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Incorporating stakeholder feedback into the modelling concept

A case study of the Lake Victoria basin

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STAKEHOLDER

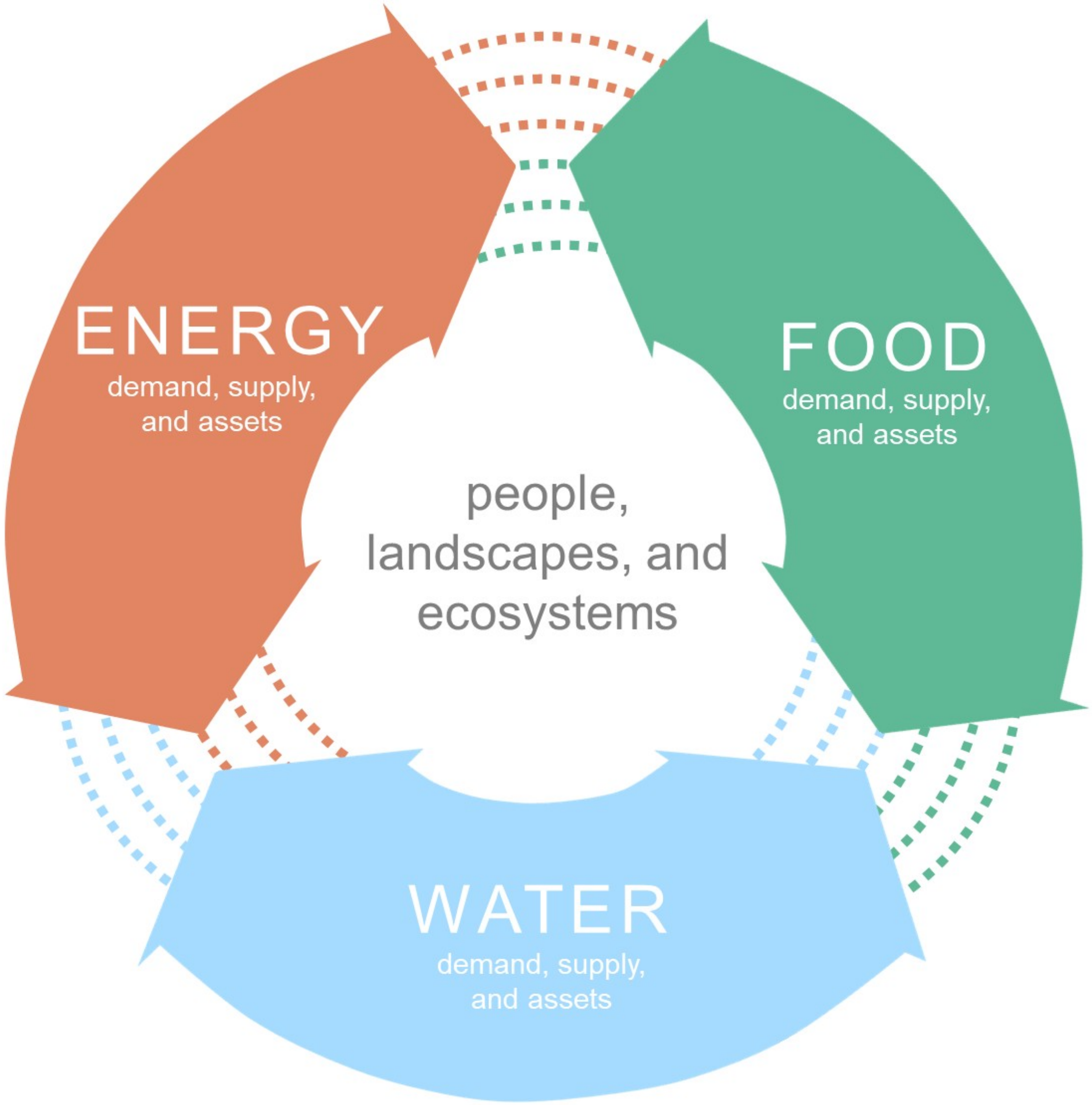
- Individuals, groups, or institutions that have a defined and **recognised interest in a decision-making process**
  - Will be affected by decision or have an influence on its outcome

- Components include:
  - **Access to information**
  - **Participation in decision making**
  - Access to justice

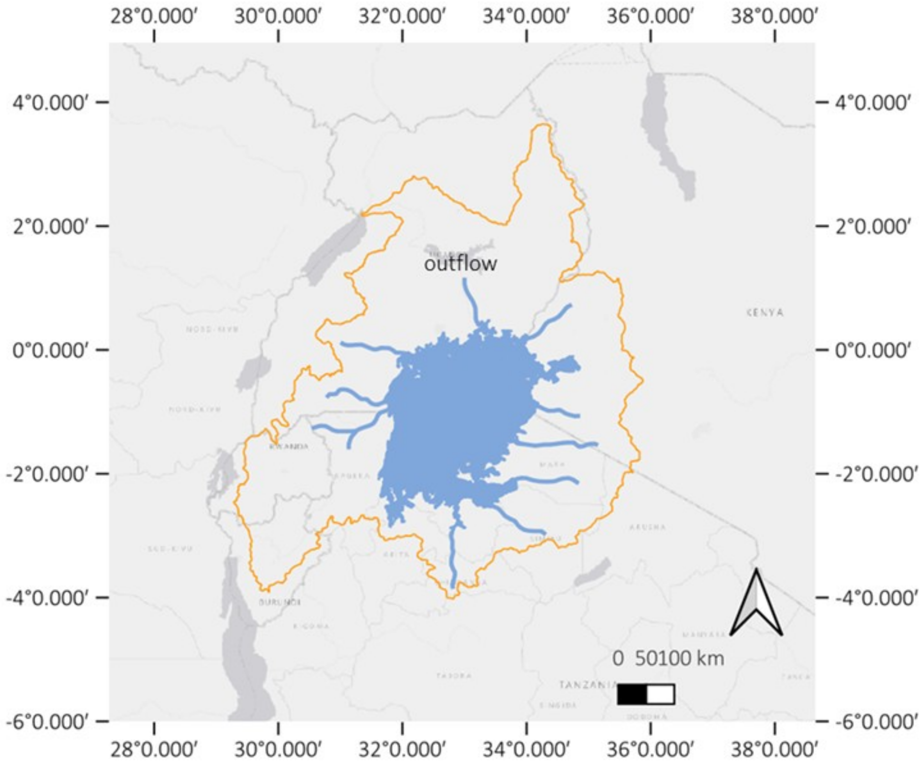
- Relationship between socio-ecological systems and the climate are interconnected
- Widely recognised that public participation is integral to effective management of natural resources (1992 Rio Declaration on

WEF NEXUS

- Socio-ecological systems are fundamental to the water-energy-food (WEF) nexus
- Difficulties translating WEF nexus theory into practice
- Cross-sectoral participation and co-production of knowledge is required to address this and ensure solutions address stakeholder needs and are fit-for-purpose

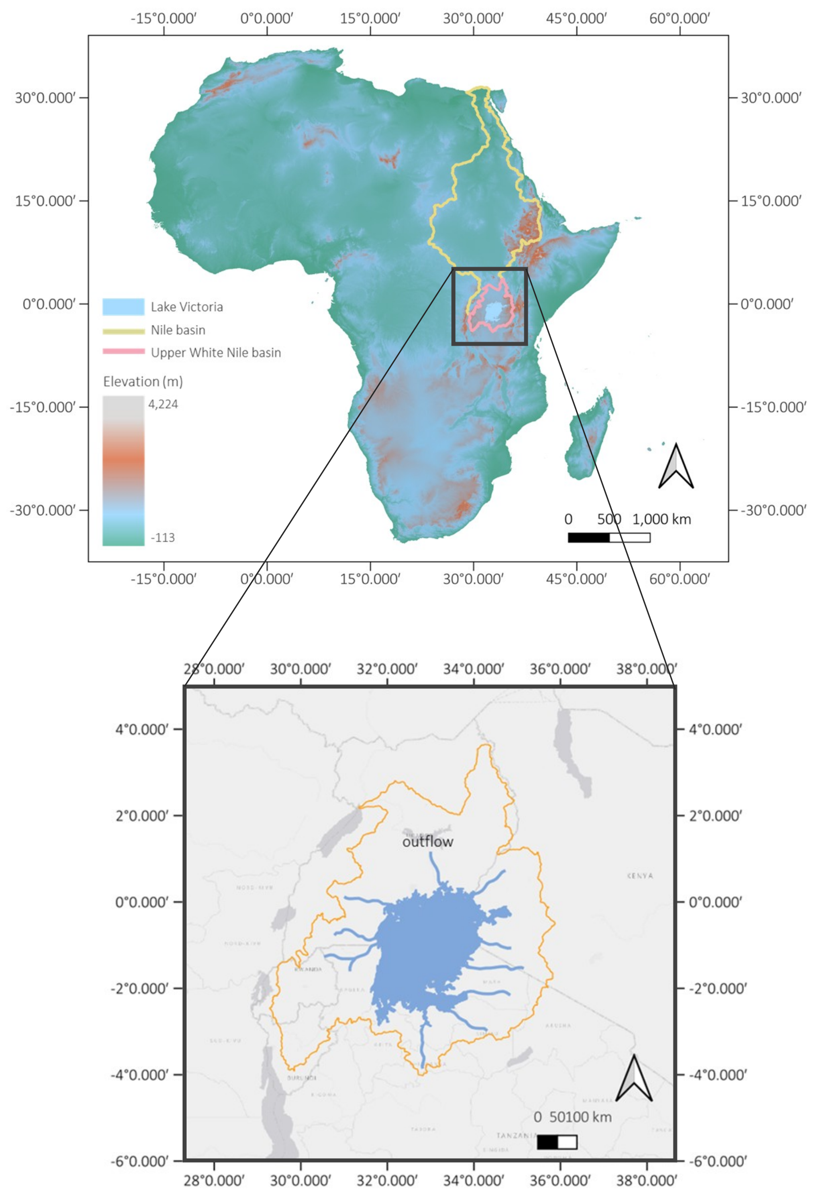


LAKE VICTORIA

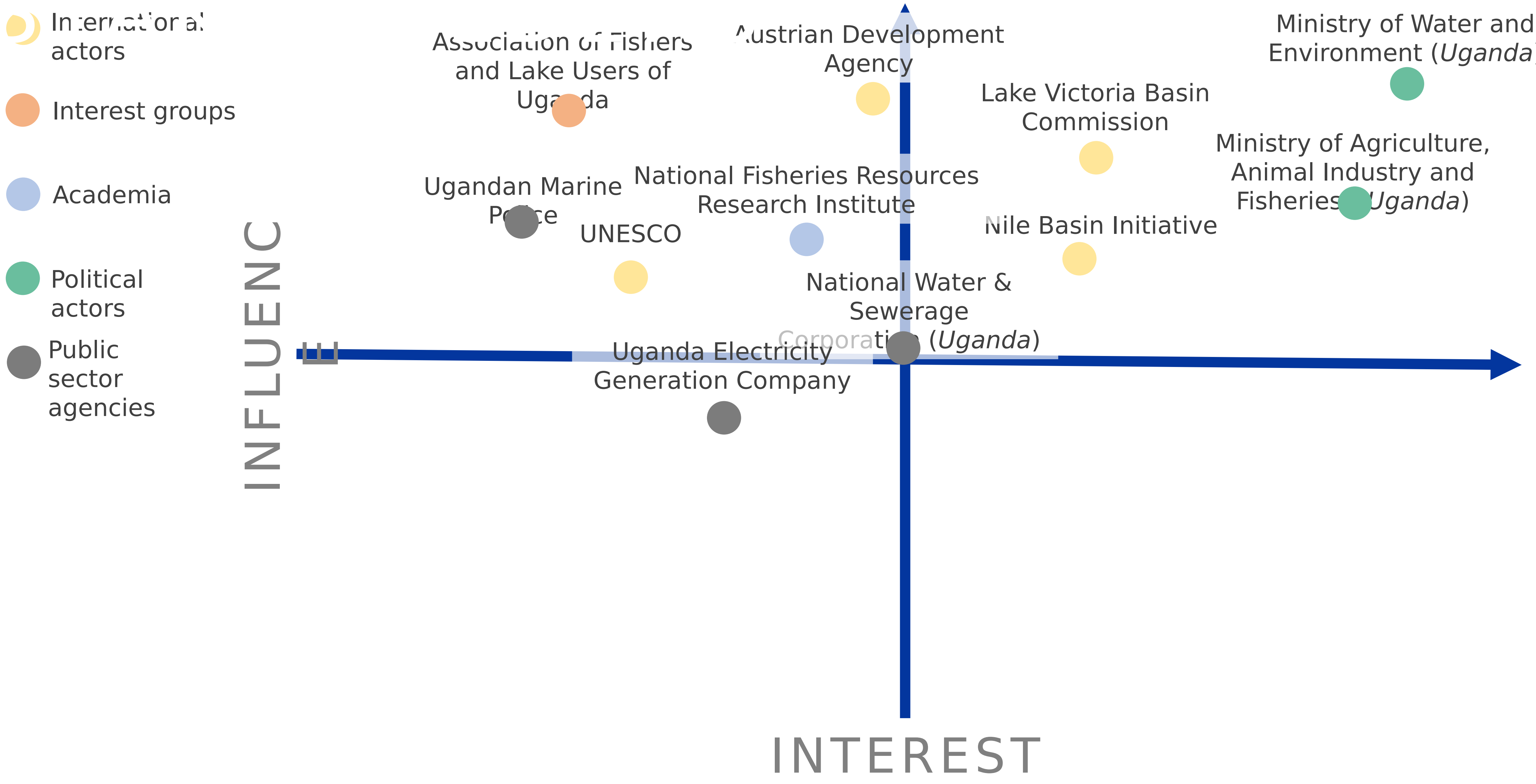


LAKE VICTORIA

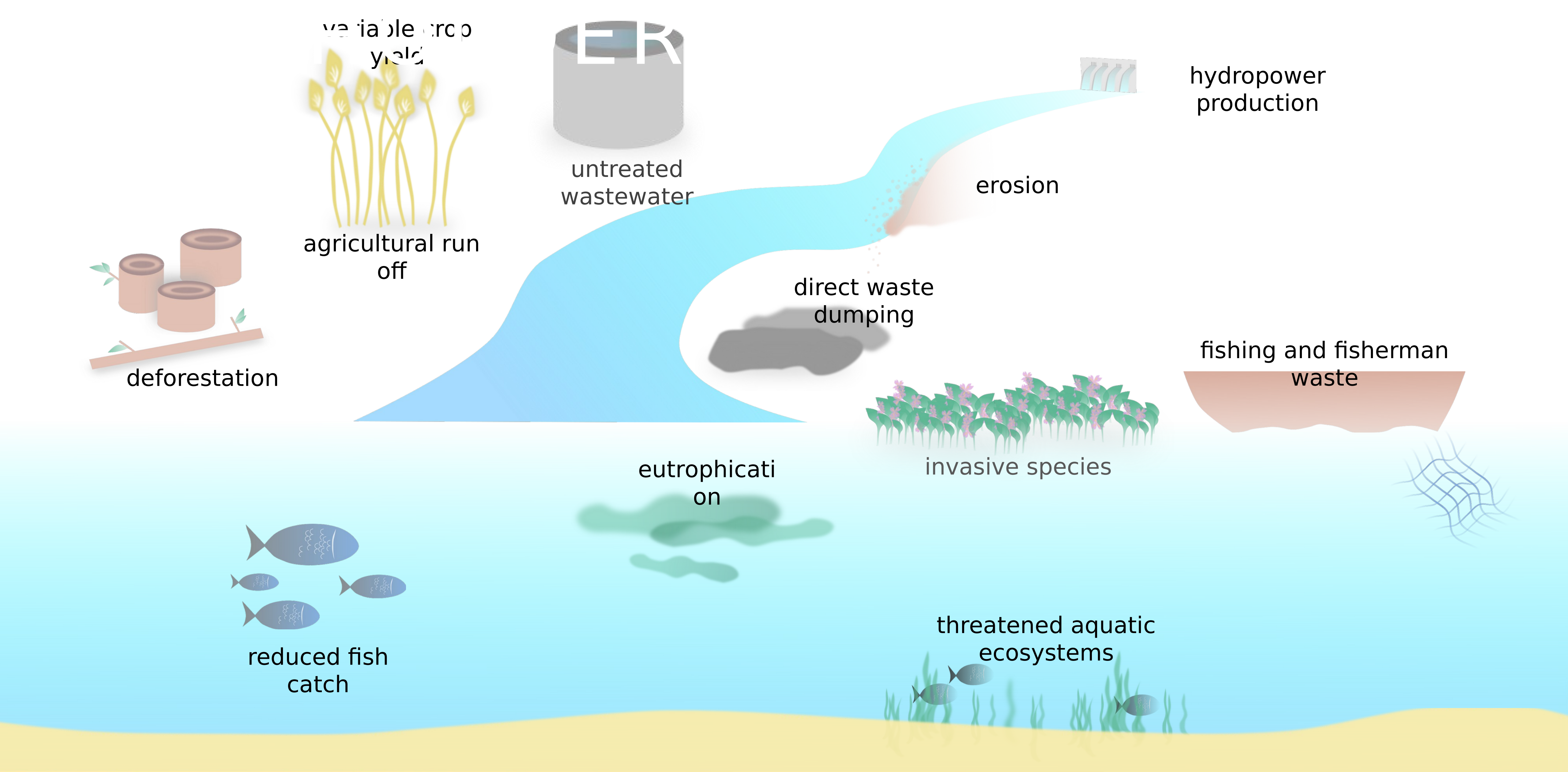
- Extends into Uganda, Kenya, Tanzania, Burundi, and Rwanda and drains an area of 351,500 km²
- Most **densely populated** rural regions in the world
- Economically supports approx. **70 million people**
- **Fisheries**, **agriculture**, **hydropower** generation, tourism, transboundary conservation
- Many **environmental challenges**



LAKE VICTORIA



LAKE VICTORIA



WEF NEXUS MODEL

	WEF nexus challenges									
Model	Water quantity	Water quality	Energy prod.	Crop prod.	Fisheries	Land degr.	Aquatic eco.	Invasive species	Eutroph.	%
CLEWs										33
DAFNE										67
Daily Model										33
Foreseer										33
GREAT for FEW										22
ITEEM										33
MAXUS										22
MuSIASEM										22
NEST										22
PRIMA										33
Q-Nexus										33
SIM4NEXUS										56
WEAP-LEAP										22
WEF Nexus Index										33
%	93	21	86	71	7	14	7	0	0	

%
- 91 – 100
- 81 – 90
- 71 – 80
- 61 – 70
- 51 – 60
- 41 – 50
- 31 – 40
- 21 – 30
- 11 – 20
- 0 – 10

36% consulted stakeholders during the development of nexus indicators and model integration

Limited inclusion of water quality and ecosystem indicators

NEXUS INDICATORS

River flow
Lake levels
Total nitrogen
Total phosphorus
Sediment transport
Dissolved oxygen

Hydropower production
Energy demand
Energy access

Crop yield
Fisheries yield
Irrigation water
Food demand
Food access

Aquatic biodiversity
Eutrophication
Land degradation
Invasive fish
Invasive plants

NEXUS INDICATORS

	ALUFU	UEGC	Ac.	NWSC	NBI	UPM	MAIIF	MWE	ADA	UNESCO	%
River flow											80
Lake levels											80
Total nitrogen											80
Total phosphorus											80
Sediment transport											50
Dissolved oxygen											40
Hydropower energy											40
Energy demand											30
Energy access											10
Crop yield											30
Fisheries yield											70
Irrigation water											30
Food demand											10
Food access											10
Aquatic biodiversity											70
Eutroph.											40
Land degradation											80
Invasive fish											50
Invasive plants											30
%	37	32	63	32	53	53	74	47	53	37	

%

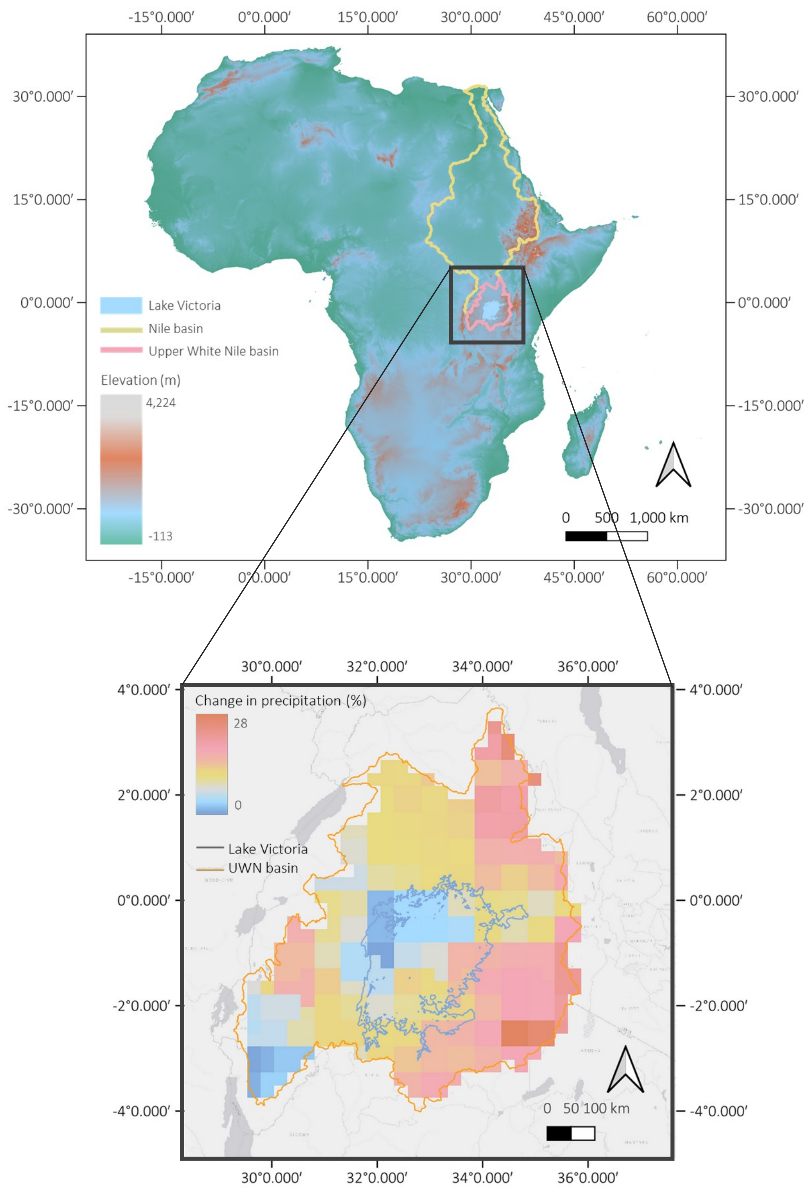
- 91 – 100
- 81 – 90
- 71 – 80
- 61 – 70
- 51 – 60
- 41 – 50
- 31 – 40
- 21 – 30
- 11 – 20
- 0 – 10

Every proposed indicator discussed by stakeholders

Shows priorities for future WEF nexus research

Ensures research is fit for purpose and addressing most pressing challenges

CLIMATE CHANGE



- SWAT+ (Soil Water and Assessment Tool) simulations for water quantity, water quality, and crop yield

- Historical (1971-2000) and future (2071-2100) simulations

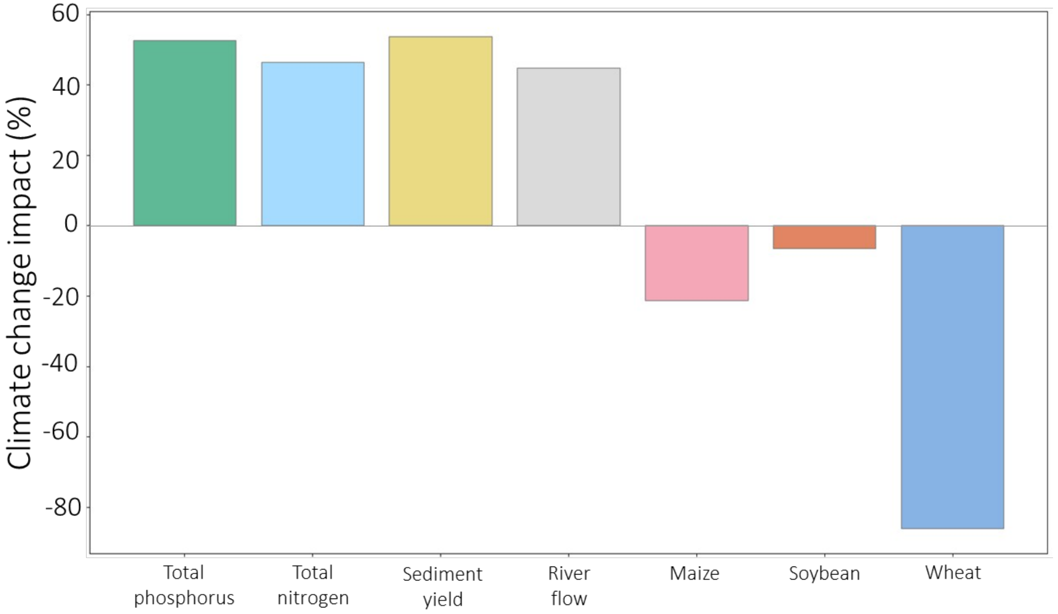
- 5 GCMs (GFDL-ESM4, IPSL-CM6A-LR, MPI-ESM1–2-HR, MRI-ESM2–0 and UKESM1–0-LL) from the bias-corrected CMIP6 climate forcing data for historical and future

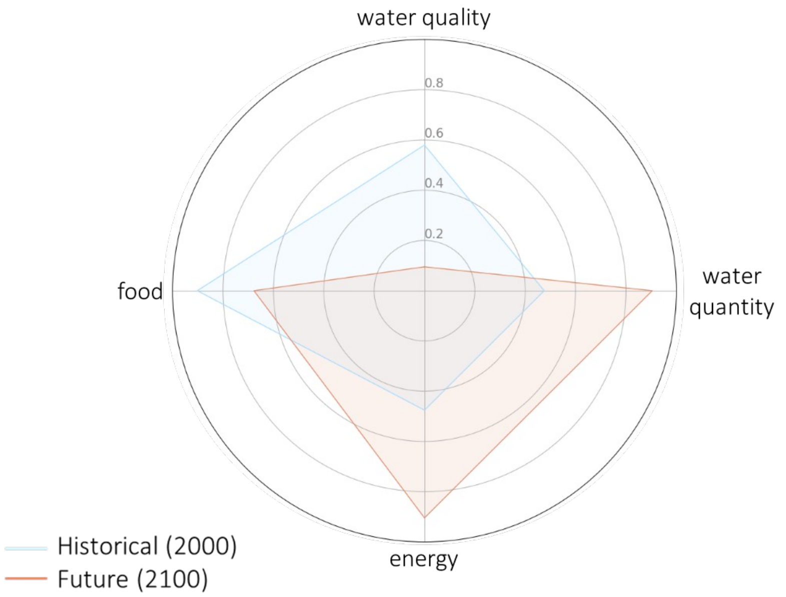
- SSP5-RCP8.5 conditions (“business as usual”/ high-

Nkwasa, A. et al (2022). Can the cropping systems of the Nile basin be adapted to climate change? *Regional Environmental Change*

Nkwasa, A. et al (2022). Regionalization of the SWAT+ model for projecting climate change impacts on sediment yield: An application in the Nile basin. *Journal of Hydrology: Regional Studies*

CLIMATE CHANGE





- Climate change will have impacts on WEF nexus resources:
  - Increase in water flow
  - Increase in hydropower production
  - Decrease in water quality
    - *increase in TN, TP, and soil erosion*
  - Decrease in crop yield
- Trends are spatially heterogenous

Nkwasa, A. et al (2022). Can the cropping systems of the Nile basin be adapted to climate change? *Regional Environmental Change*

FUTURE WORK

- Couple SWAT+ with ecological model (Ecopath with Ecosim) to address environmental and ecological indicators
- Further stakeholder meetings to develop future management and adaptation scenarios and provide feedback on current work
- Undertake WEF nexus modelling of future scenarios (including **ISIMIP forcing data**)
- Disseminate results to stakeholders

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Thank you for listening!

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Appendices

Normalising the WEF nexus indicators

Equation 1 is used when the minimum (xi) of the indicator is the least preferred value and Max (xi) is the most preferred value, where Eq. 2 is used for the opposite situation. Xi refers to normalized indicator, xi actual value of the indicator, Min (xi) and Max (xi) are the minimum and maximum values of the indicator

1) $$X_i = \frac{x_i - \mathrm{Min}\,(x_i)}{\mathrm{Max}\,(x_i) - \mathrm{Min}\,(x_i)}$$

2) $$X_i = \frac{\mathrm{Max}\,(x_i) - x_i}{\mathrm{Max}\,(x_i) - \mathrm{Min}\,(x_i)}$$

Calculating the impacts of climate change

Equation 3 is used to calculate the impacts of climate change (%) on the WEF nexus indicator, where S_c is the future indicator value under climate change (2070-2100), and S_o is the historical indicator value (1970-2000)

3) $$\mathrm{CC_i} = \left(\frac{\mathrm{S_c} - \mathrm{S_o}}{\mathrm{S_c}}\right) \mathrm{x}100$$

El-Gafy (2017). Water–food–energy nexus index: analysis of water–energy–food nexus of crop's production system applying the indicators approach. *Applied Water Science*

Nkwasa et al. (2022). Detection and attribution of changes in river... *Research Square*