Impacts on freshwater ecosystems & mitigation measure to reduce impacts of dams

By
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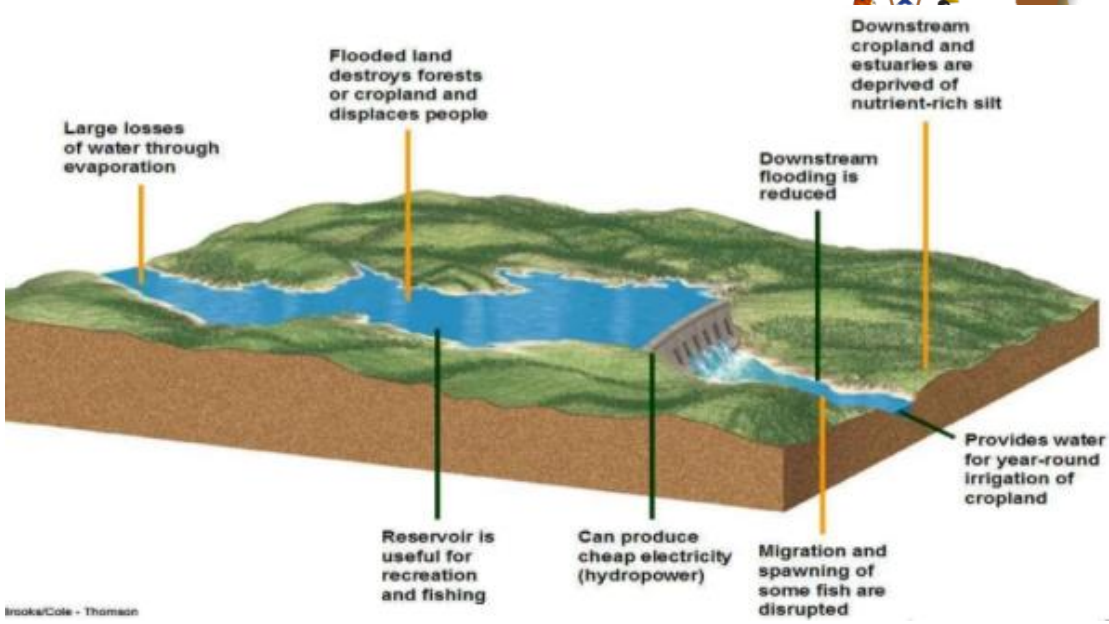
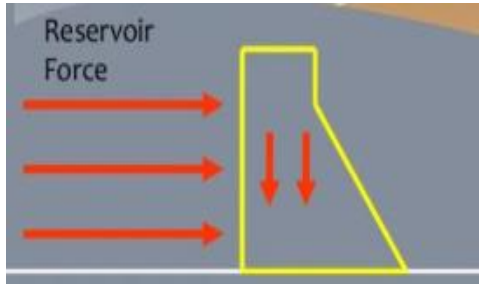
Presentation at to Water Journalists in Africa Reporting on Dams and Biodiversity in the Nile Basin organized by InfoNile on 22nd July 2022

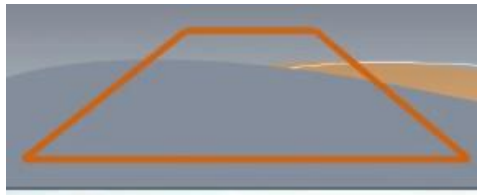
What is a dam, types of dams

- Dams : - A solid barrier constructed at suitable location across a river valley to store flowing water



- Types of dams (structure)
  - Gravity dams: - heavy wall like structure and the whole weight acts vertically
  - Earth dam: – trapezoid in shape and constructed in areas with week foundation
  - Arch dams: - these are concrete dams which are curved or convex upstream (built across narrow deep river gorges)
  - Buttress dam: - gravity dam reinforced by structural supports (Buttress- are supports that transmits force from a roof or wall to another)





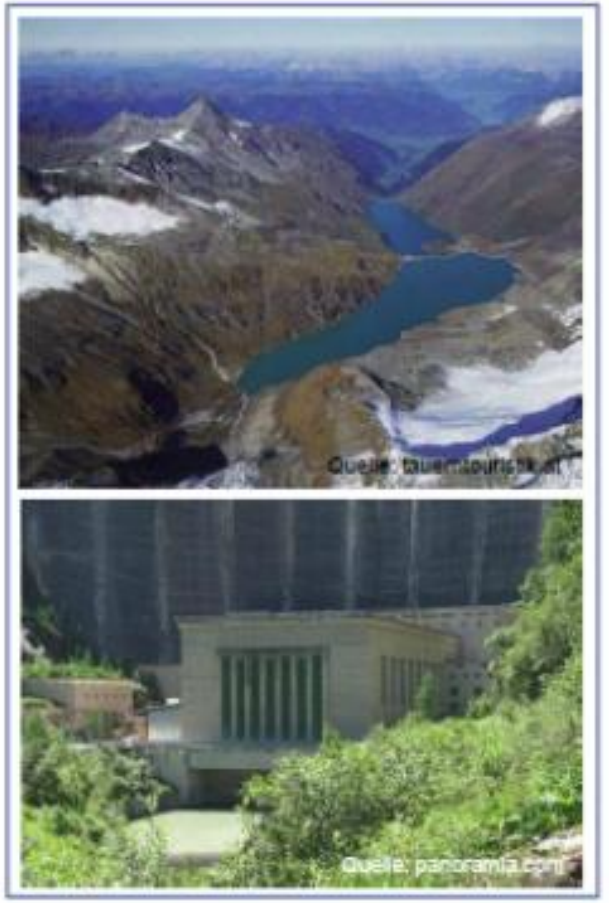
What is a dam, types of dams - operation

Small hydropower

Run-of-the river plant

Storage plants

Pumped –storage plants



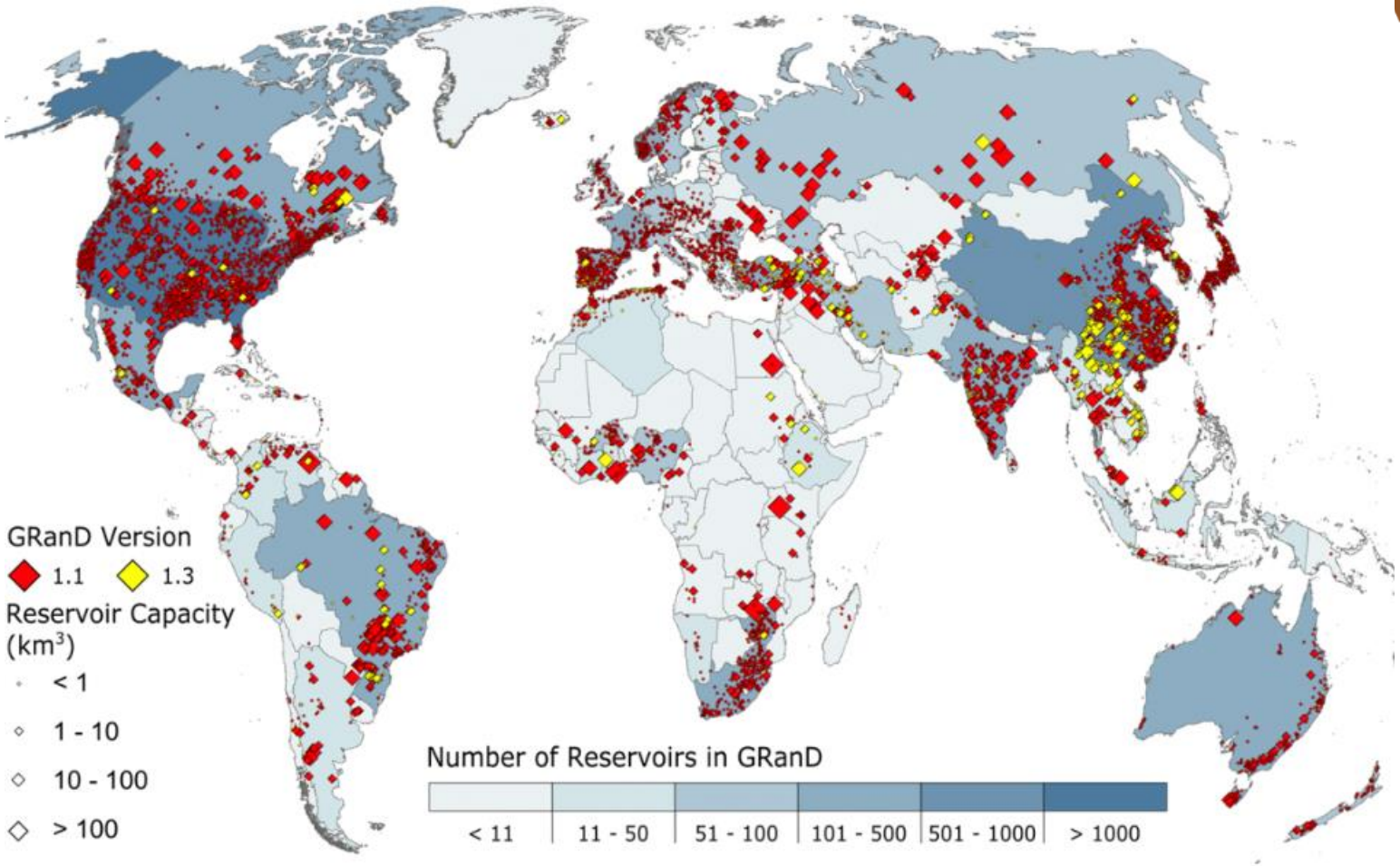
Habersack et al. (2011)

Status of Dams and Reservoirs - Globe

- About 60% of the world's rivers regulated - Do we have free flowing rivers ?

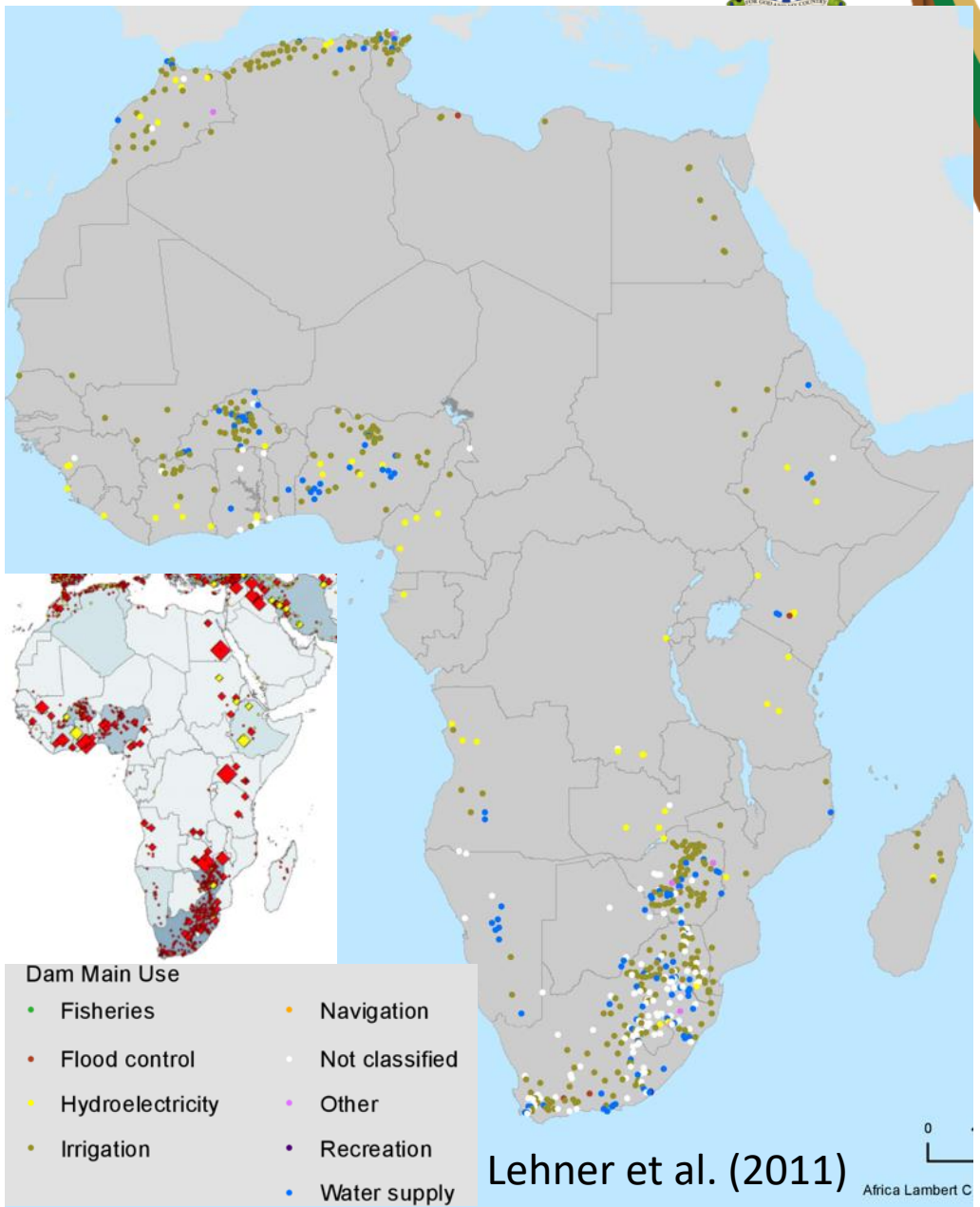
Grill et (2019)

- HydroSHEDs - there are ca. 7,320 dams & reservoirs
  - Storage >100 million cubic meter of water (6,197 km^3)
    - 1 cubic km = 1 billion litres
  - Height > 150 m
  - Constructed between 1960 -1979 and between 2000 – 2016
  - Electric dams most controversial due to –biodiversity loss



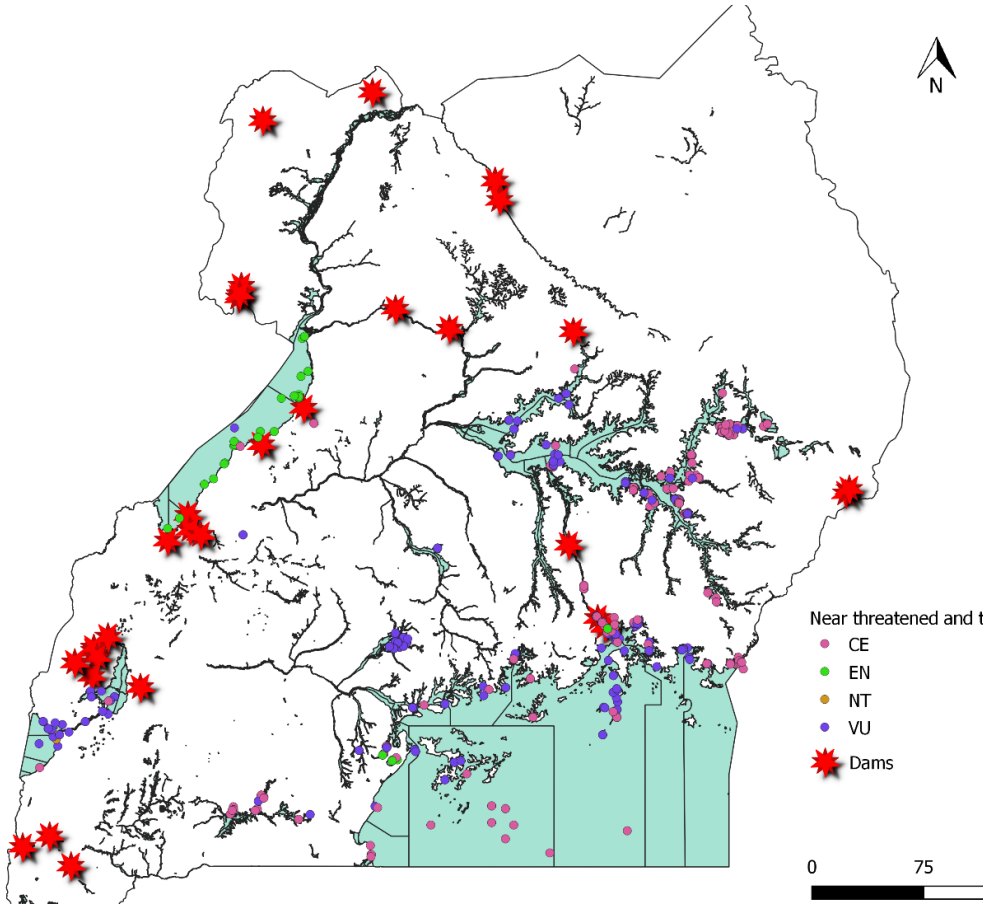
Dams and Reservoirs - Africa

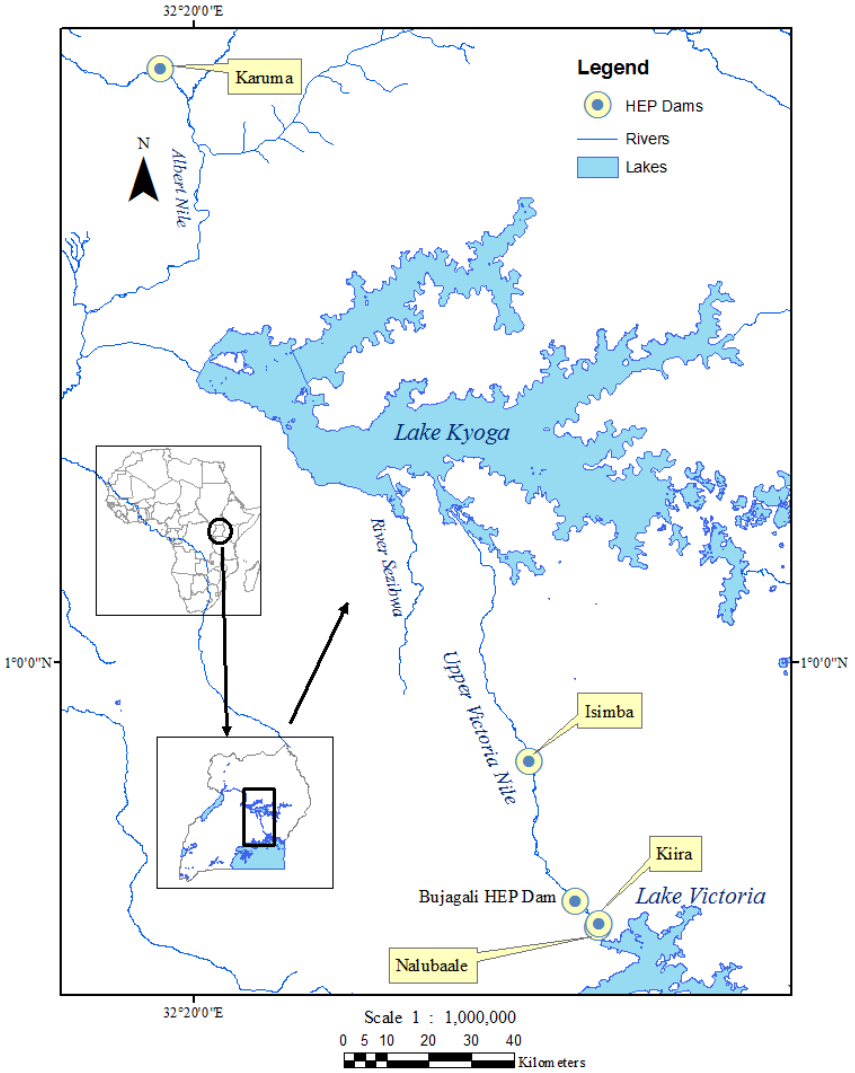
- There 980 large dams with over 60%(589) of them in South Africa; Some of Africa's largest dams.
  - Grand Ethiopian Renaissance Dam (GERD) – (length =1,800m, height =155m)
  - Gibe III Dam – (height =243m, length =610m)
  - Tekezé Dam - Africa's tallest arch dam (height =185m, length =710 m)
  - Kariba Dam - The world's biggest man-made reservoir (length =579 m, height =128 m)
  - Merowe Dam-The world's biggest man-made reservoir (length =9km, height =67 m)
  - Katse Dam – second largest arch dam (length =9km, height =67 m)
- The first dam on R. Nile was Aswan (1899 -1902) to allow navigation



Dams and Reservoirs – Uganda (operational and

- Majority not known to Ugandans
- Large dams are storage dams on F Nile
- Small dams are either diversion dams or pump-storage





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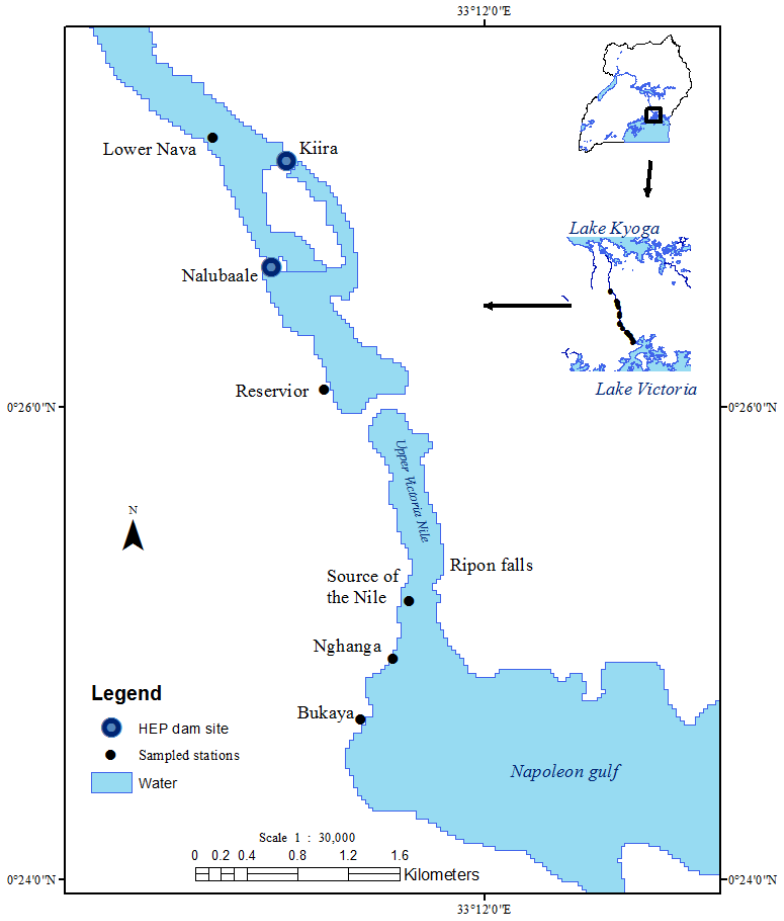
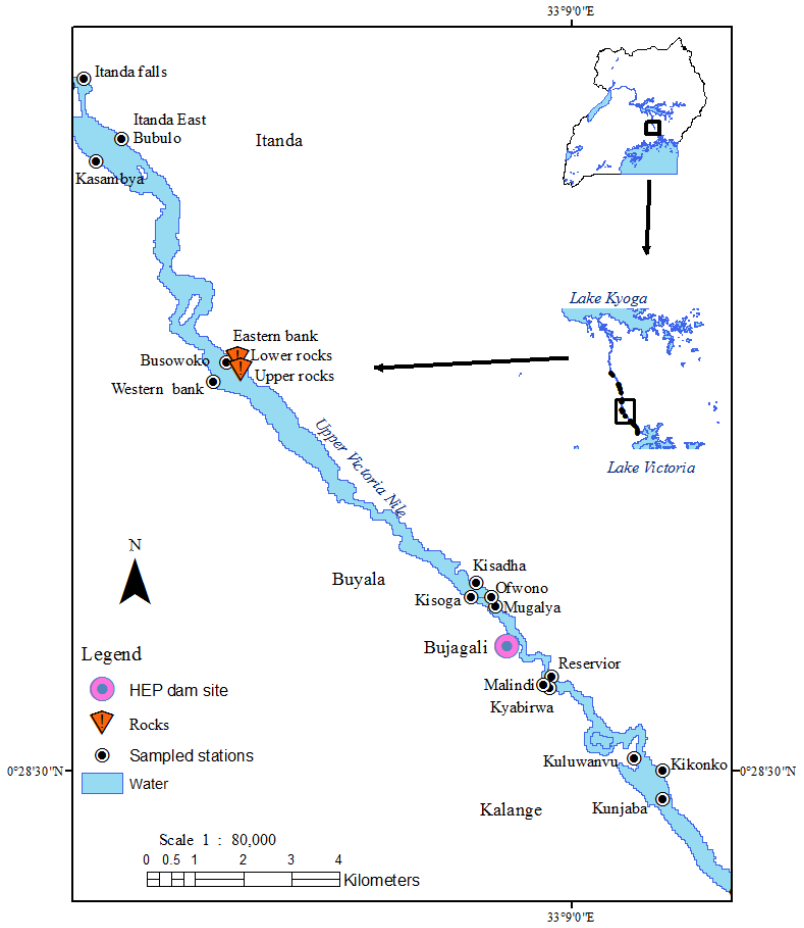
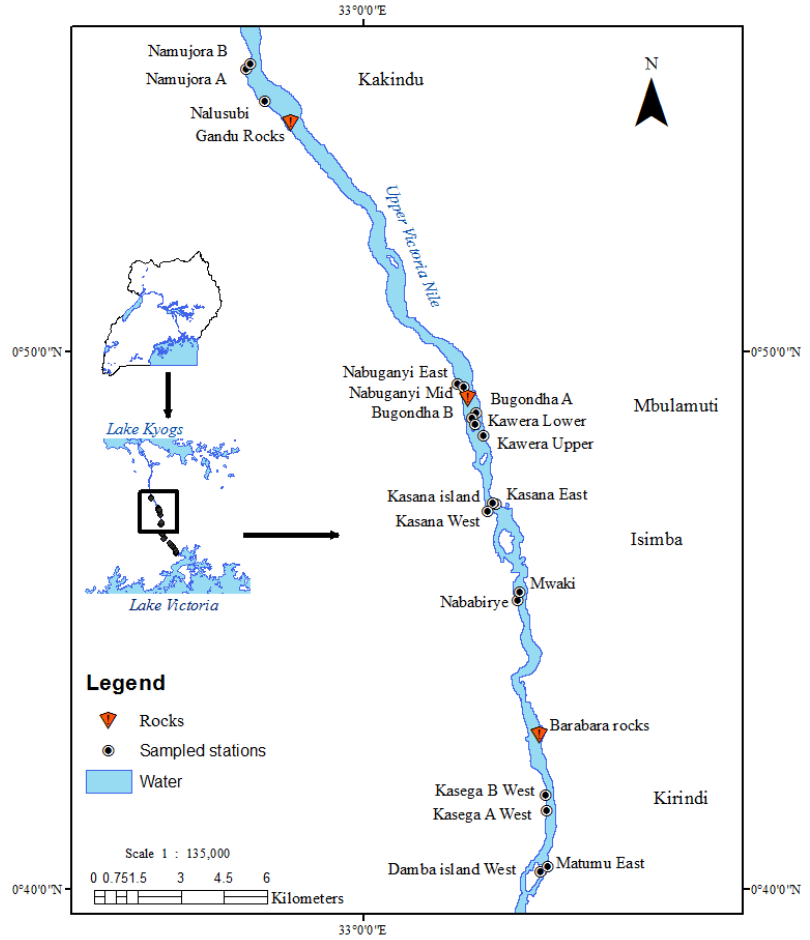


Nalubale Dam area

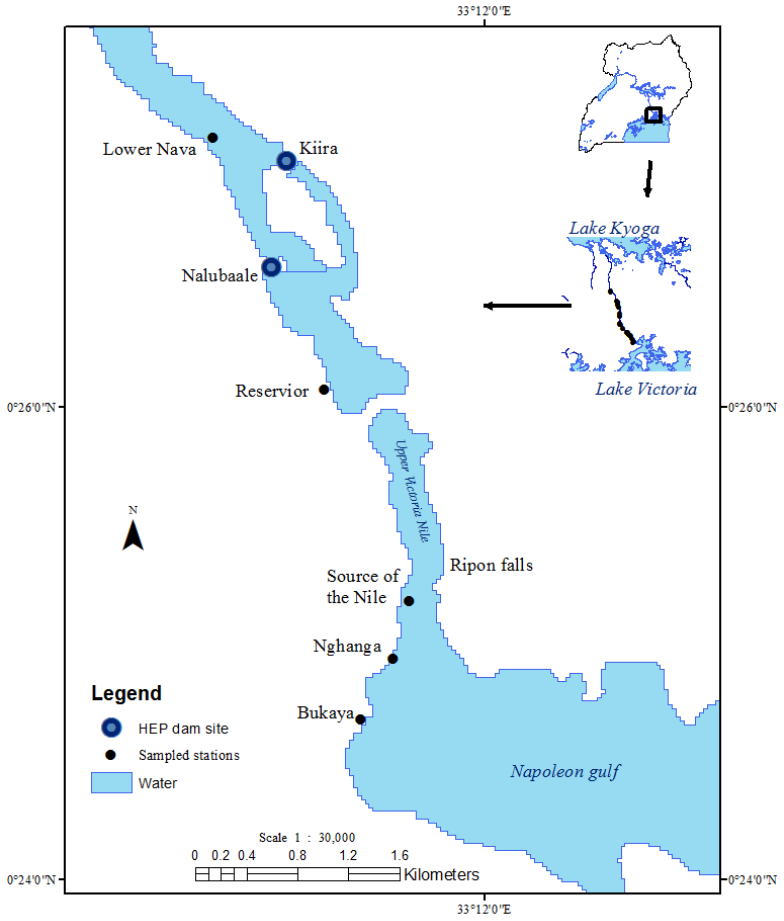


Bujagali Dam area



Isimba Dam area

Dams and Reservoirs – Uganda (operational and



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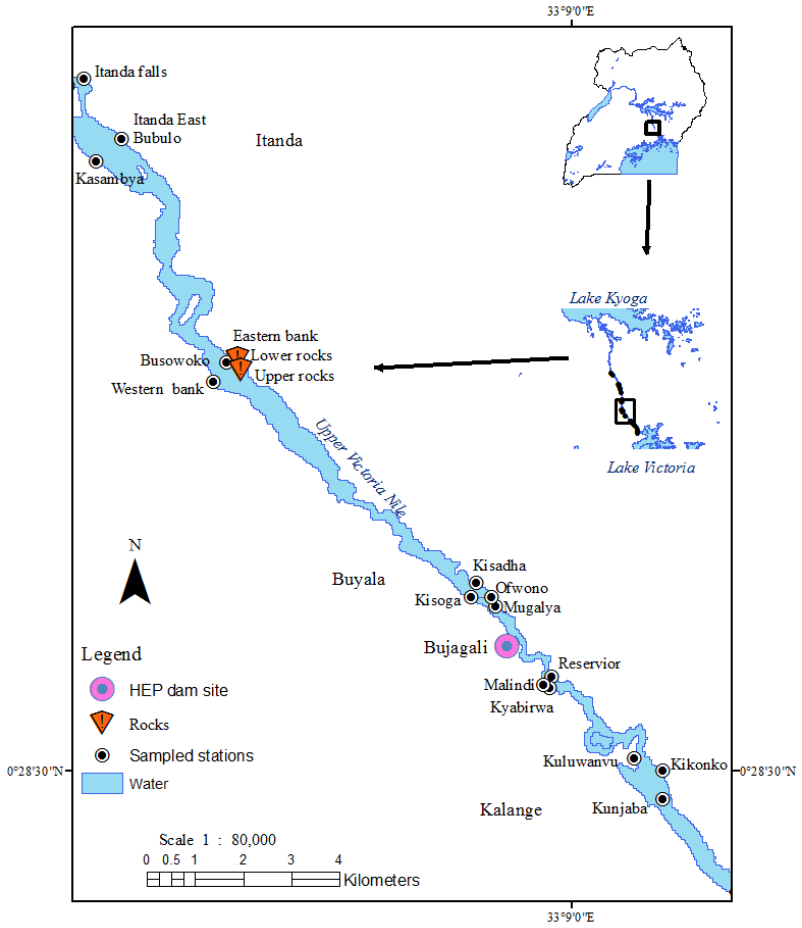
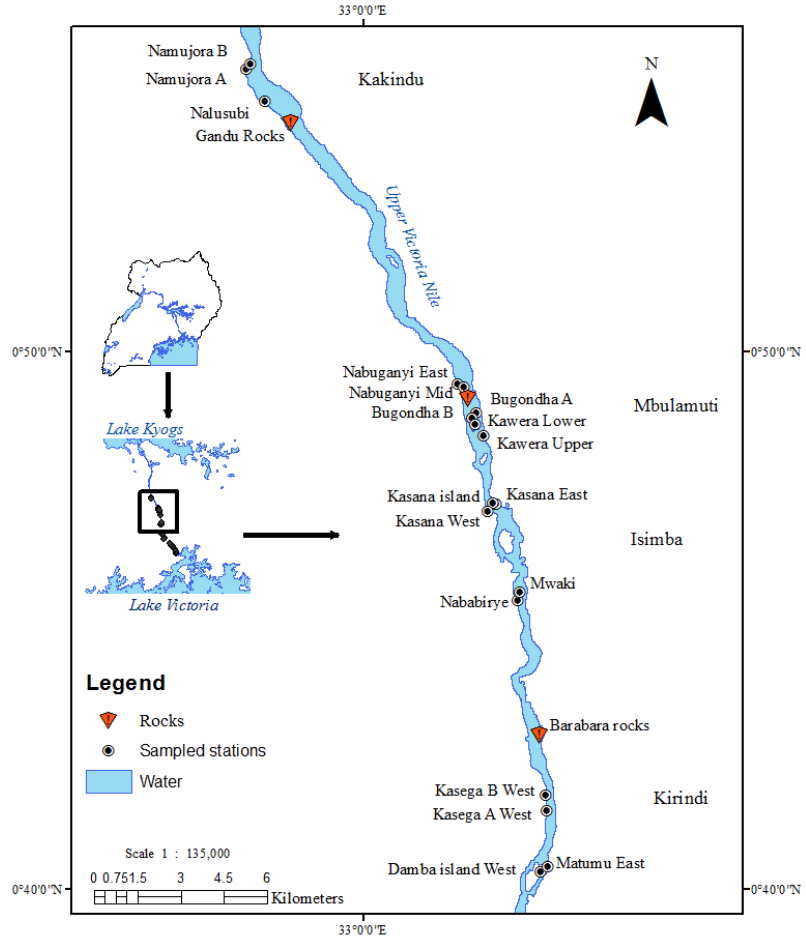
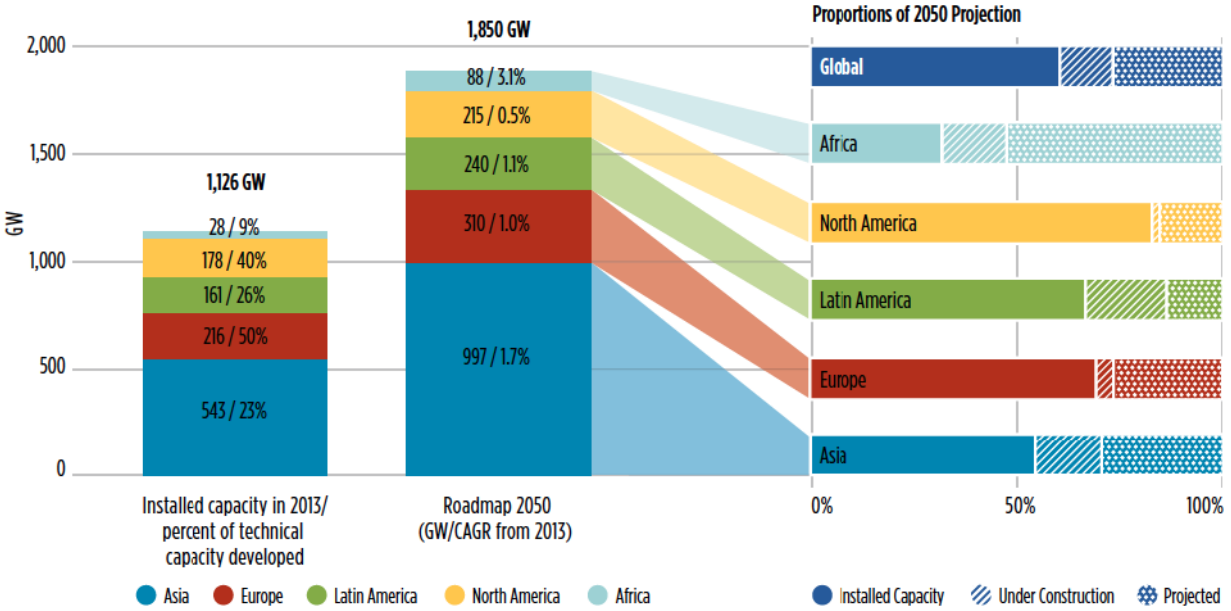


Bujagali Dam area



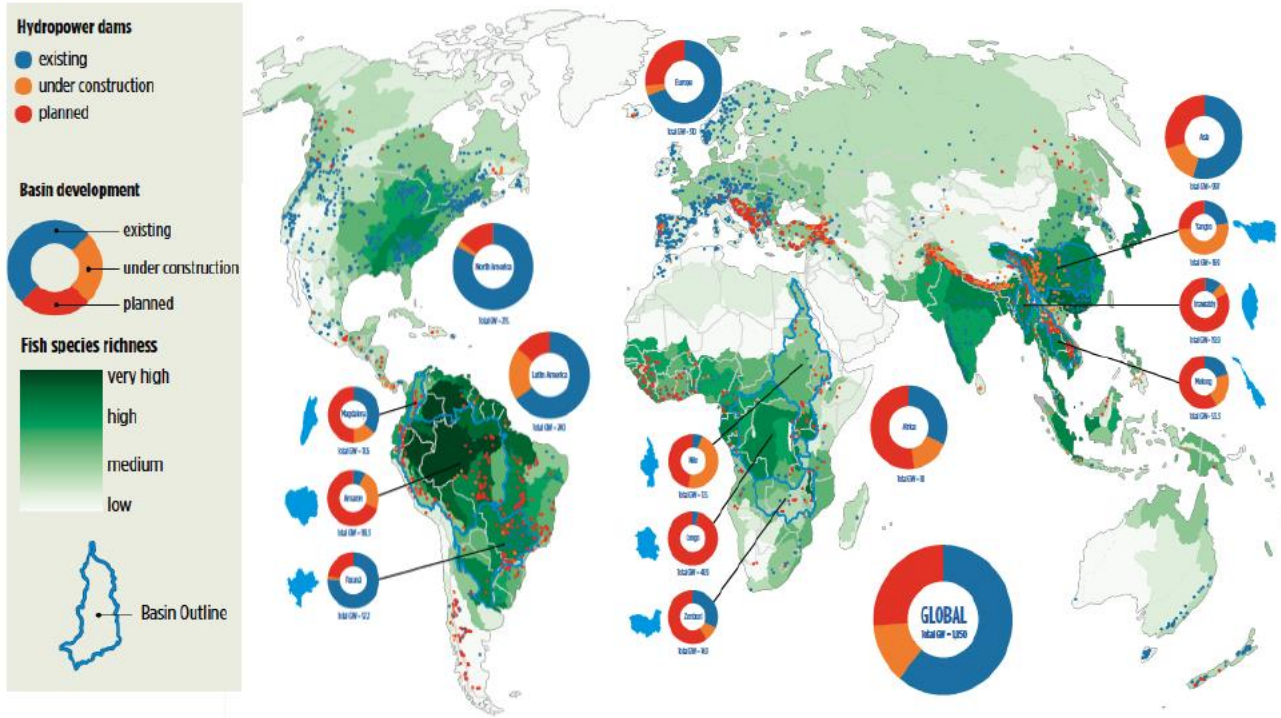
Isimba Dam area

Current and projected future global installed hydropower capacity



http://www.worldenergyoutlook.org

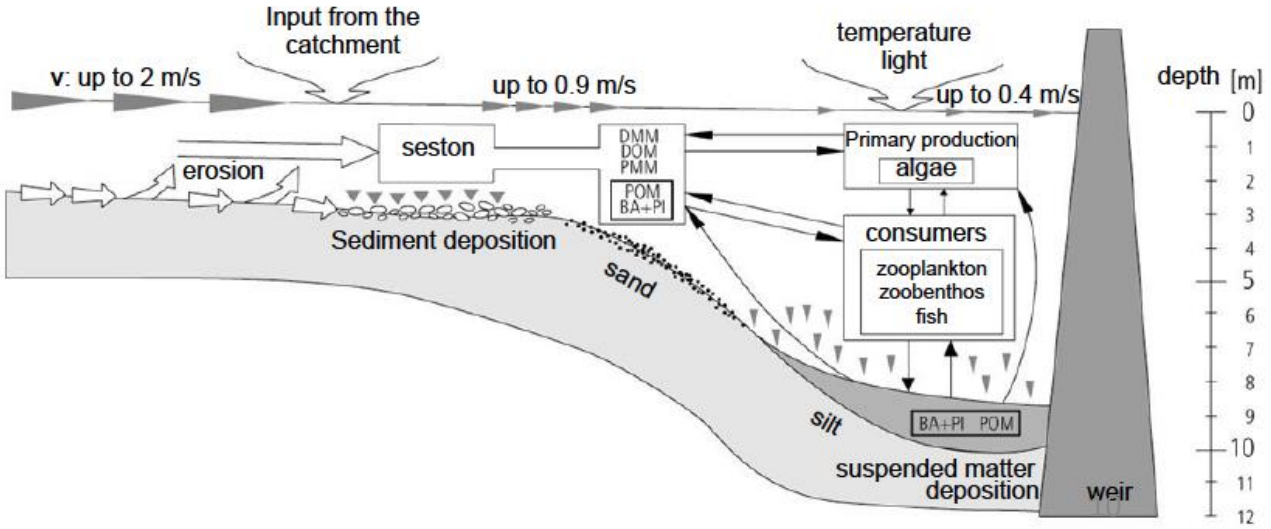
- The power of rivers: finding a balance between energy and conservation in hydropower development



Ecological impacts of dams

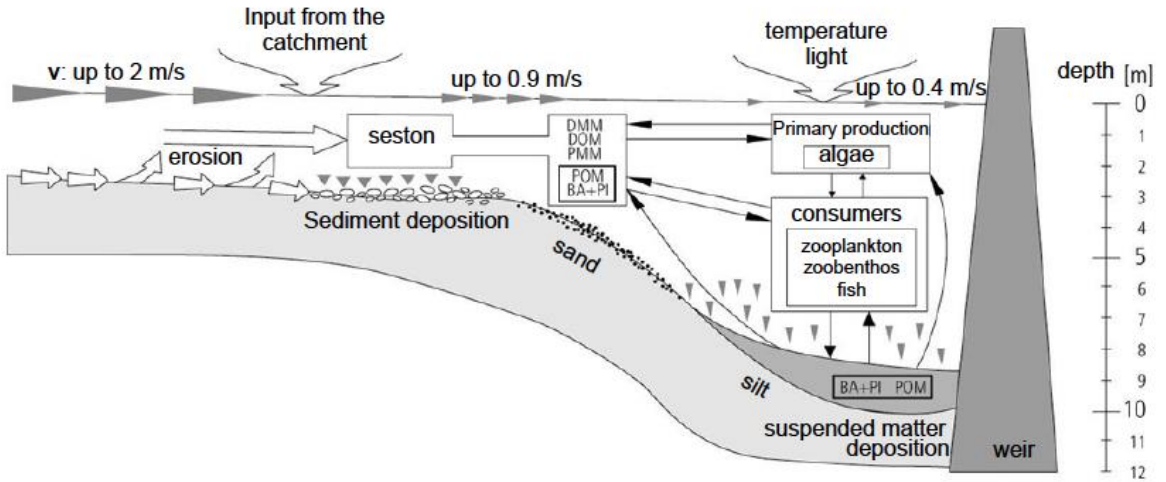
- Humans have regulated rivers since 240 BC
  - Disrupt dynamic process and impact of ecological integrity of rivers
  - Disrupt river continuum, shifts in biotic and abiotic parameters

- Order of impacts on environment
  - 1st order: - immediate abiotic effect
  - 2nd order: - changes in channel and floodplain biology
  - 3rd order: - long term biotic changes " new equilibrium"



Ecological impacts of dams..

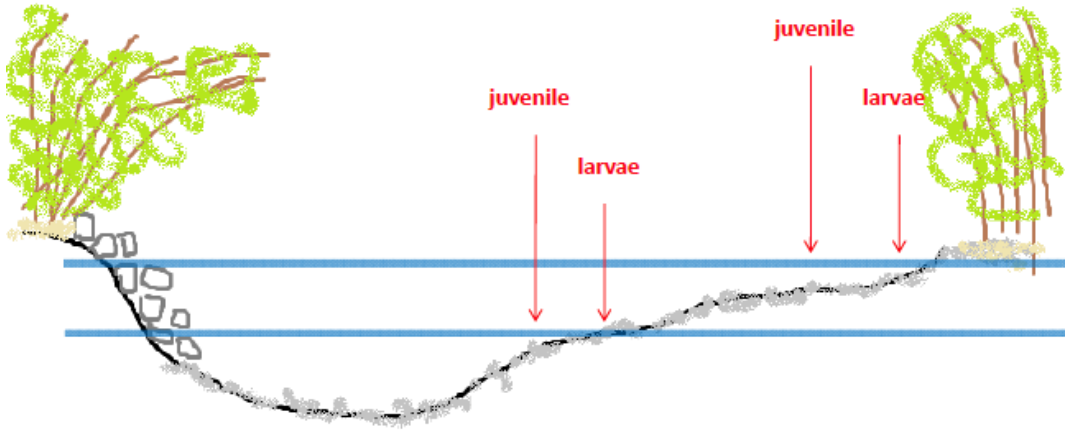
- Loss of free-flowing sections (neither lake nor river)
  - Running water becomes still,
  - Deep water zones &
  - Temperature and dissolved oxygen changes



- Disconnection of river continuum
  - Prevention of spawning
  - Deposition of sediments
  - Sediment deficit downstream
  - Anadromous (salmons) and potamodromous fish – Loss of the breeding stocks
  - No downstream movement of larvae and juveniles
  - Reduced downstream productivity
  - Filters out woody debris – macro invertebrates habitats

Ecological impacts of dams…

- Destabilization of groundwater levels
  - Raising water level upstream
  - Lowering water level downstream
- Disconnection of floodplains/waterbodies
  - Changes in estuarine discharge,
  - reduced supply of nutrients and fisheries productivity
- Hydropeaking : - rapid fluctuation caused by hydropower operations (peak vs off peak)
  - Drift of biotic communities
  - Altering hydrological regime (i.e., water balance vs. water loss)
  - Change of habitats (low biomass, missing species, disturbed population structure)

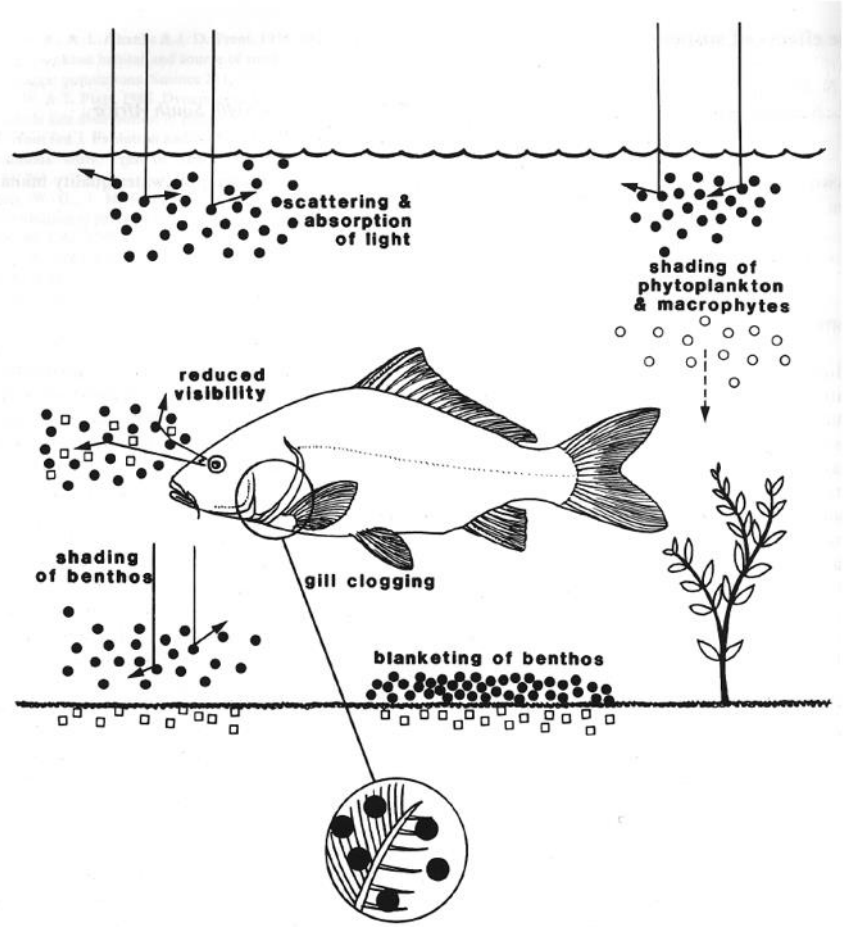


Ecological impacts of dams….

- Reservoir flushing - This is due to siltation upstream of the reservoirs
  - Destruction of fish communities (eggs, larvae, juveniles and adults)
  - Gas bubble diseases in fish &
  - Temperature and dissolved oxygen changes
  - Loss and reduction of benthic invertebrates
  - Changes in turbidity

Photo credit: Boku (Field trip in Austria)

Impacts of turbidity ➔



Bruton, 1985

Ecological impacts of dams…..

- Instability for riverine species
  - Running water becomes still,
  - Deep water zones &

- Colonization of deep zones by vectors and other species (exotic species)

Kariba weed at Isimba dam site

Fish species richness (all, and haps) around Bujagali

Taxa	Upstream	Reservoir	Downstream	All transects
Bagrus docmak	-	2.3	4.2	1.2
Haplochromines	57.7	-	20.8	37.0
Lates niloticus	17.5	56.8	66.7	35.2
Mormyrus kannume	3.1	15.9	-	6.1
Oreochromis niloticus	-	2.3	-	0.6
Oreochromis variabilis	1.0	-	-	0.6
Synodontis afrofischeri	8.2	11.4	4.2	8.5
Synodontis victoriae	4.1	11.4	-	5.5
Coptodon zillii	5.2	-	4.2	3.6
Labeobarbus altianalis	3.1	-	-	1.8

Fish species richness (all, and haps) around Bujagali, (Oct, 2021)

Ecological impacts of dams….. Aswan High Dam

- Protection from floods and drought
- Increased agricultural production
- Electricity production
- Improved navigation

- Relocation of 1 lakh people
- Coastal erosion
- Health problems (Bilharzia -*Schistosomiasis*, waterborne disease)
- Sardine catch declined from 18,000 tons in 1962 to 85,90 tons in 1992
- 30 of 47 fish species becoming economically or biologically extinct

Ecological impacts of dams……

- Filtering out large organic debris (woody debris) which provides habitat and sustain a food chain
  - Divert, slow and speed current in a river
  - Most rivers, 4% is woody debris supplying 60% of invertebrates biomass and 75% of drifting invertebrates (Bryant & Sedell, 1995)
- Changes in estuarine discharge, reduced supply of nutrients and fisheries productivity
  - Some species are adapted to strong seasonal flow
  - 47 commercial fish species in the Nile before Aswan High Dam, only 17 harvested 10 years after the completion of the dam (Abromovitch, 1996)

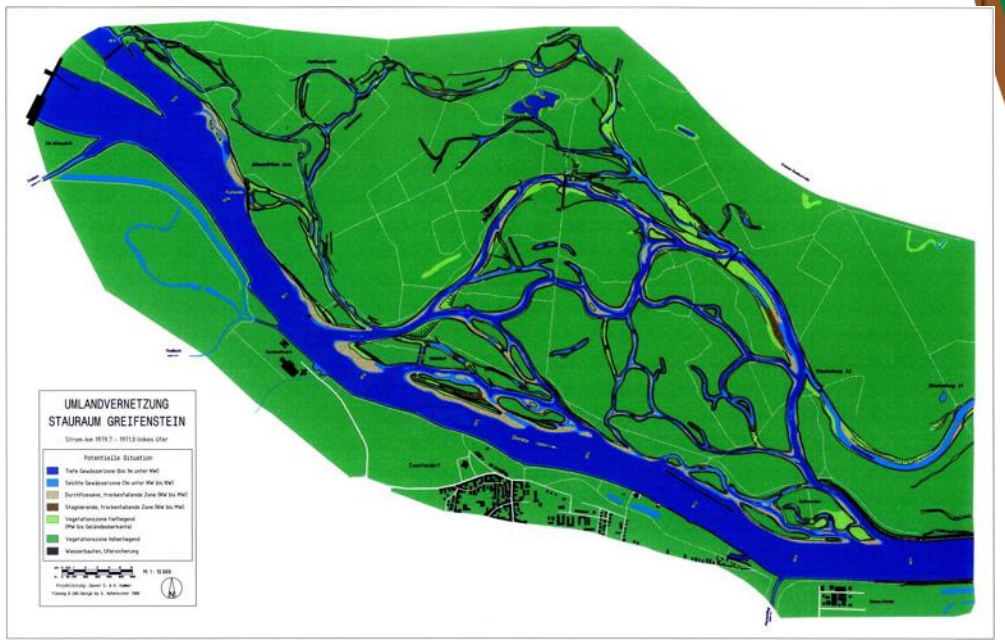
Ecological impacts of dams…….

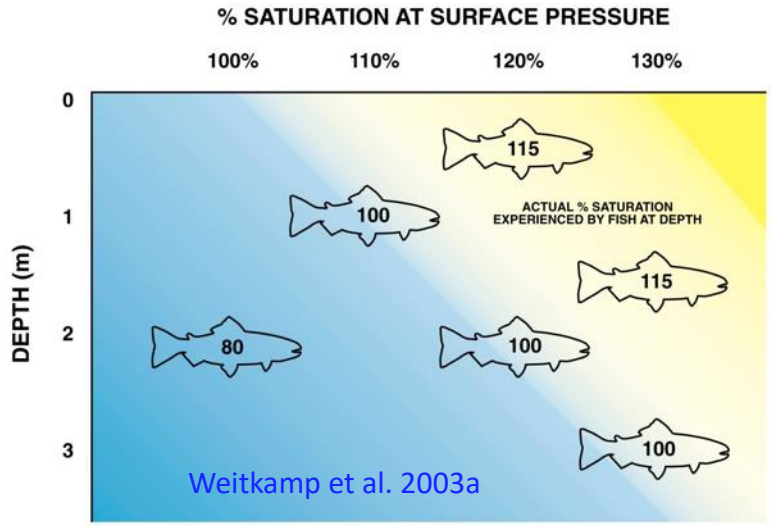
- Reservoirs trap suspended particles - hence reduced turbidity downstream
  - Turbid water catfishes have small eyes, refined sense of smell and touch in their barbels,
  - Increased predation by birds &
  - Sediment barrowing species reduce
  - Filter feeders may flourish
  - Extinction of mollusks
  - Suspended silt may reduce the feeding efficiency of filter feeding bivalves

- Water table changes due to diversions for irrigations
  - Residual flow – Environmental flow requirements
  - Turbine injuries and mortality

Measures to mitigate impacts of dams

- Use of fish turbine friendly
- Construction of fish passes and possibly fish ladders
- Regulated sediment flushing and discharge downstream
- River restoration projects from small dams
- Spill flows controls to regulate the saturation of gases for hydrostatic pressure compensation

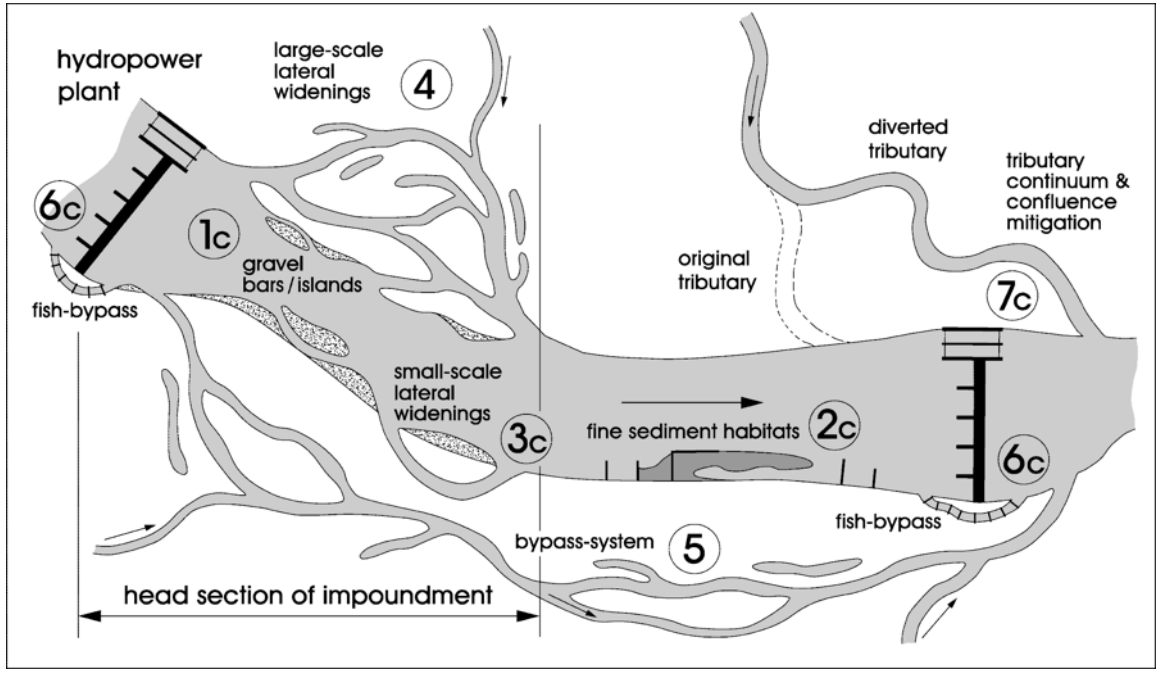


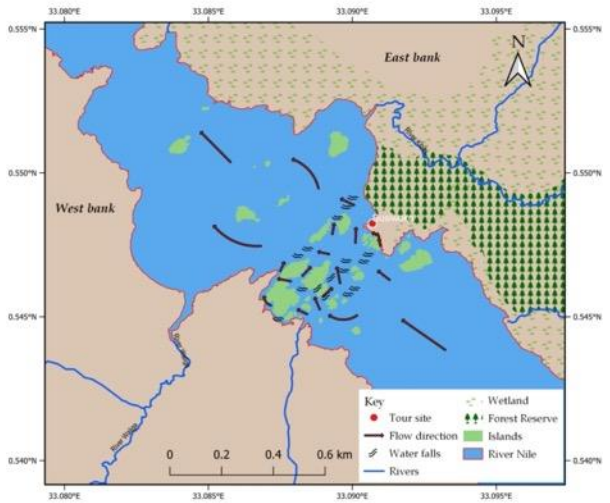


Measures to mitigate impacts of dams

- Re-establishment of flowing sections (lowering of impoundment level)
- Removal/elimination of dams
- Restoration of possibility by means of fish passes
- Habitat improvement of the head of impoundment – Offset areas

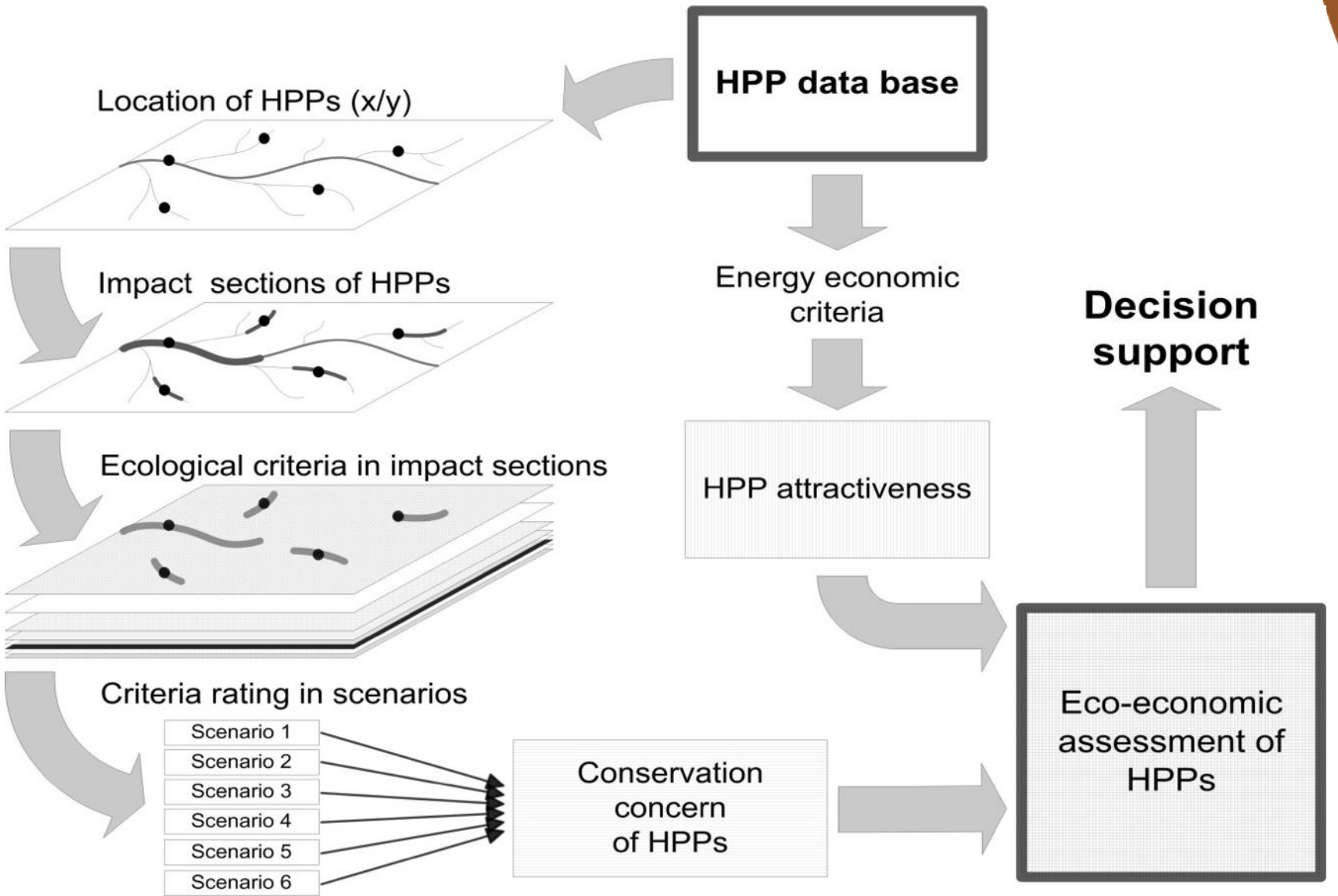
Weitkamp et al. 2003a





Measures to mitigate impacts of dams…

- Strategic planning for locations of hydropower plants



General conclusion

- Dams accrue humans with high energy, water supply, transportation, flood protection, fishing and recreation

- Dams alter river ecosystems and ecological processes

Thank you

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