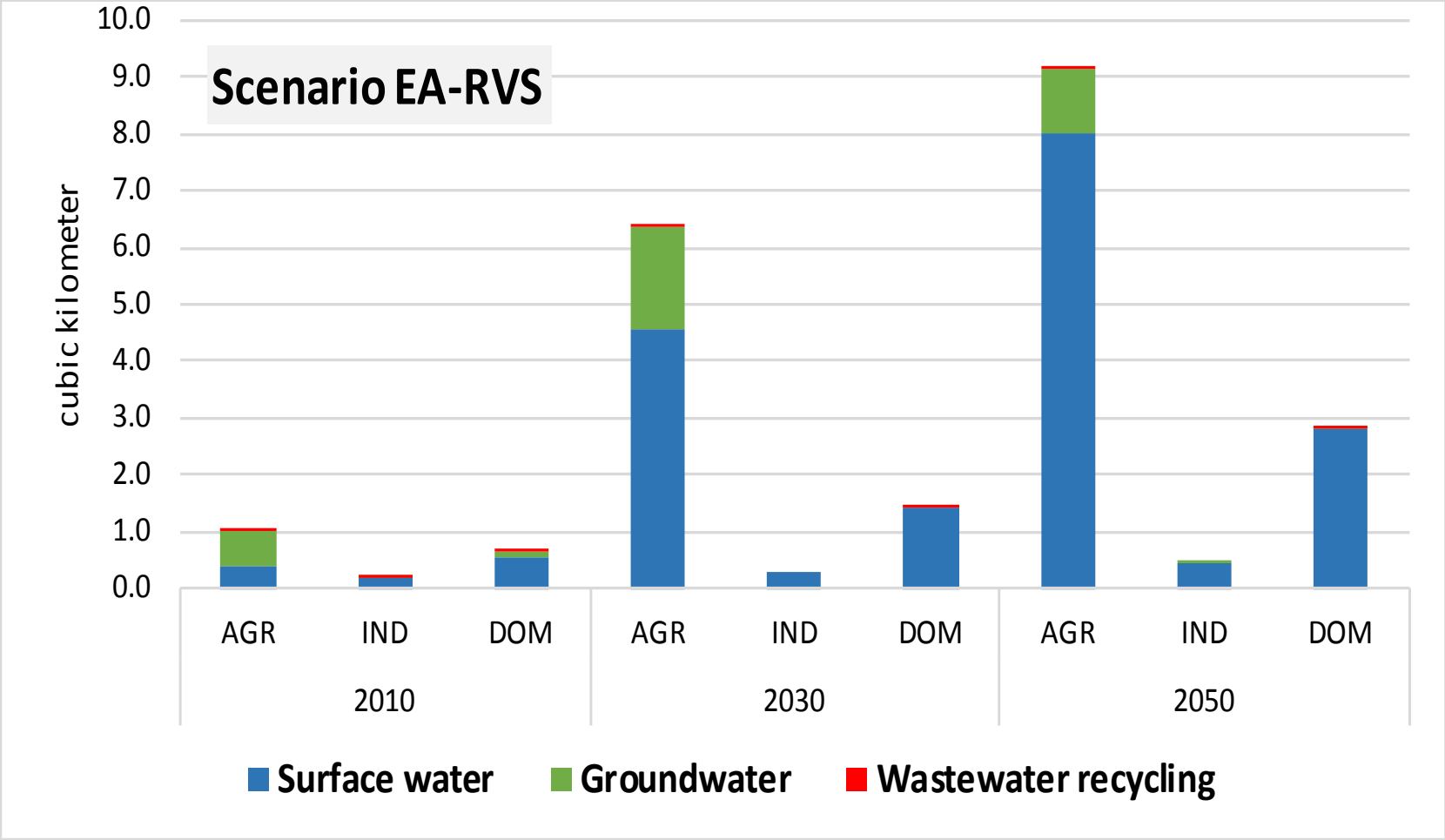
- Biophysical drivers of hydrology
- Human water demand
- Socio-ecological water system characteristics (combining biophysical, human and economics)

# SOCIO-ECOLOGICAL WATER SYSTEM CHARACTERISTICS

Combining the
biophysical, human and economic dimension

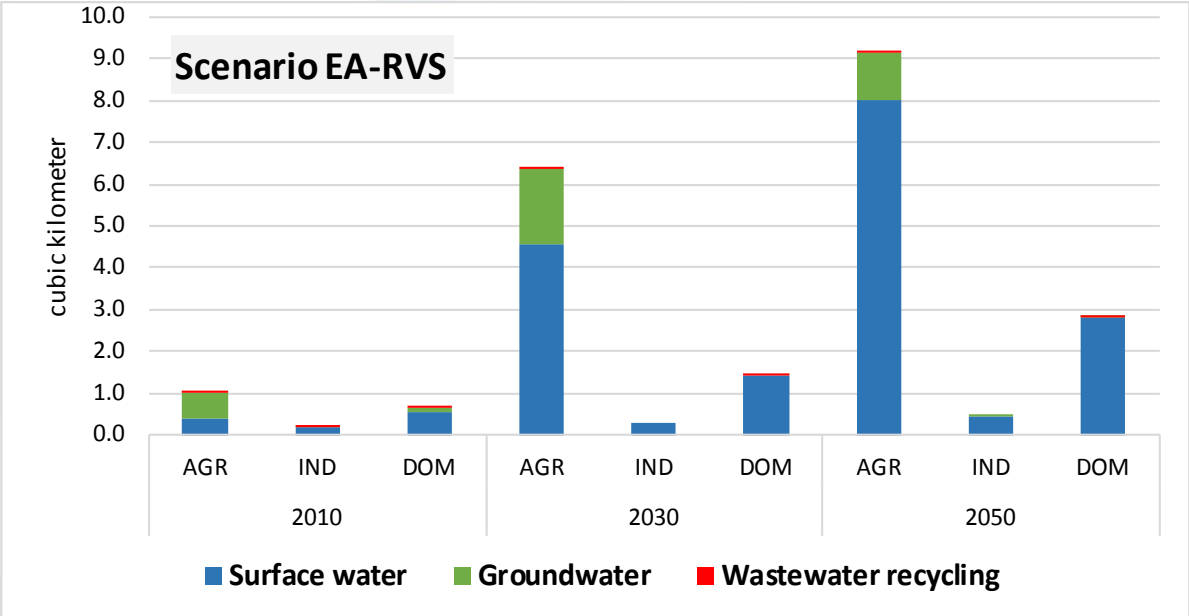
# Cost-efficient water withdrawals, EA-RVS

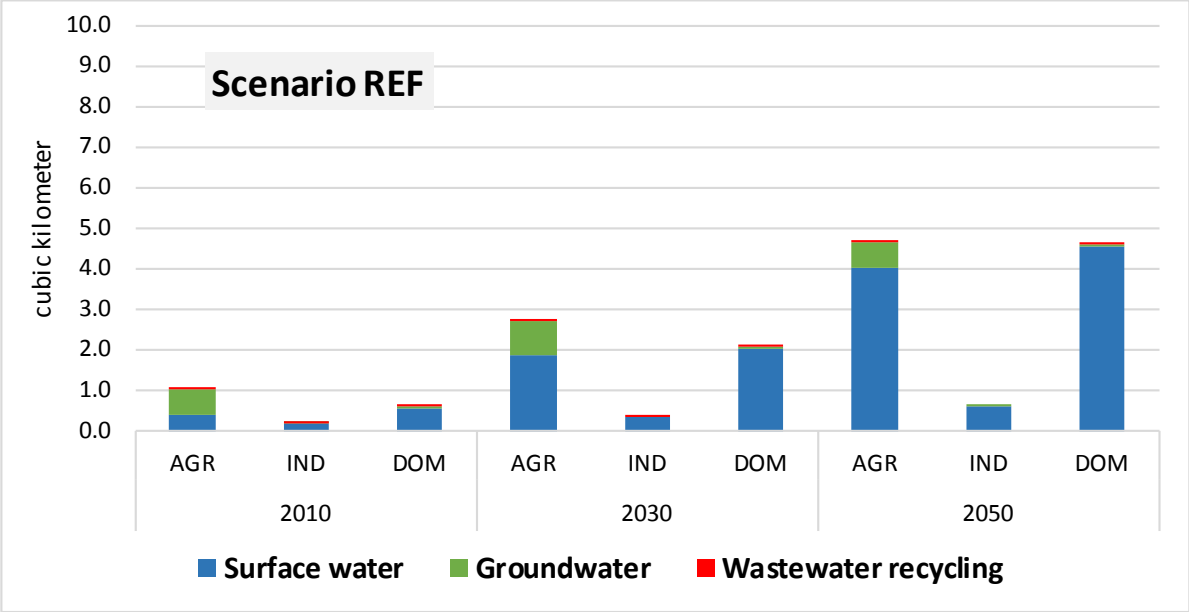
**Water withdrawal development in the eLVB, by use sector and source**



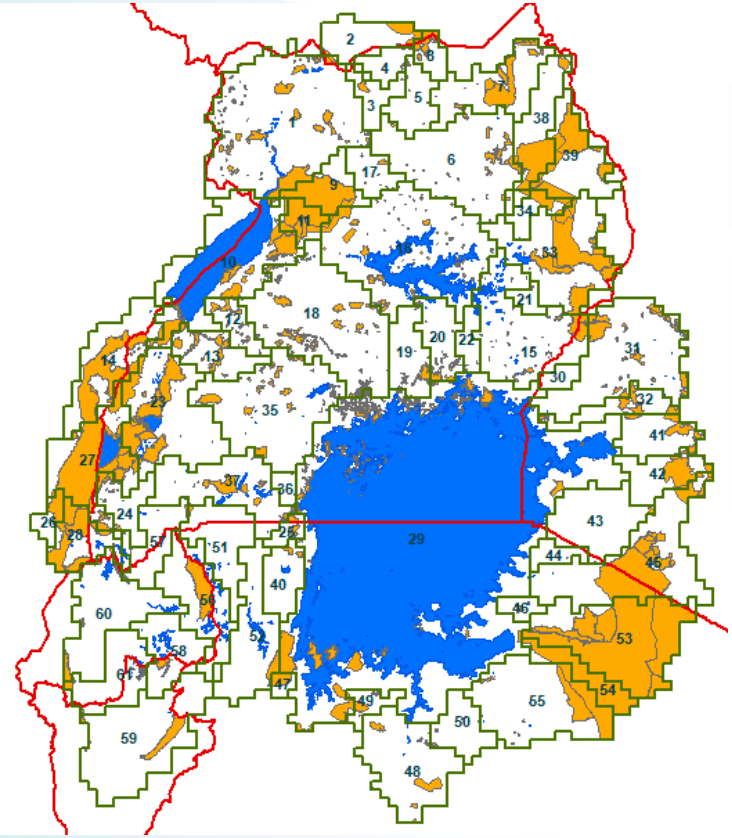

*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

# Cost-effective water withdrawal to meet people's water needs



# Potential further analysis



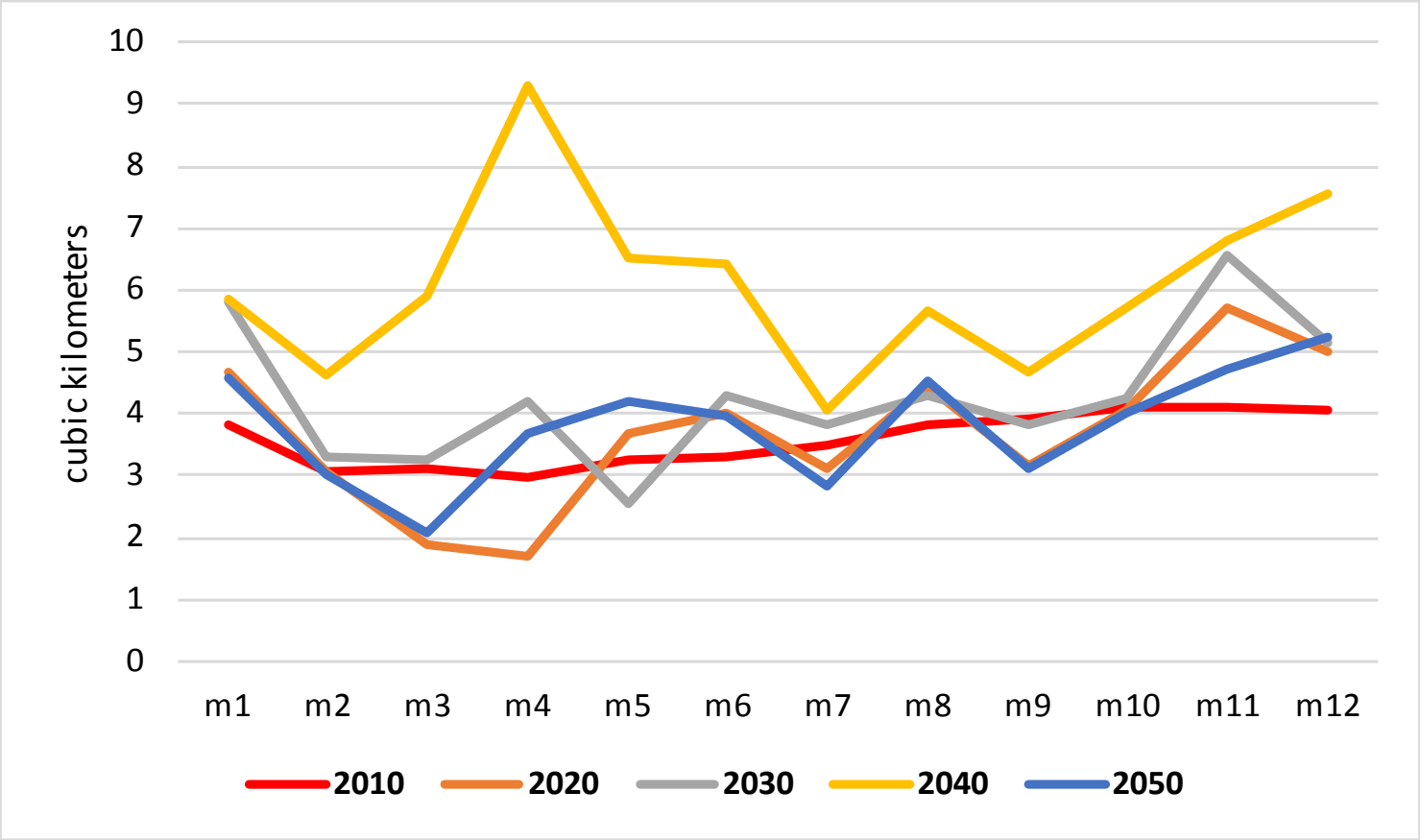
Yellow areas show regions of high environmental value as designated in the World Database of Protected Areas (WDPA).

[download from Oct 2018]

*How would water allocation change if more emphasis were given to environmental flows?*

# River streamflow when considering people's water needs

**Discharge in LAROPI, 2010 – 2050, Scenario EA-RVS**




*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

# COSTS

How much will it cost
to meet people’s water needs?

# **Annual** costs, Scenario EA-RVS

| million $ / year | 2010 | 2030 | 2050 |
|---|---|---|---|
| ENERGY costs | 27 | 74 | 126 |
| OPERATIONAL & MANAGEMENT costs | | | |
| Surface water reservoirs | 0 | 3 | 3 |
| Waste water treatment (Recycling) | 3 | 30 | 82 |
| Surface water withdrawal (diversion) | 343 | 842 | 1469 |
| Groundwater withdrawal (pumping) | 60 | 16 | 32 |
| Wastewater re-use | 11 | 10 | 10 |
| TOTAL | **444** | 975 | **1721** |

*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

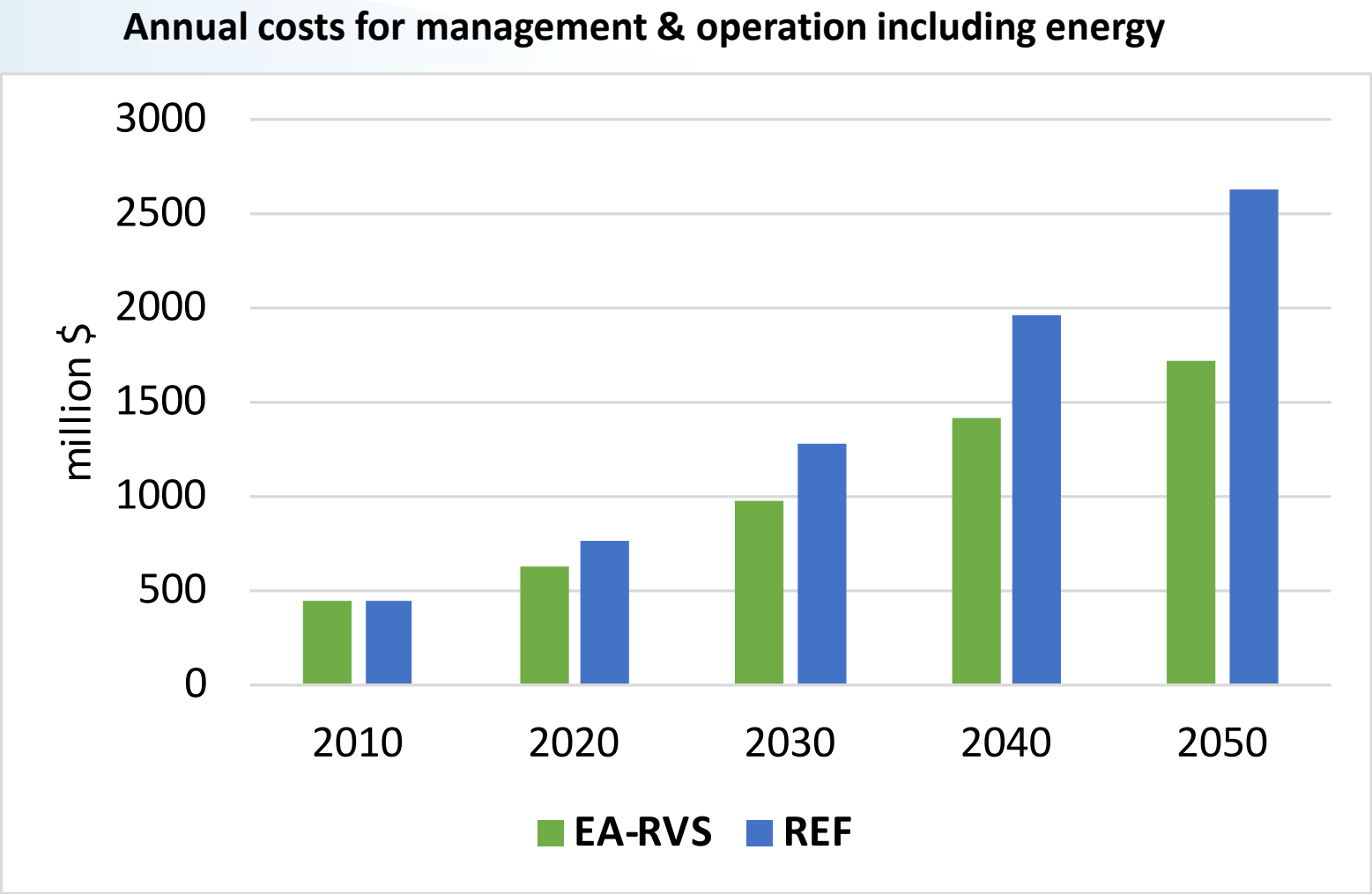
# **Investment** costs, Scenario EA-RVS

**Investment costs over 10-year periods in the eLVB**

| million $ / year | 2010 | 2020 | 2030 | 2040 | 2050 | TOTAL |
|---|---|---|---|---|---|---|
| Domestic / Industry sector | 0 | 86 | 82 | 78 | 234 | 481 |
| Reservoirs | 0 | 28 | 2 | 0 | 4 | 33 |
| Irrigation systems | 30 | 98 | 165 | 182 | 231 | 706 |
| Water supply | 0 | 261 | 574 | 784 | 1054 | 2672 |
| TOTAL | 30 | 473 | 822 | 1044 | 1522 | **3892** |

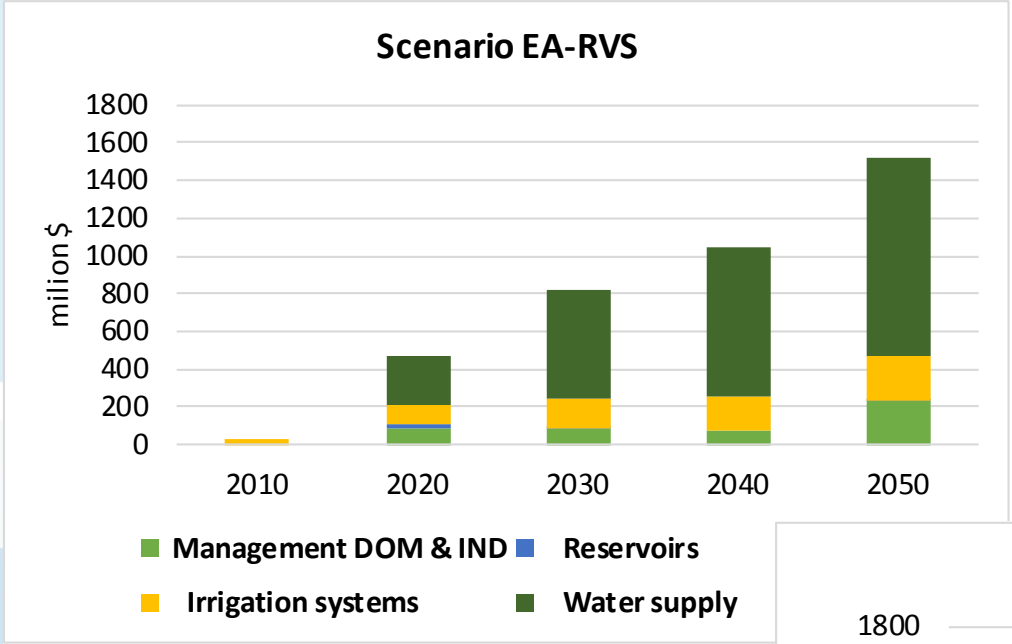
*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

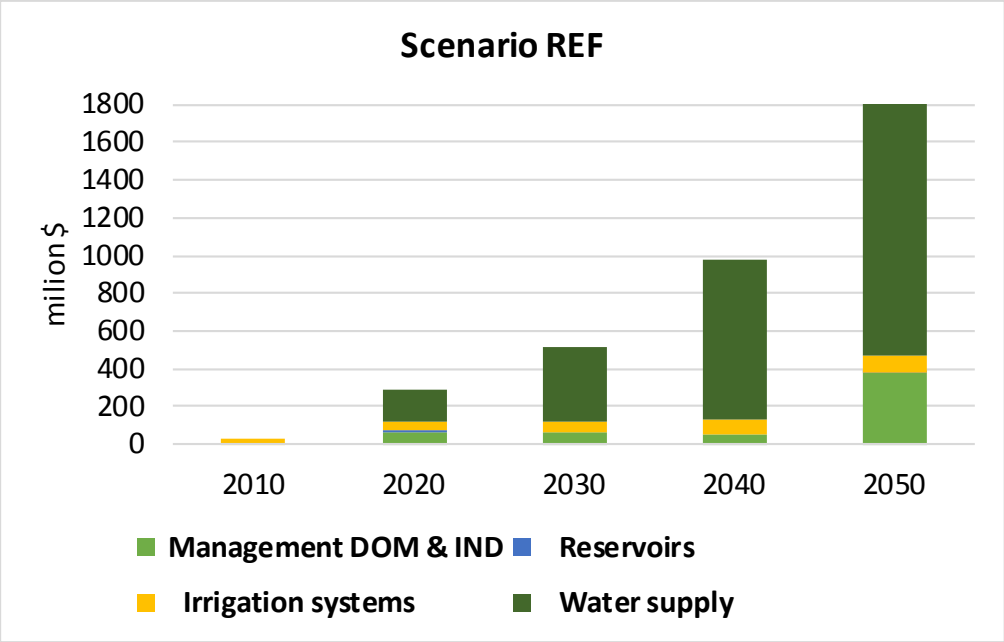
# Annual costs in EA-RVS and REF




*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

# Investment costs in EA-RVS and REF



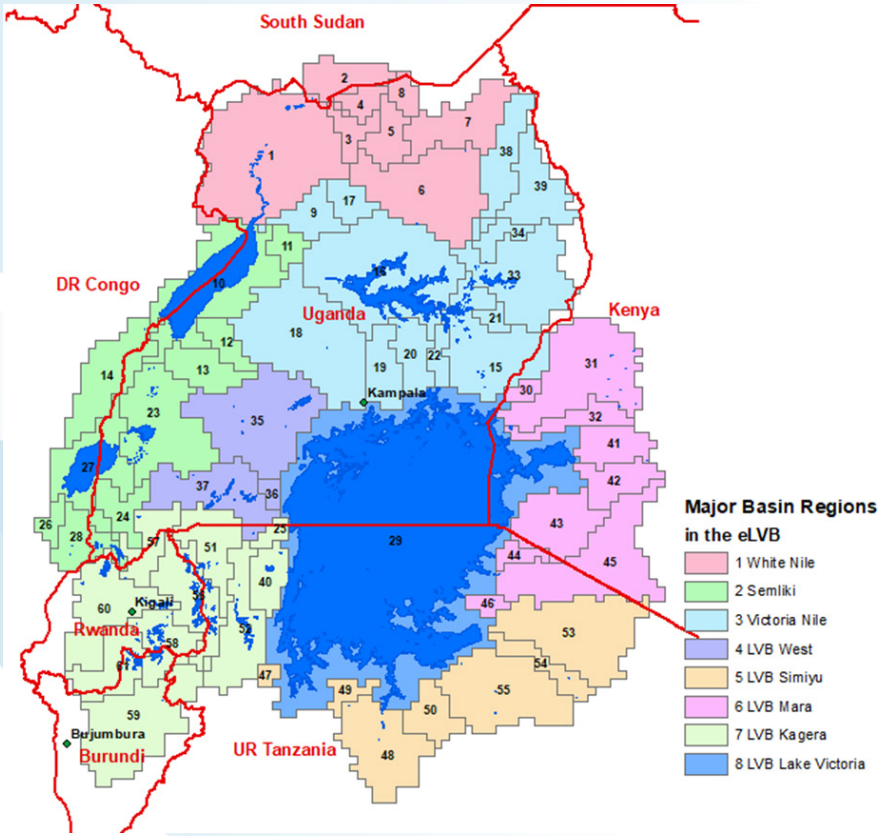




**Cumulative investment costs 2010-2050**

| EA-RVS | REF |
|---|---|
| 3,893 mio $ | 3,654 mio $ |

*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*

# Potential further analysis

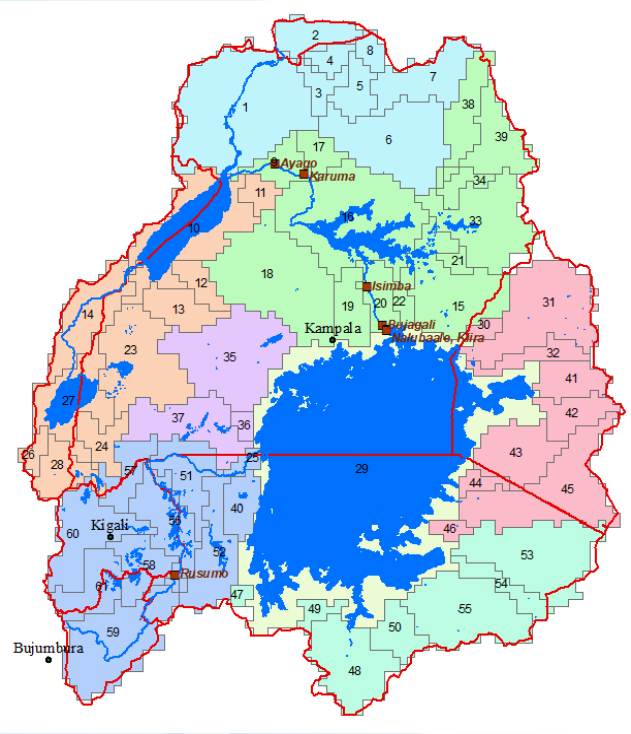



***Where** in the eLVB will the costs for the water sector be incurred, in which sub-basins, in which countries?*

# NEXUS

Analysis across sectors

# Energy – Water Nexus




**Large-scale hydro-power stations**

Current stations:

Nalubaale (180 MW), Kiira (200 MW)

Bujagali (250 MW)

From 2020 onwards:

Isimba (183 MW), Rusumo (80 MW)

Karuma (600 MW), Ayago (600 MW)

| 1000 MWh | 2010 | 2030 | 2050 |
|---|---|---|---|
| Electricity for water services | 550 | 1,625 | 3,048 |
| Hydro-electric power production | 3,137 | 14,464 | 13,572 |
| Percentage used for water sector | 18 % | 11 % | 22 % |

*Source: IIASA WFaS East Africa (CWAT-ECHO model system)*