Conjunctive use of transboundary surface and groundwater resources

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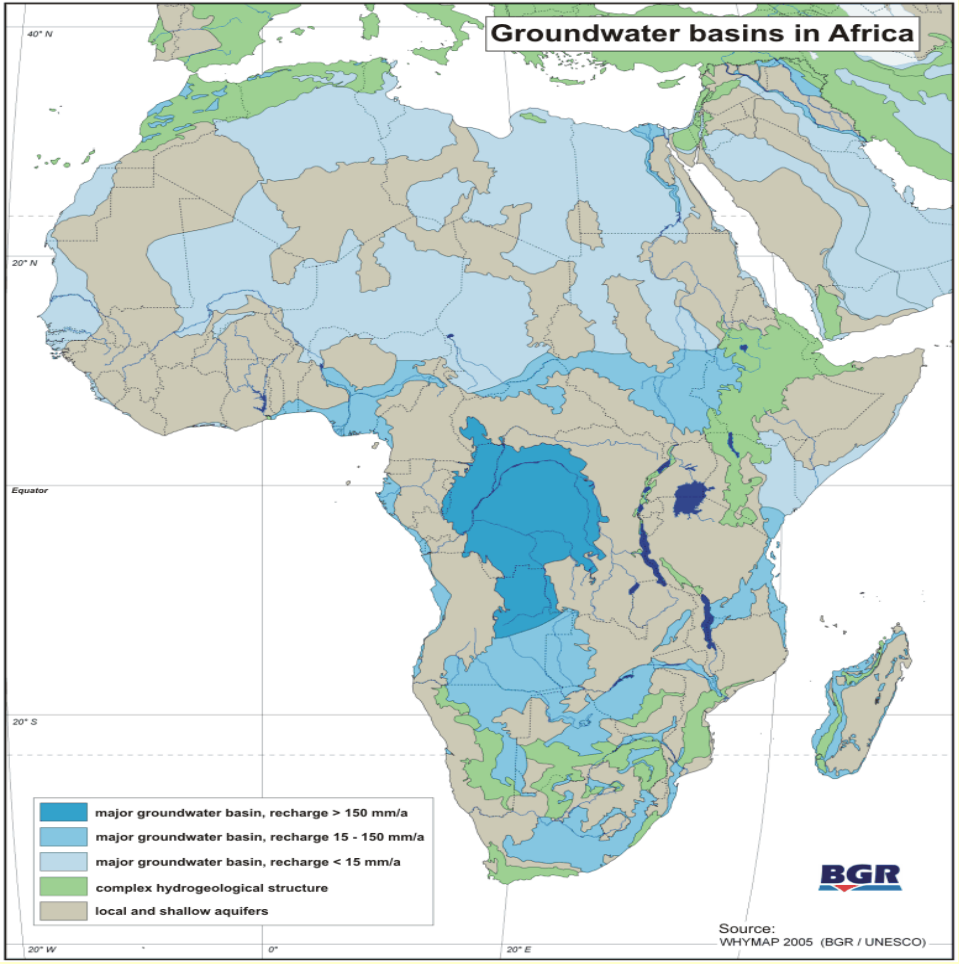
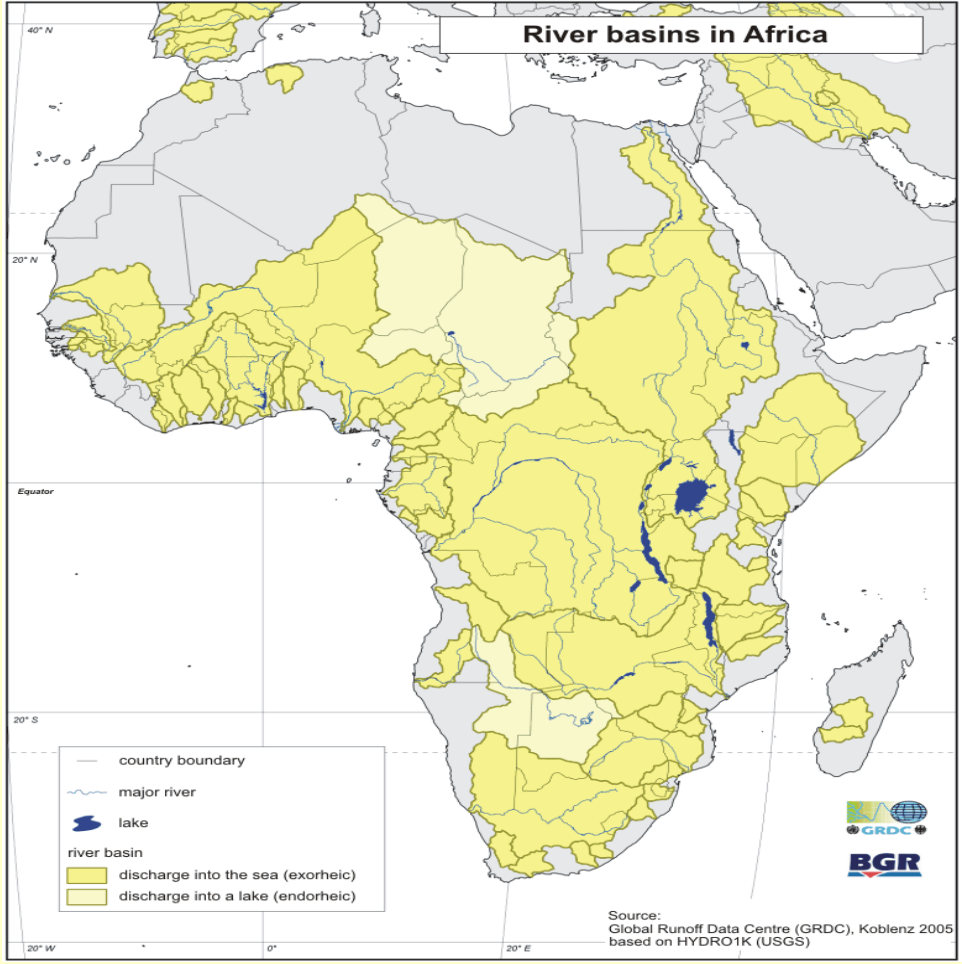
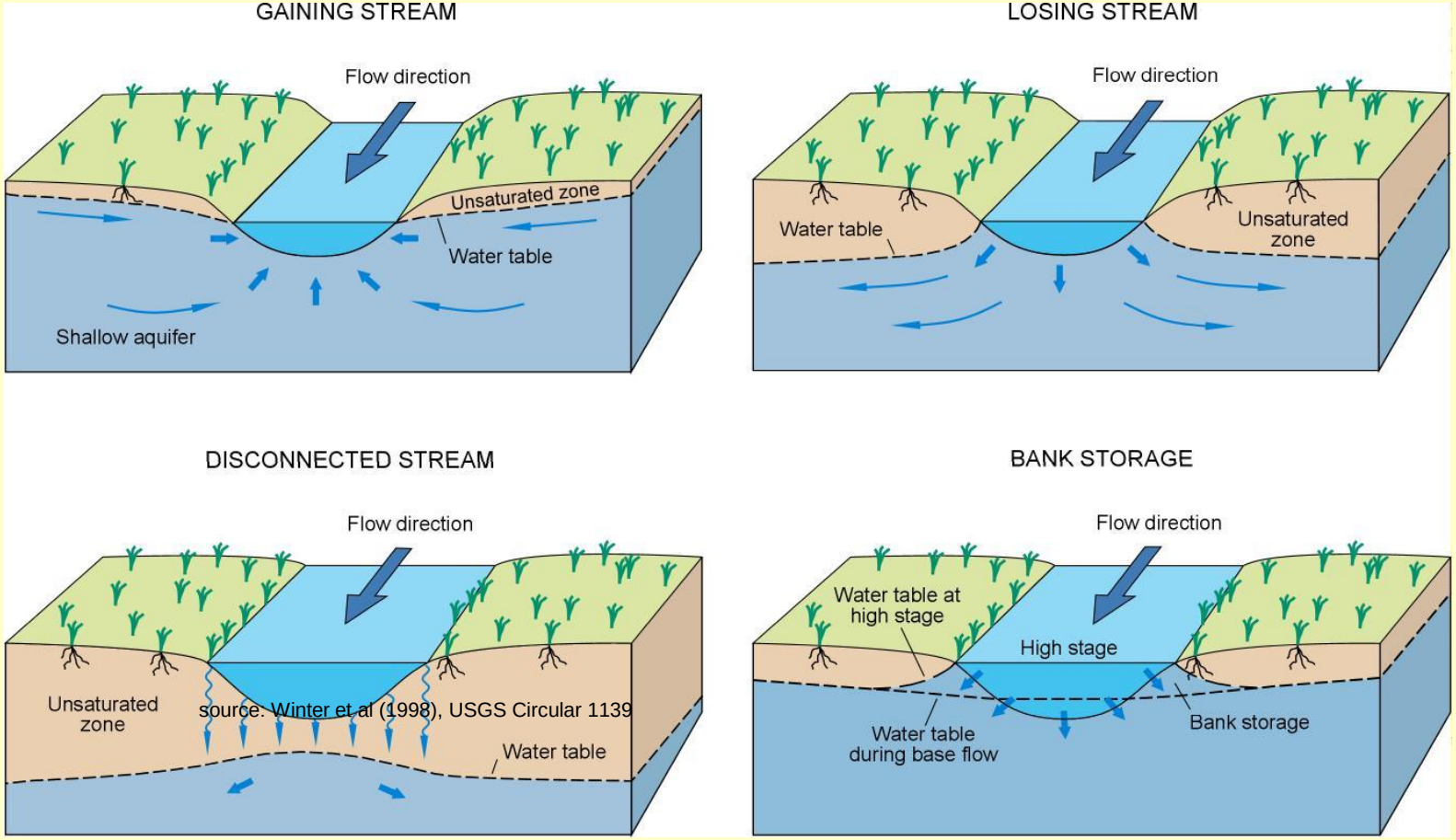




- River basin and the aquifer boundaries may not coincide, especially in sedimentary environments
- Significant volumes of inter-basin water transfer may occur
- Potential for river basin and aquifer management authority conflicts
- Complex interactions take place and conjunctive management is needed

Interaction of groundwater and surface water



source: Winter et al (1998), USGS Circular 1139

Transboundary Aquifer Constellations

- Phreatic aquifer
- GW connected to river
- Countries sharing the same aquifer

Figure 1: Riparian constellation: Type A

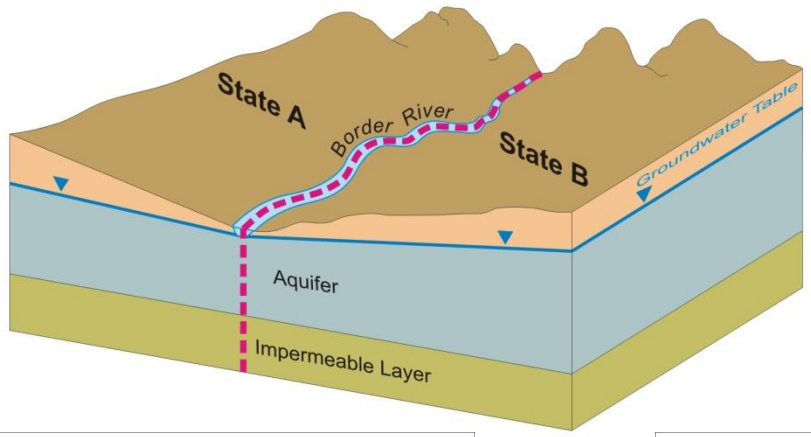
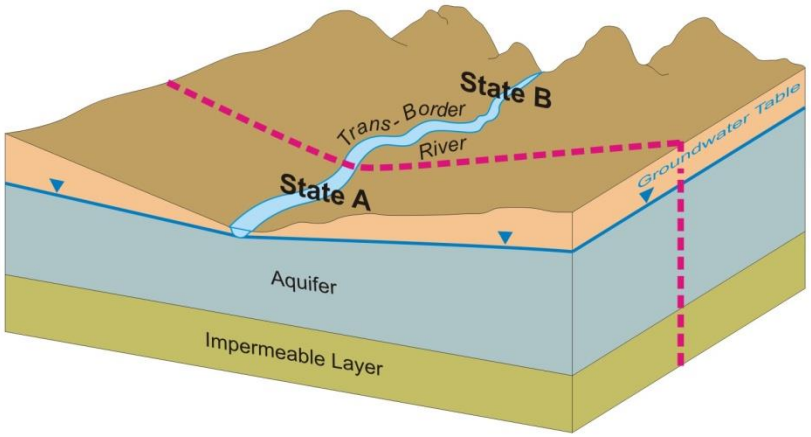
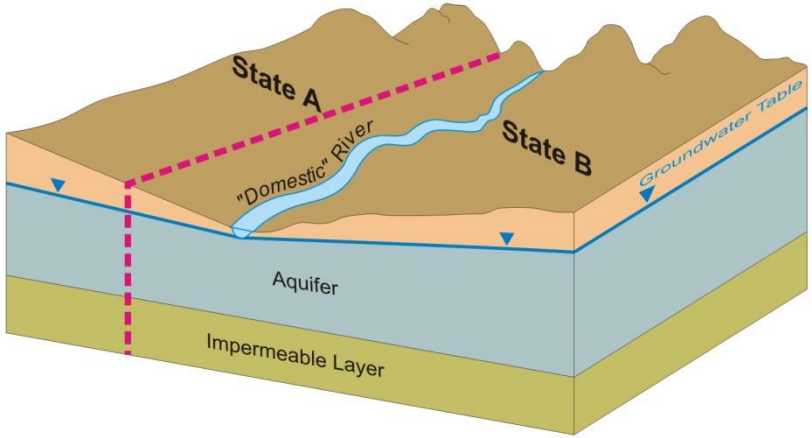


Figure 2: Riparian constellation: Type B



Source: Eckstein / Eckstein (2005)

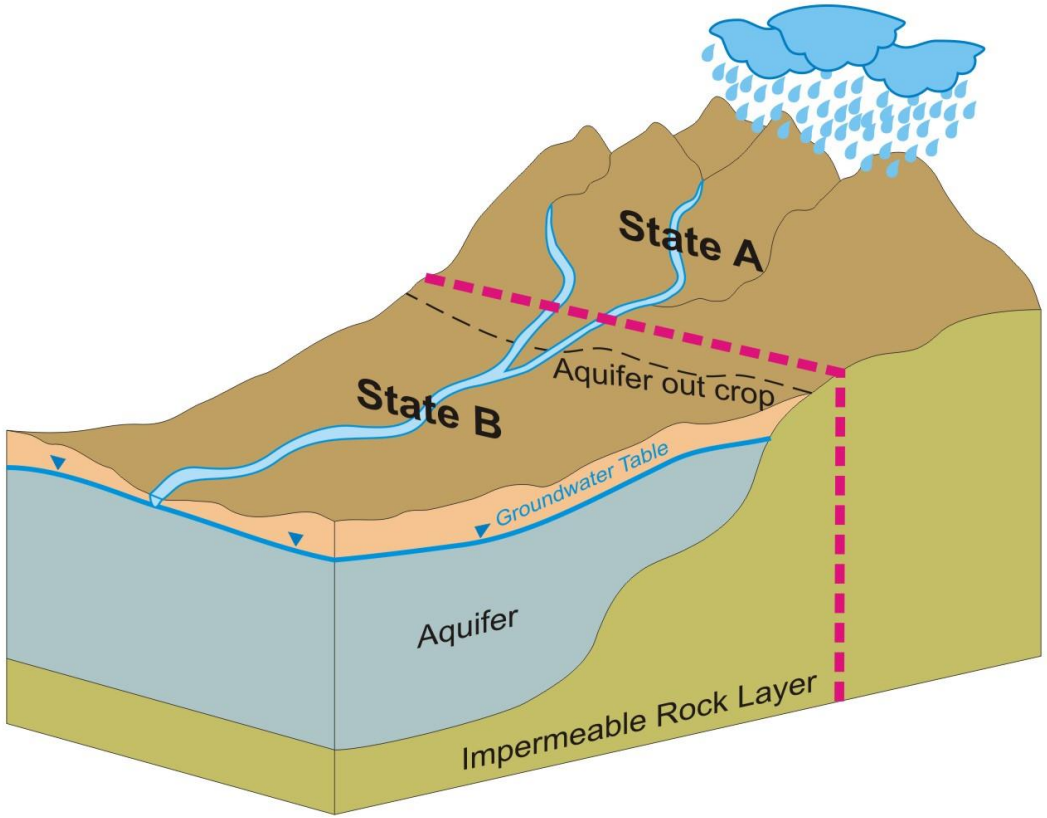
Figure 3: Riparian constellation: Type C



Source: Eckstein / Eckstein (2005)

- Phreatic (water table) aquifer
- River connected to GW in aquifer
- Inflow of river water from uphill state A across border
- State A outside aquifer, just connected by river

Figure 4: Riparian constellation: Type D

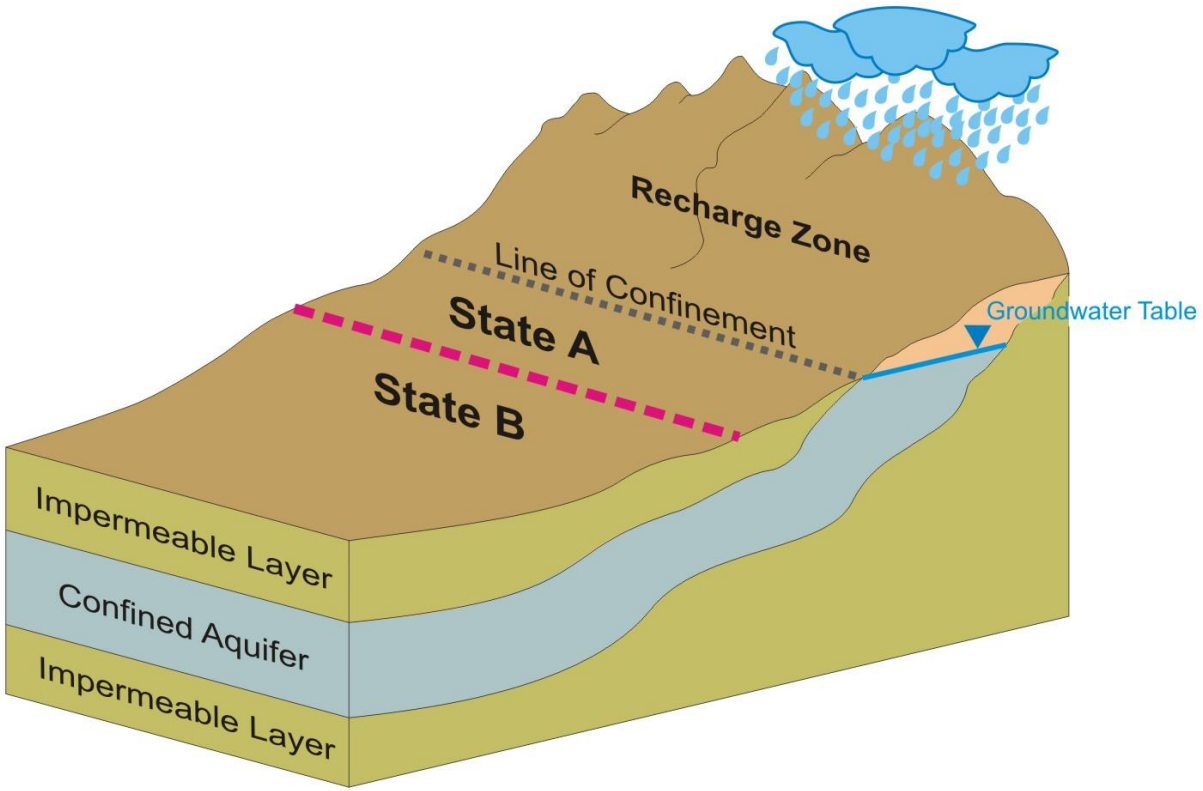


Source: Eckstein / Eckstein (2005)

- Confined, deep aquifer
- No relation with surface water
- Recharge (free water table) only in state A, but confined aquifer shared by states A and B

= what, if state B heavily abstracts confined GW and lowers GW table?

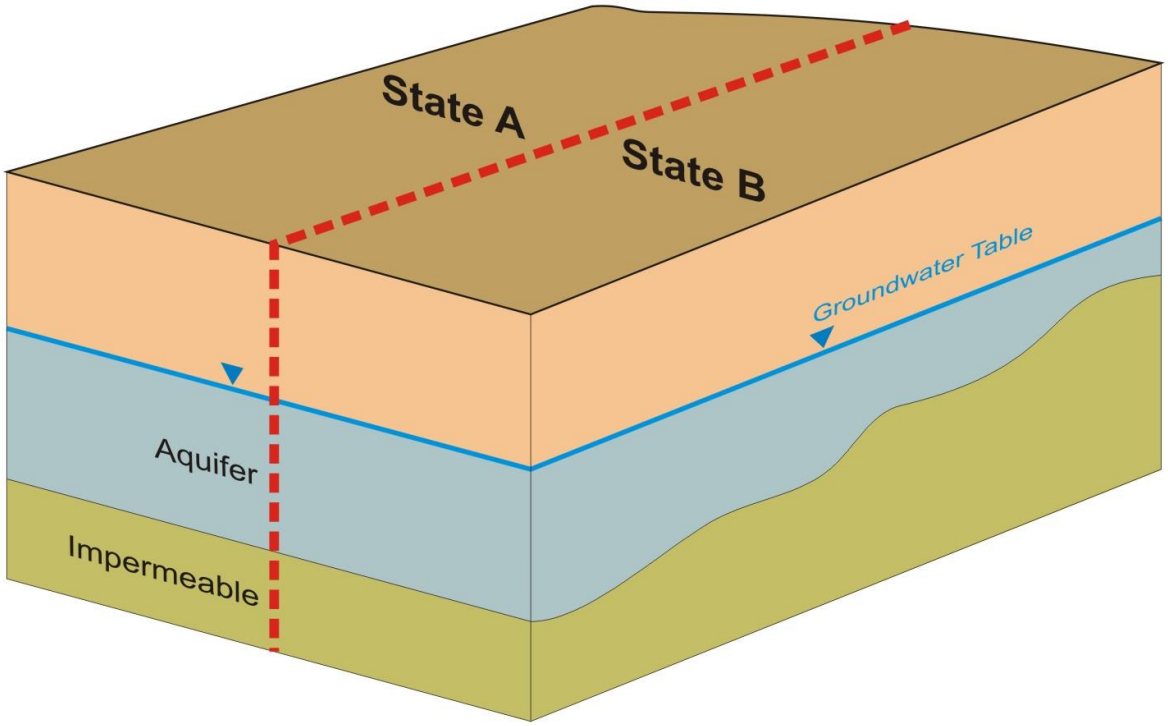
Figure 5: Riparian constellation: Type E



Source: Eckstein / Eckstein (2005)

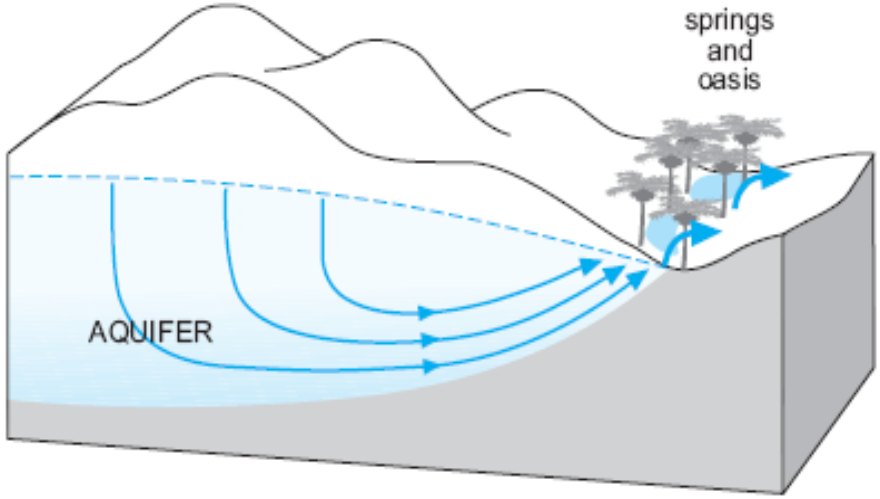
- Usual setting for aquifers with non-renewable GW
- Deep water table
- Little or no gradient
- No surface water and no connection with GW

Figure 6: Riparian constellation: Type F



Source: Eckstein / Eckstein (2005)

GW and Environment

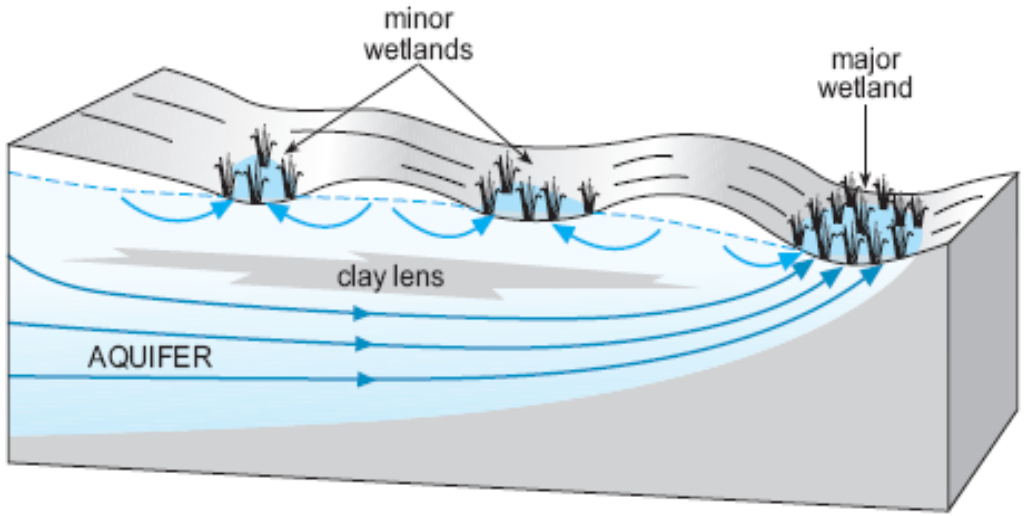


(A) WETLAND ECOSYSTEM IN ARID REGION

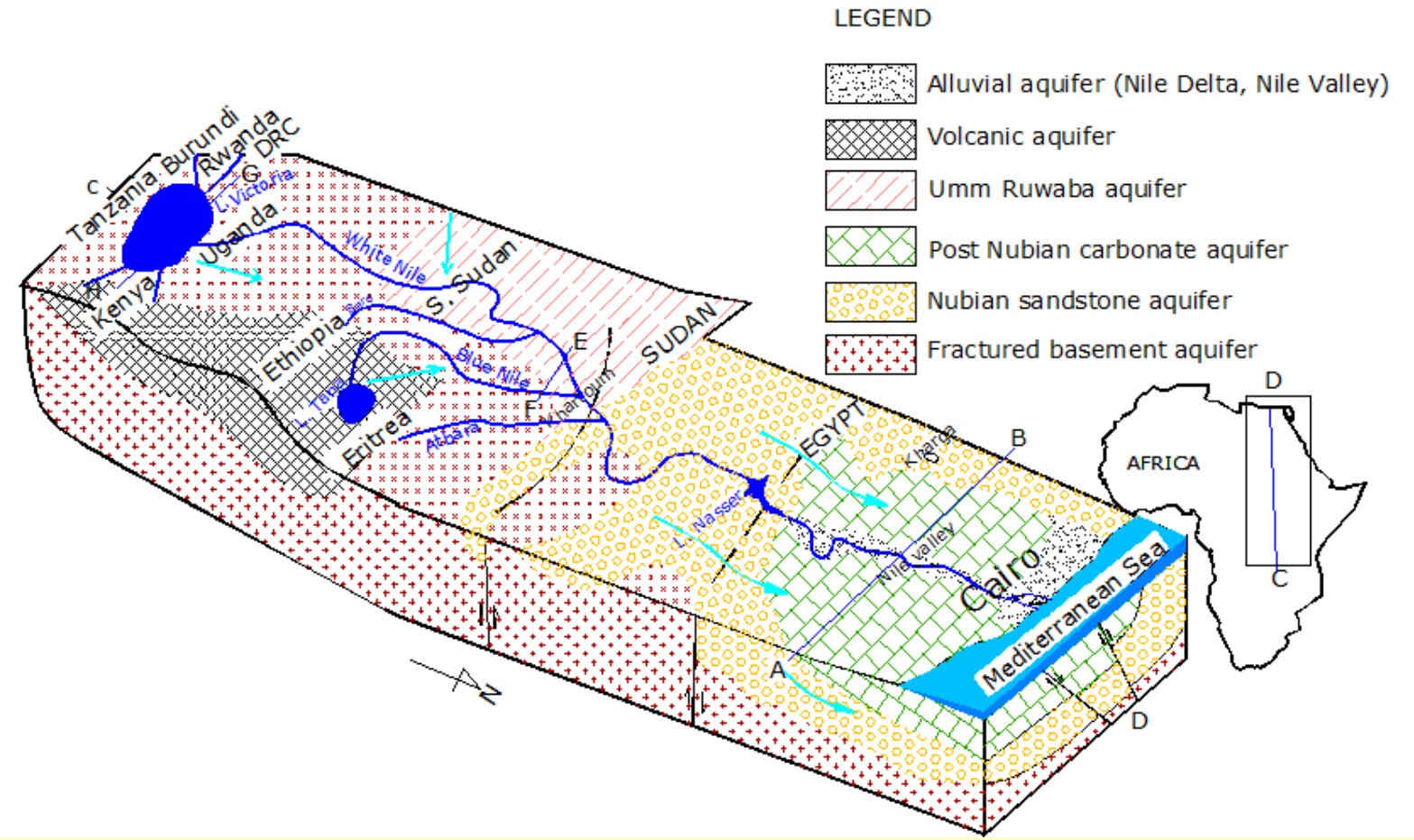
dependent upon deep groundwater flow system, sometimes with only limited contemporary replenishment and fossil aquifer flow

(B) WETLAND ECOSYSTEM IN HUMID REGION

individual ecosystems can be dependent upon (or using) groundwater from different depths in a multi-layered aquifer flow system

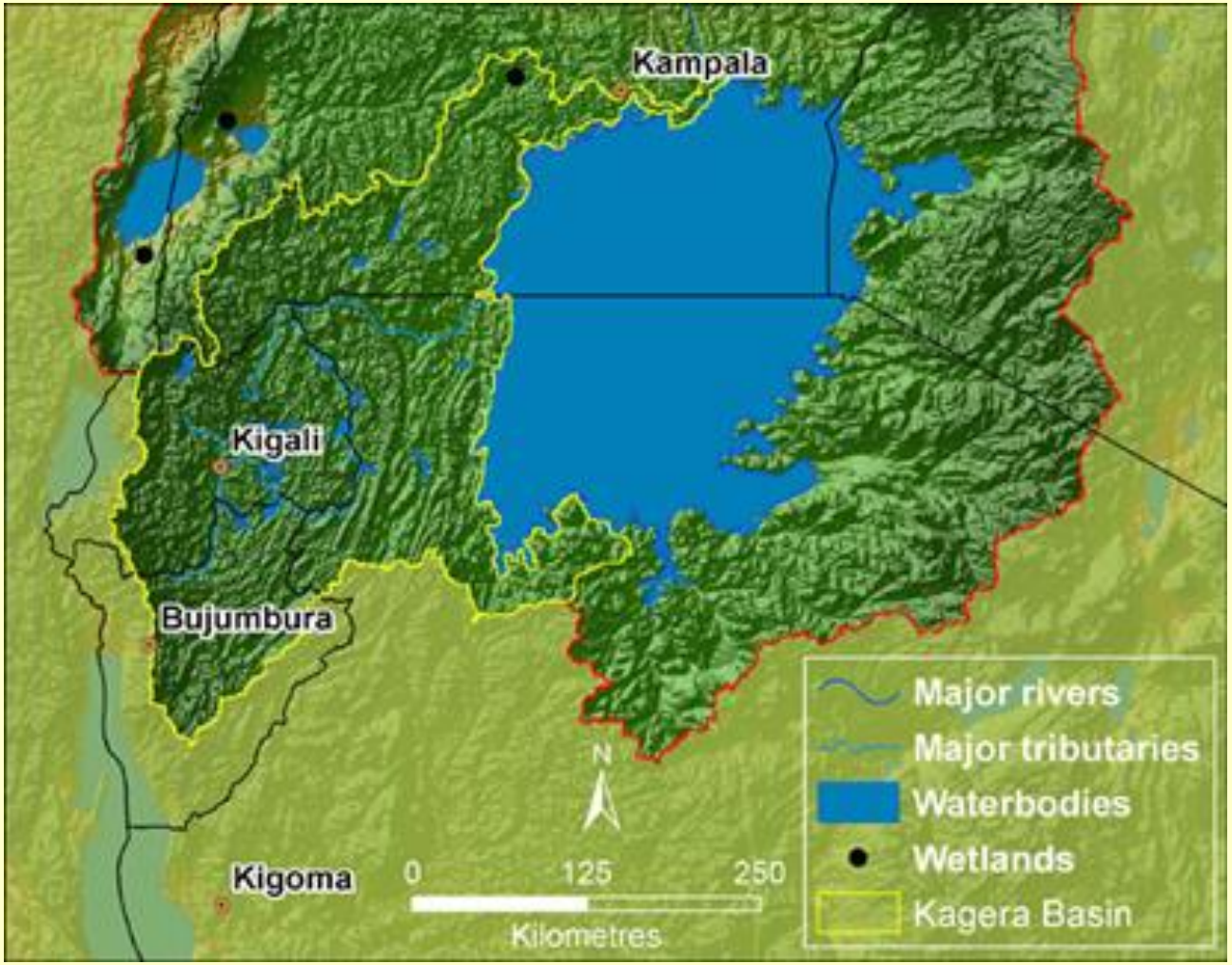


Conceptual model of surface water-groundwater interactions in the Nile basin



After Alemayehu *et al. (2016)*

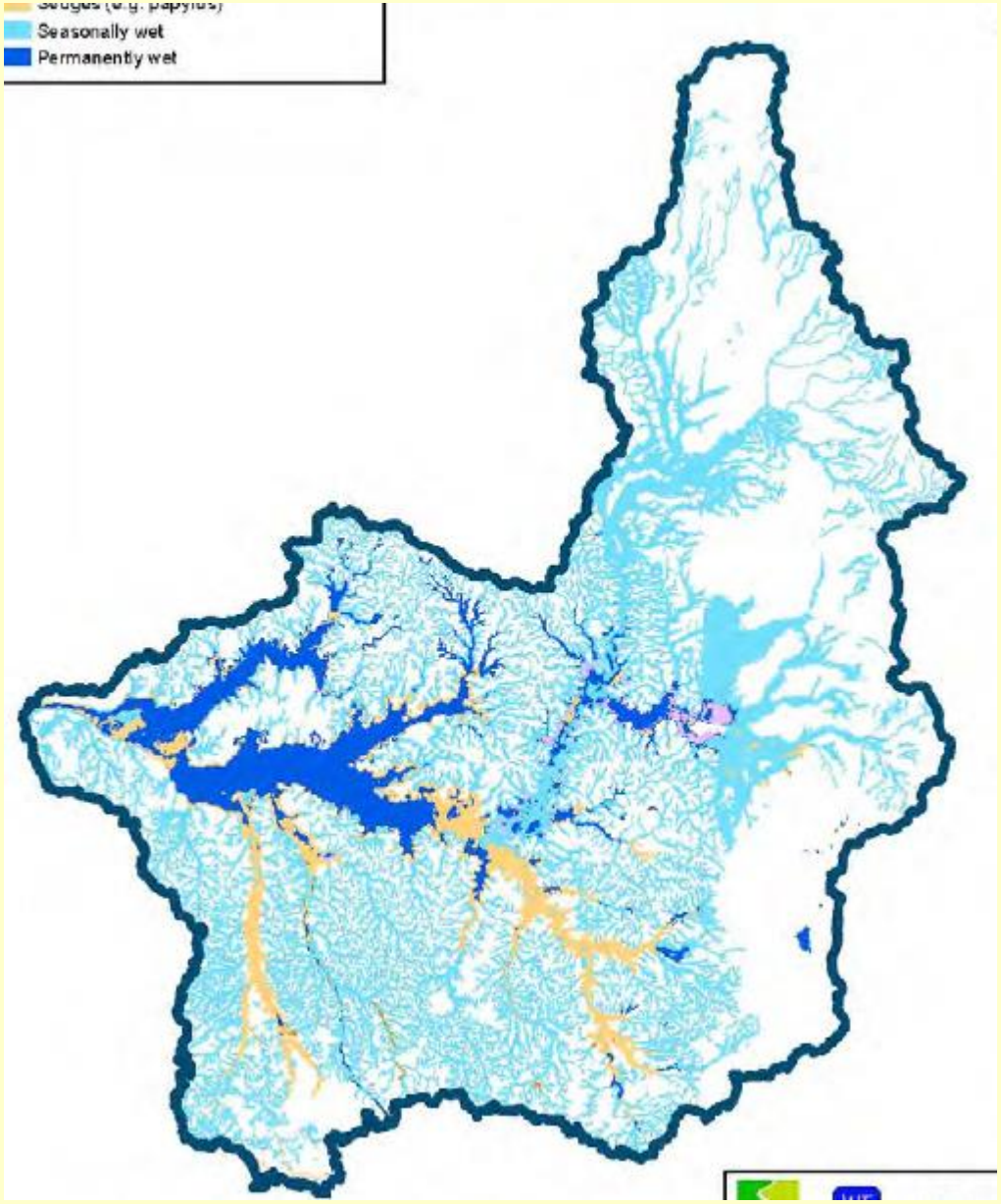
NBI- Unplanned Conjunctive Use
Inadequate Regulatory Frameworks



- City water supplies around L.Victoria e.g **Kampala and Kigali** -primary source of water supply is surface water – unplanned production well drilling –satellite towns - could affect surface water yields

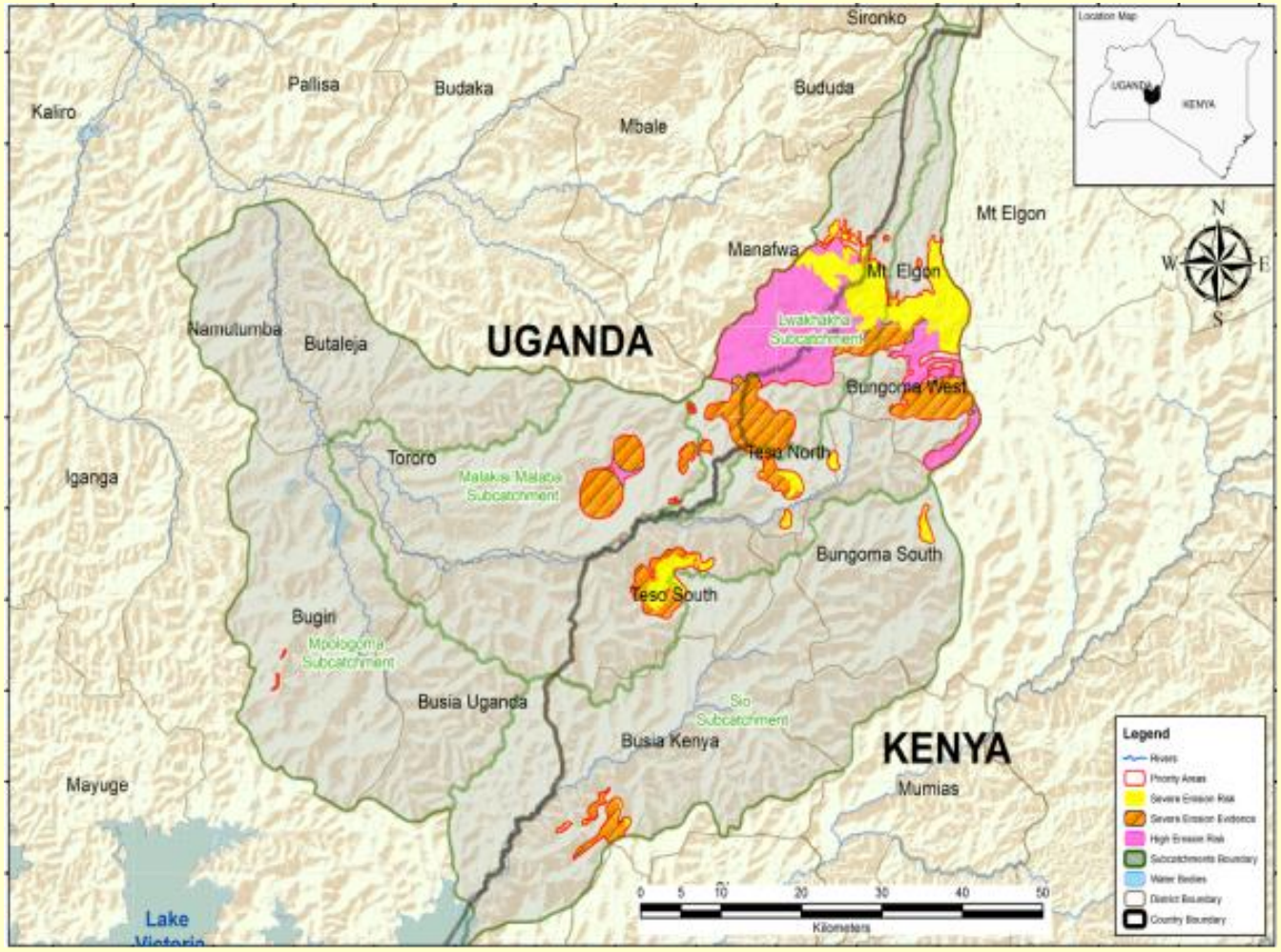
Planned Conjunctive use

Watershed approach to sub basin development



- Lake Kyoga basin – planned water supply, livestock and small holder irrigation served by both ground and surface water
- Dar-es-salaam water supply – main town served by surface water from dams- satellite towns supplied by ground water

Ground Water - Surface Water Interactions – River Basin management



- Terraces (Ethiopia, Kenya-Uganda etc
- Dams for water harvesting and ground water recharge (numerous)
- Infiltration galleries and sand dams in semi arid Uganda and Kenya (Turkana- Area)

Management Interventions

- Where possible, the entire water cycle should be managed in an integrated way, with all inflows and outflows to / from the water balance accounted for

- Conjunctive use of surface water and groundwater allows managers to make use of the large volumes of surface water flows during the rainy season and the large stored groundwater volumes in the dry season.