Groundwater quality in river basins

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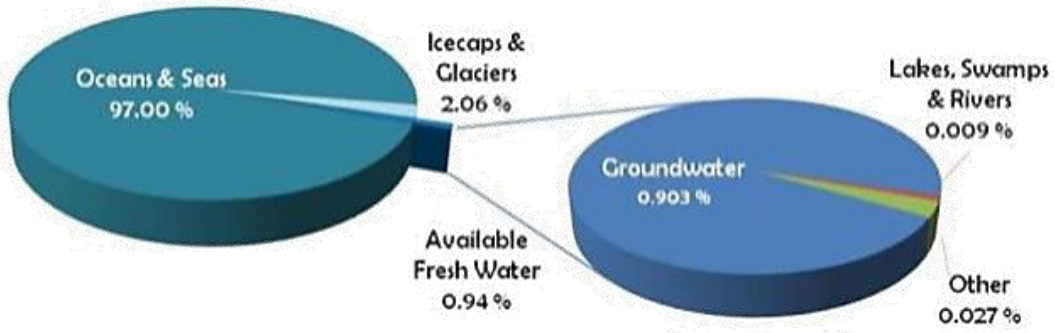
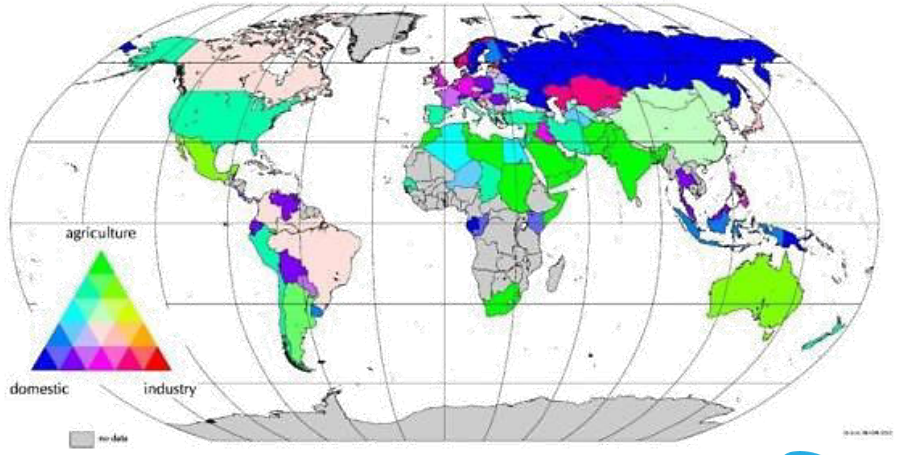
Groundwater: From a global perspective & Why a global groundwater quality assessment is needed



- About **50% of people globally** obtain drinking water from GW
- GW provides over **40% of world's irrigation water**
- Access to (good quality) GW for drinking and irrigation is impacted by **economic status**
- Meeting **SDGs will increase demand** for GW
- GW **sustains important ecosystems** such as wetlands, **keeps our rivers flowing** during droughts
- Aquifer systems offer **potential buffer** against impacts of **climate change**

- **Human activities** (e.g. growth of population, wealth), **climate variability** are **increasing pressures** on GW resources
- Protection of GW resources necessary for **protecting human health, maintaining food supplies and conserving ecosystems**
- GW is **poorly understood and often poorly managed**: vital resource needs to be protected from impacts of overexploitation and pollution



Global groundwater consumption per sector

www.groundwater-quality.org

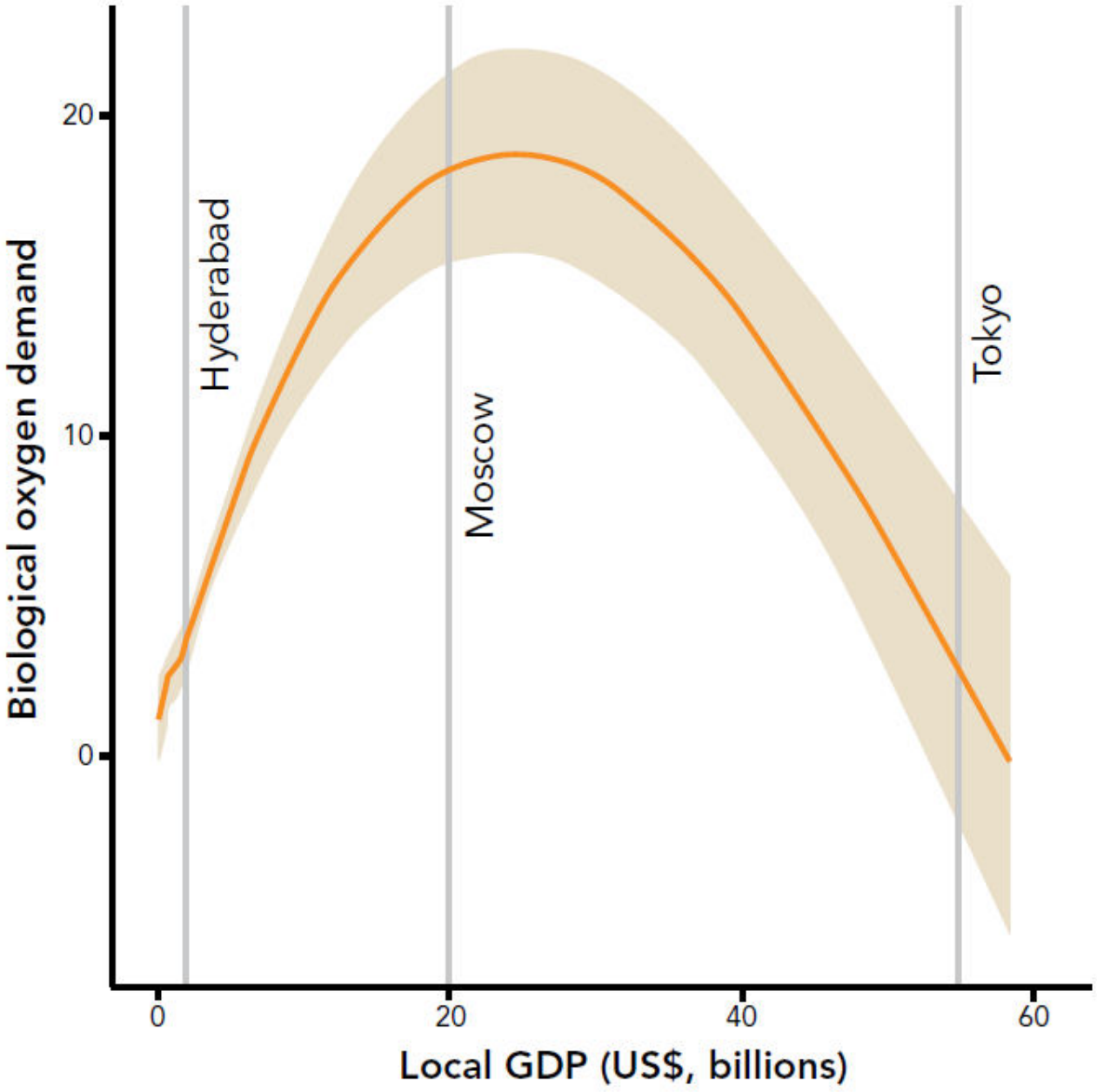
WWQA
World Water Quality Alliance

Impacts of poor water quality

Poor Water Quality harms economies

Water Quality lowers GDP of countries by a third

Economic impact of poor water quality is felt in Poor and Wealthy nations alike.

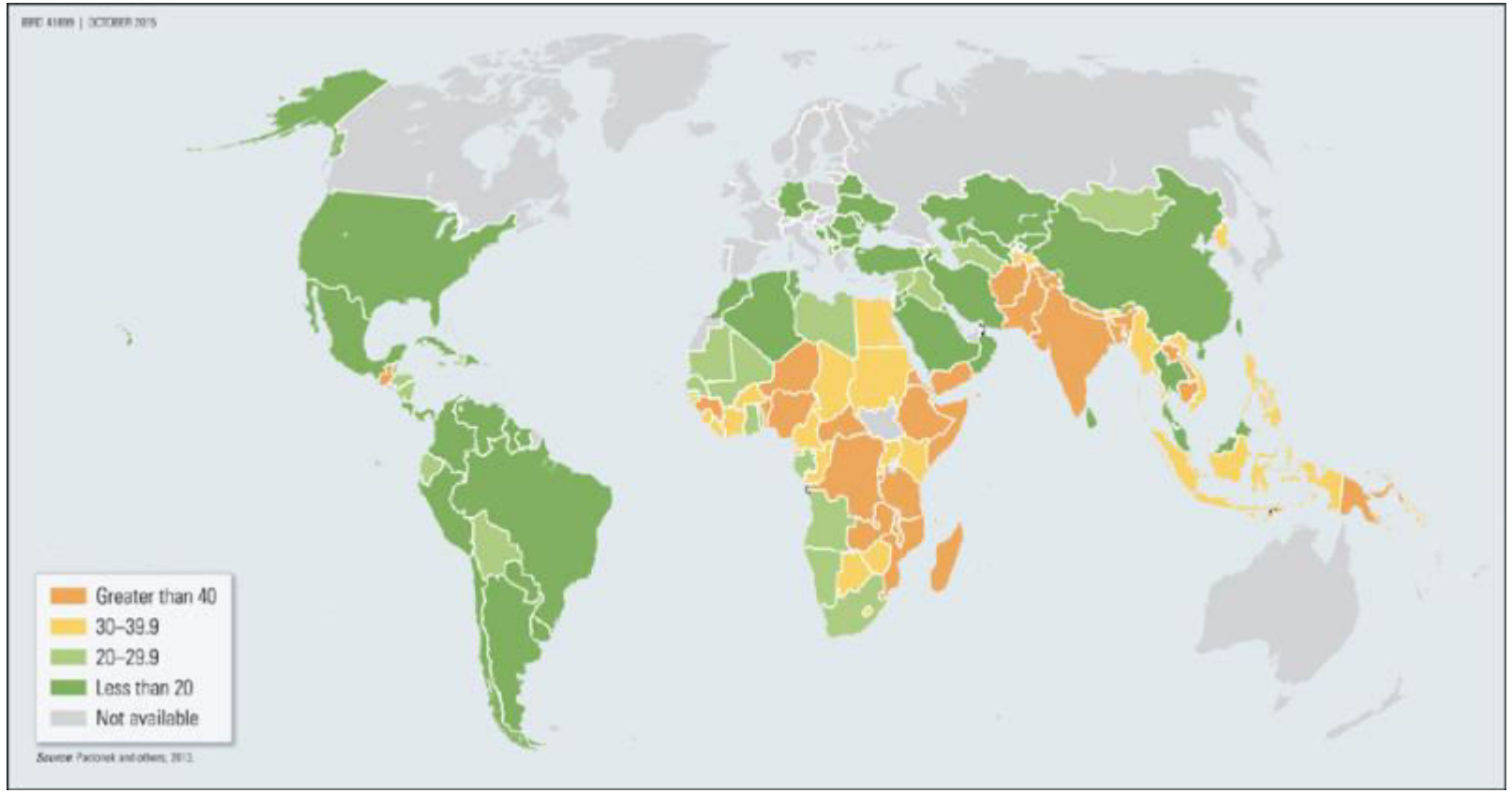


www.worldbank.org/qualityunknown

Poor Water Quality shortens people and shortens life

A host of water- and excreta-related diseases contribute to higher rates of undernutrition, anemia, and inflammation—conditions that impair cognitive functioning and physical development in children and whose impacts can be long lasting. The accumulation of these conditions throughout childhood often results in the physical marker of stunting, which occurs when a child is more than two standard deviations below the reference height for the age cohort.

Stunting is generally caused by lack of nutrition, which prevents the body from developing to its potential. This could be the result of consuming too few macro- and micronutrients or exposure to an adverse disease environment, especially diarrheal diseases that prevent the body from absorbing nutrients that are consumed. A plethora of water- and excreta-related diseases affect the gastrointestinal tract and can give rise to diarrheal diseases. As a result, poor sanitation and poor water quality are the second and third leading risk factors for stunting worldwide,



Global Stunting Prevalence Estimates among Children Younger than Age Five Years; UNICEF, WHO, and World Bank 2012.

Water Quality affects food production

Enough food to feed 170,000,000 is lost to saline waters

Unknown new pollutants emerging everyday

Impacts of emerging contaminant largely unknown

Pharmaceuticals/hormones

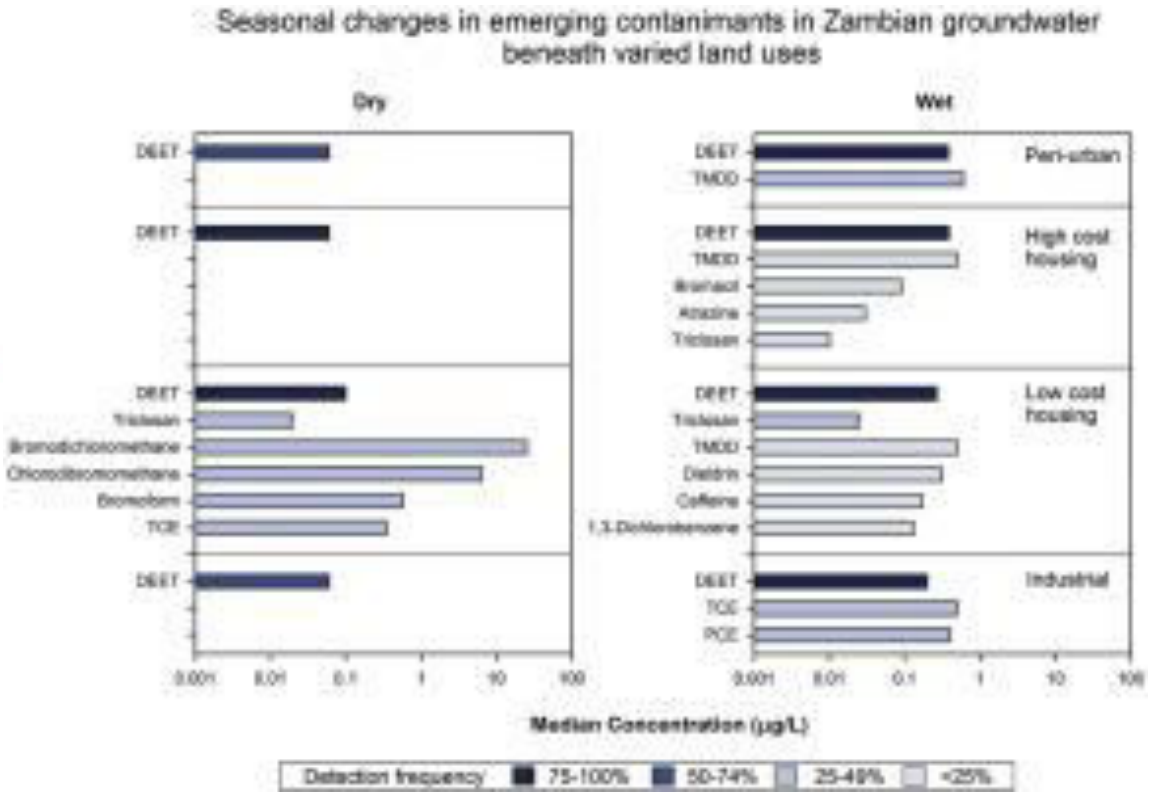
PFAS

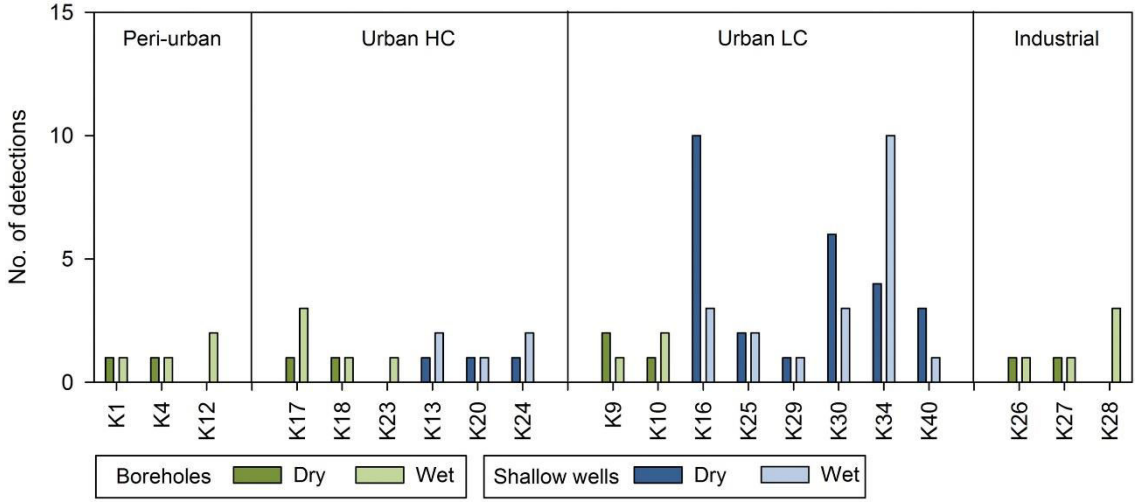
Drug resistant Bacteria

Viruses/COViD 19

Micro-plastics

Synthetic fibers





Emerging contaminants in urban groundwater sources in Africa

J.P.R. Sorensen [a], D.J. Lapworth [a], D.C.W. Nkhuwa [b], M.E. Stuart [a], D.C. Gooddy [a], R.A. Bell [a], M. Chirwa [b], J. Kabika [b], M. Liemisa [c], M. Chibesa [c], S. Pedley [d]

Examples of Impacts of poor water quality in Africa

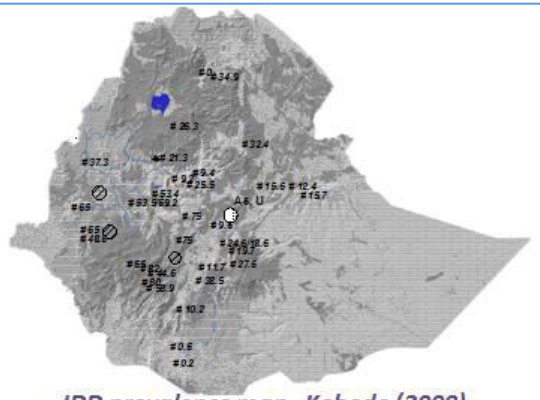
Affects human health

- Groundwater is the pathway for particulates to get to human metabolism- Salinity, Fluoride, Nitrate, etc

- Concentrations of fluoride above 1.5 mg/l in drinking water can cause dental and skeletal fluorosis. These clinical conditions are commonly encountered in the groundwaters of the Rift Valley.
- With dental fluorosis, the teeth have brown discolouration. Pitting and chipping of the teeth cause functional problems. Dental fluorosis is a life-long handicap
- Skeletal fluorosis is caused by high concentrations of fluoride in drinking water consumed over many years.

RiPPLE, Factsheet

Top figure- Dental fluorosis in Youngester in and Bottom photo showing people affected by skeletal fluorosis Photos from Gizaw- MAWARI Project



IDD prevalence map , Kebede (2009)

- Lack of adequate iodine in foods and drinking water could lead to Iodine Deficiency Disorder (IDD).
- This causes goiter, cretinism, poor pregnancy, still birth, mental retardation and infant mortality.
- Iodine deficiency is the world's most common cause of mental retardation and brain damage and goiter incidence

- According to ministry of health and UNICEF report in 1993, 42 million people (78%) of the total population of Ethiopia are exposed to iodine deficiency, 35 million (62%) are iodine deficient, 14 million (26%) have goiter and at least one in 1000 people is cretin; with about 50,000 prenatal deaths.

Groundwater salinity is the most prominent water quality problem, and salinity affects human health!

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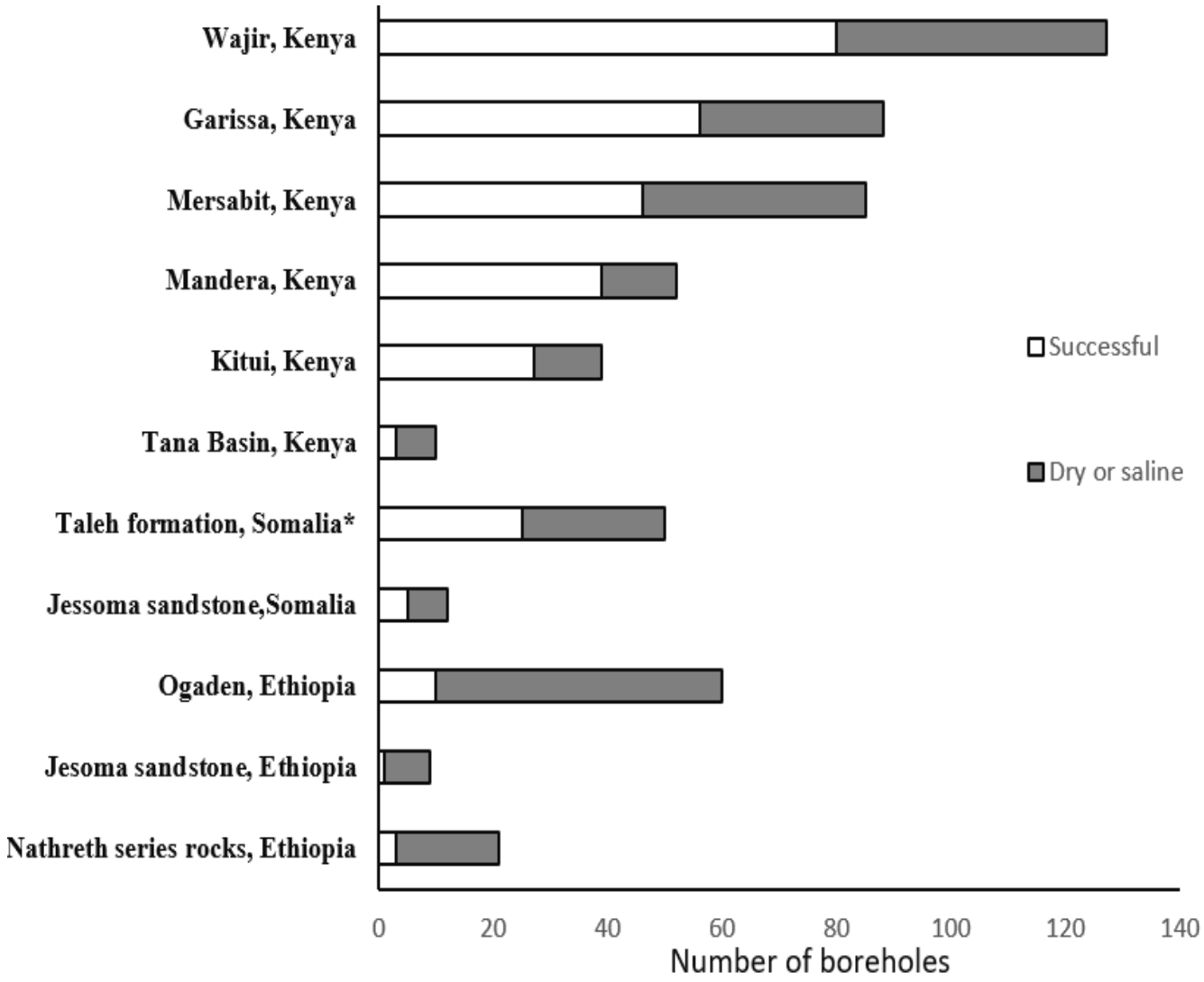
Drinking water salinity is associated with hypertension and hyperdilute urine among Daasanach pastoralists in Northern Kenya

Asher Y. Rosinger [a,b,*], Hilary Bethancourt [a], Zane S. Swanson [c], Rosemary Nzunza [d], Jessica Saunders [c], Shiva Dhanasekar [e], W. Larry Kenney [f], Kebin Hu [g], Matthew J. Douglass [h], Emmanuel Ndiema [i], David R. Braun [j,k], Herman Pontzer [c,l]

High proportion of unsuccessful Boreholes in difficult hydrogeology environments: Kenya, Ethiopia, Somalia- partly related to poor water quality

High proportion of unsuccessful Boreholes in difficult hydrogeology environments: Kenya, Ethiopia, Somalia



Kebede and Teferi 2020 in Global Groundwater

Groundwater quality uniqueness

Surface Water vs Groundwater

	Characteristic	Groundwater resources and aquifers	Surface water sources and reserv
Hydrogeological	Storage volumes	Very large	Small to moderate
	Resource areas	Relatively unrestricted	Restricted to water courses and canals
	Flow velocities	Very low	Moderate to high
	Residence times	Generally decades/centuries	Mainly weeks/months
	Drought propensity	Generally low	Generally high
	Evaporation losses	Low and localised	High for reservoirs
	Resource evaluation	High cost, significant uncertainty	Lower cost with generally less uncertain
	Abstraction impacts	Delayed and dispersed	Immediate
	Natural quality	Generally high (not always)	Very variable
	Pollution vulnerability	Variable natural protection	Largely unprotected
	Pollution persistence	Often extreme	Mainly transitory
Socio-Economic	Public perception	Mythical, unpredictable	Aesthetic, predictable
	Development cost	Generally modest	Often high
	Development risk	Less than often perceived	More than often assumed
	Style of development	Mixed public and private	Largely public

Source: ***GWMATE Briefing Note nr.1 /*** **Modified after Llamas (1998)**

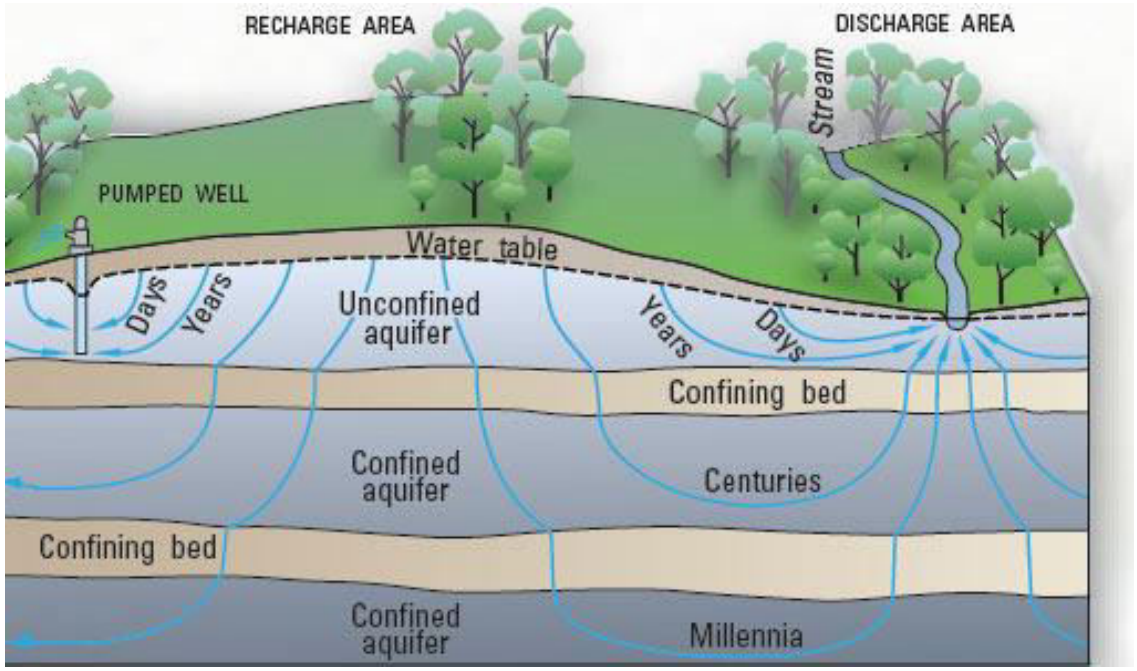
Albert Tuinhof kindly shared this slide : www.stichtingnicc.nl

Groundwater quality in the context of River and Lake Basins

Groundwaters and surface waters are connected

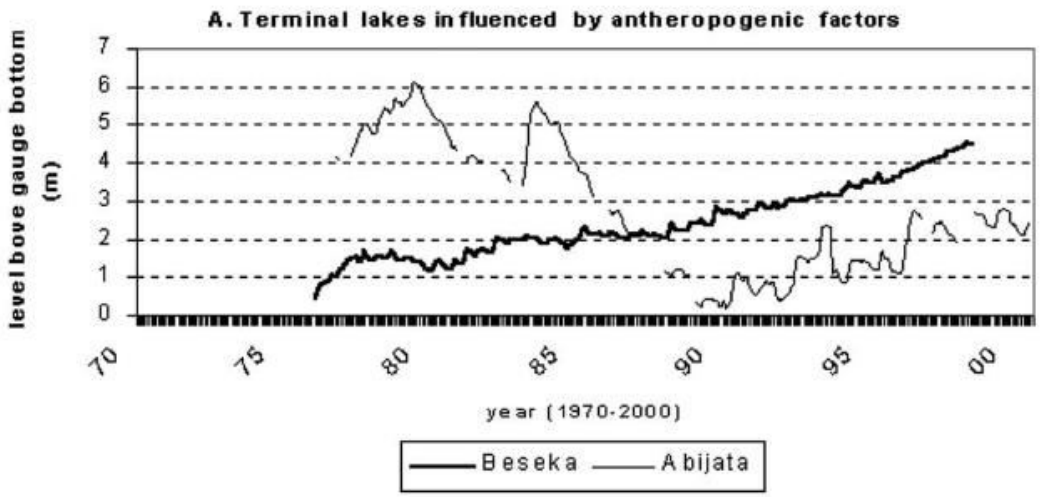
Traditionally RBOs and LBOs are surface water focused and their focus is: irrigation, flood control, hydropower development, drainage, flow regulation etc

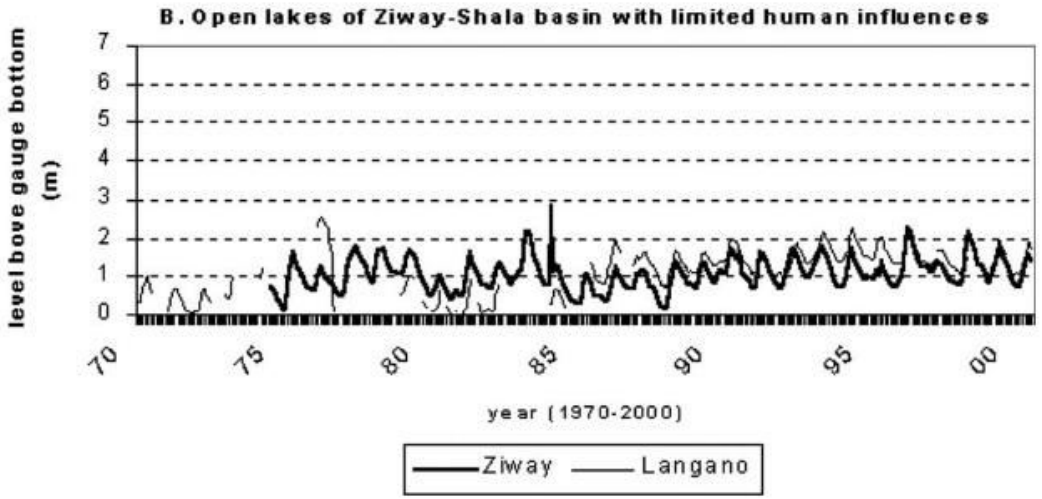
A number of emerging evidence exist that water resources development of one source impact the other source

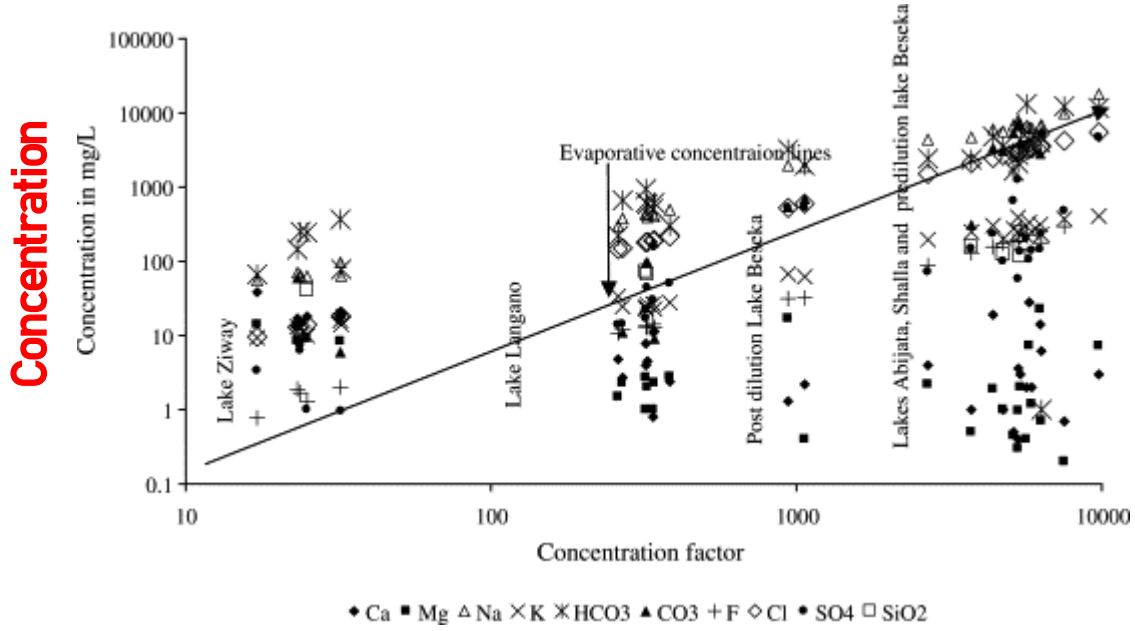


USGS

What is special about lake basins?- Clear gauges for the fact that hydrological disturbance/water balance changes leads to changes in chemistry/water quality



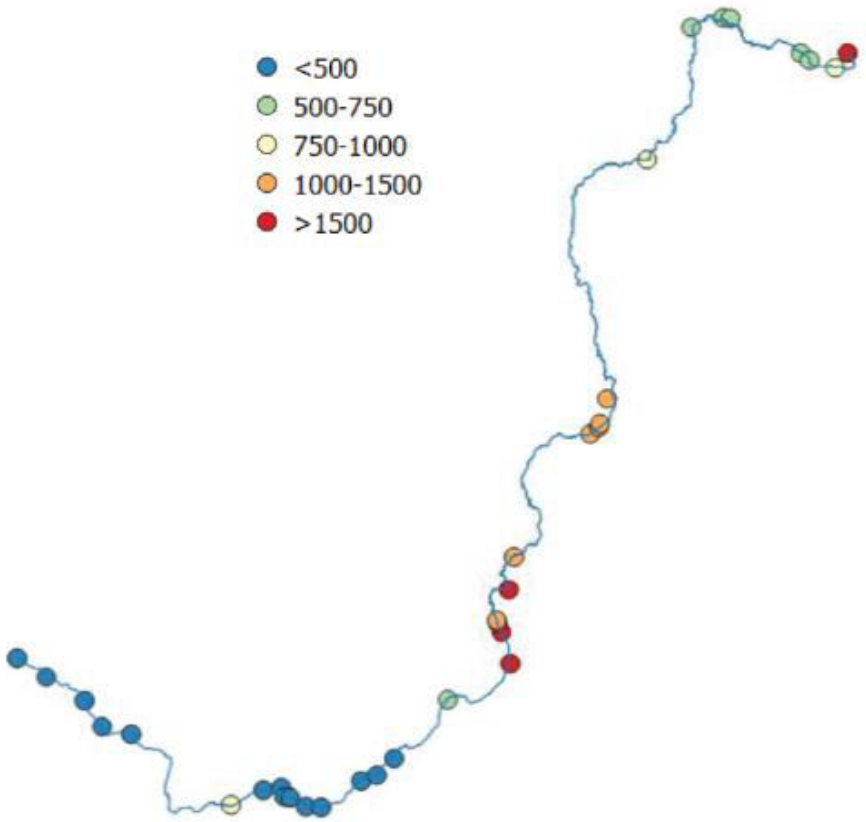


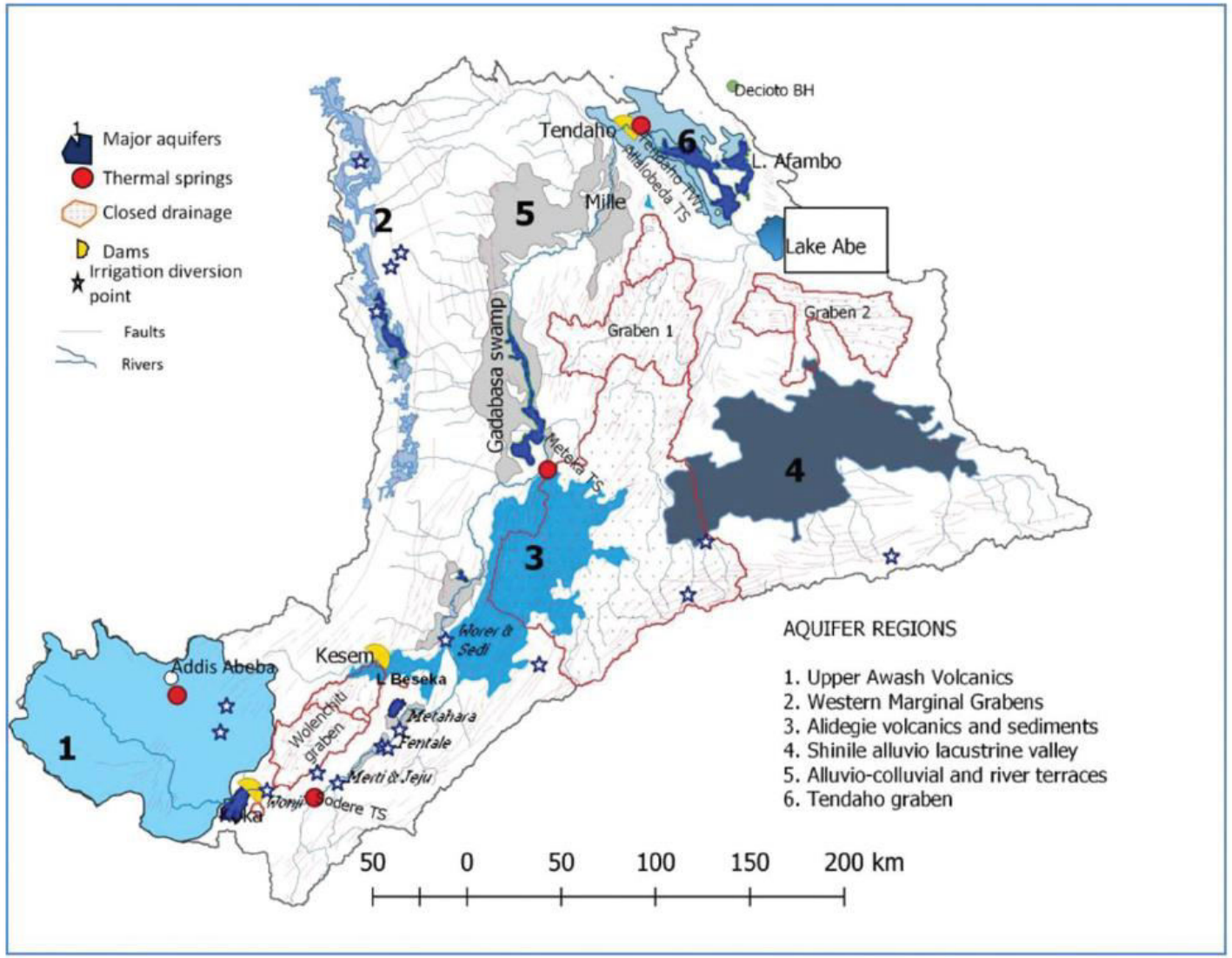


Evaporative Water loss with respect to inflows

Alemayehu, Kebede, Ayenew, 2006

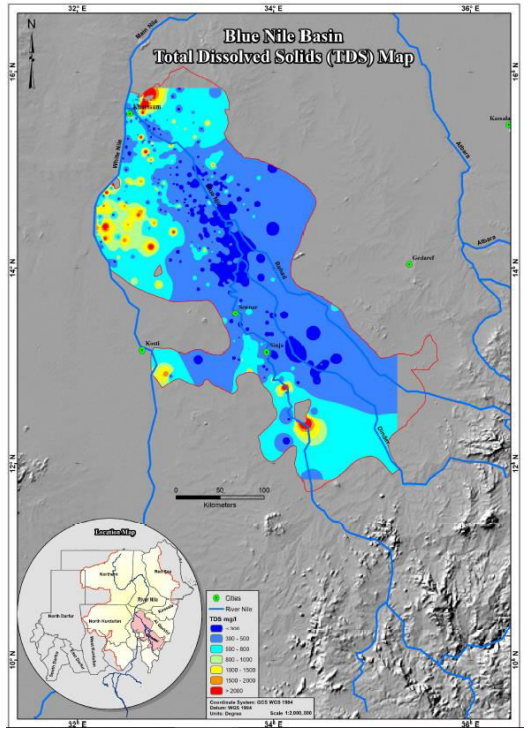
Examples: Salinization of surface waters because of salt groundwater upwelling in Awash following irrigation development. The development of engineering infrastructure impacts surface water–groundwater interaction regimes and water Quality of both

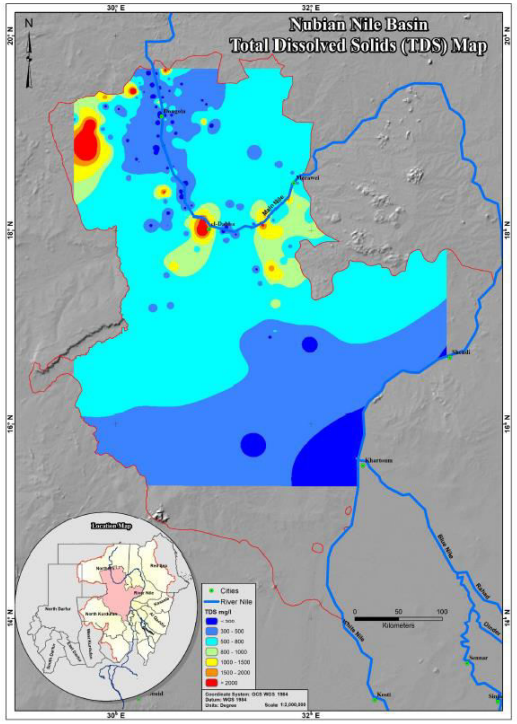




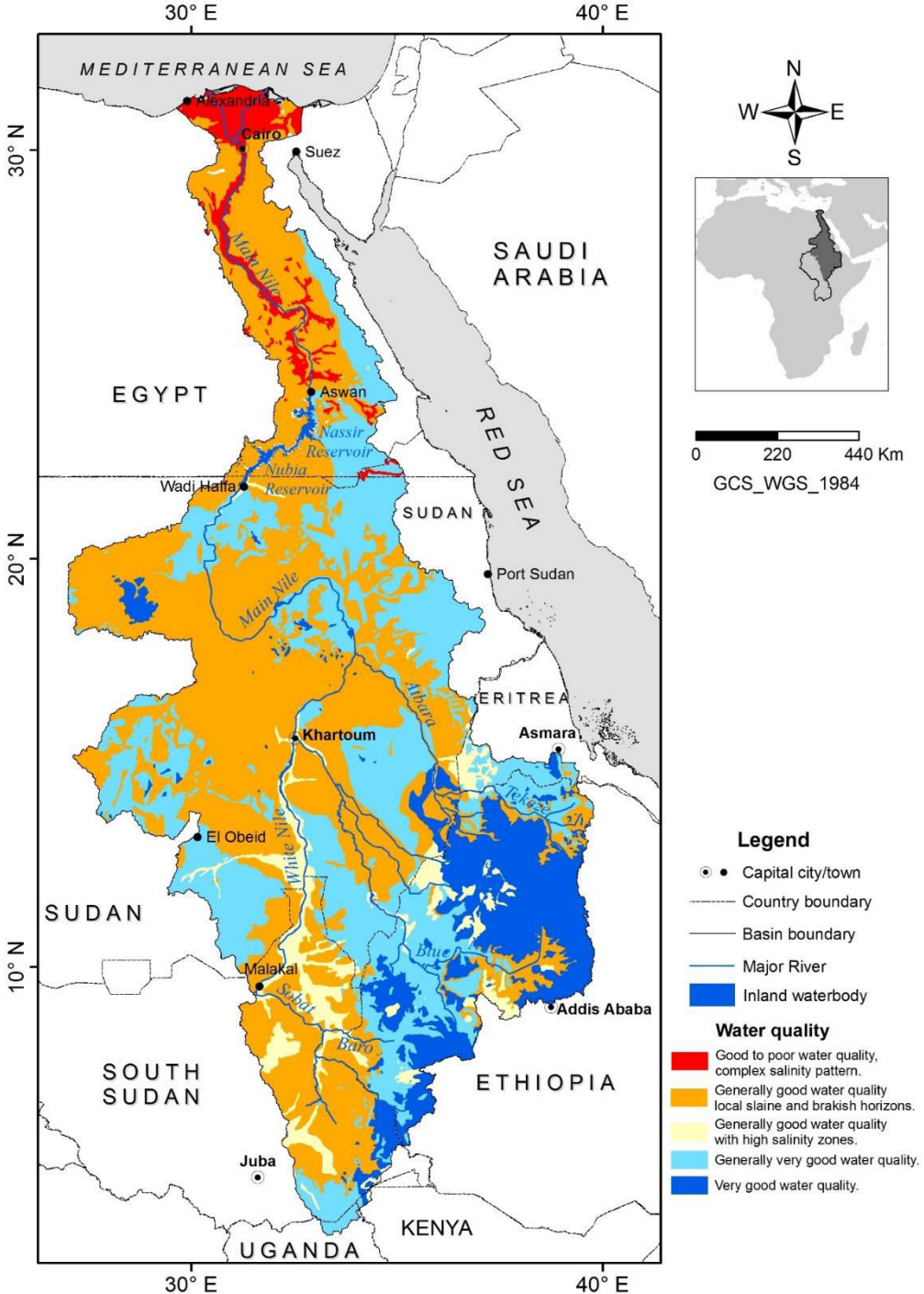
Kebede et al. 2021

Examples: Irrigation return water and poor irrigation practice leading to poor groundwater quality salinity - Nile.





ENTRO, 2020



Policies responses pertaining to salinity and poor groundwater quality

Existing policy and practice responses in Africa

- Relaxation of water quality standards/guidelines [Many countries]
- Revert to other unsafe water sources [Many countries]
- Managed aquifer recharge [Tunisia, South Africa]
- Biosaline agriculture [Mena region]

Possible other technical measures

- Managed aquifer recharge
- Groundwater Quality safe sourcing
- Irrigation water management
- Salt tolerant agriculture
- Blending water sources

Key messages from WWQA perspective paper-UNEP

Key messages

1. Increased attention to GW quality utmost importance for **achievement of SDGs**.
2. Dedicated **global GW quality assessment is necessary and timely**.
3. GW systems are **heterogeneous, three-dimensional** water reservoirs in complex rock formations. Contaminant transport and remediation involve **long time scales**. Mapping contaminant distributions is challenging.
4. Information and **data on GW quality** are very variable across the globe. Often less information available in countries of Global South. Substantial efforts are needed for a comparable global assessment.
5. Important **new advances** are becoming more common, e.g. earth observations, citizen science, machine learning, numerical modelling of contaminant fate and transport, complementing traditional methods.