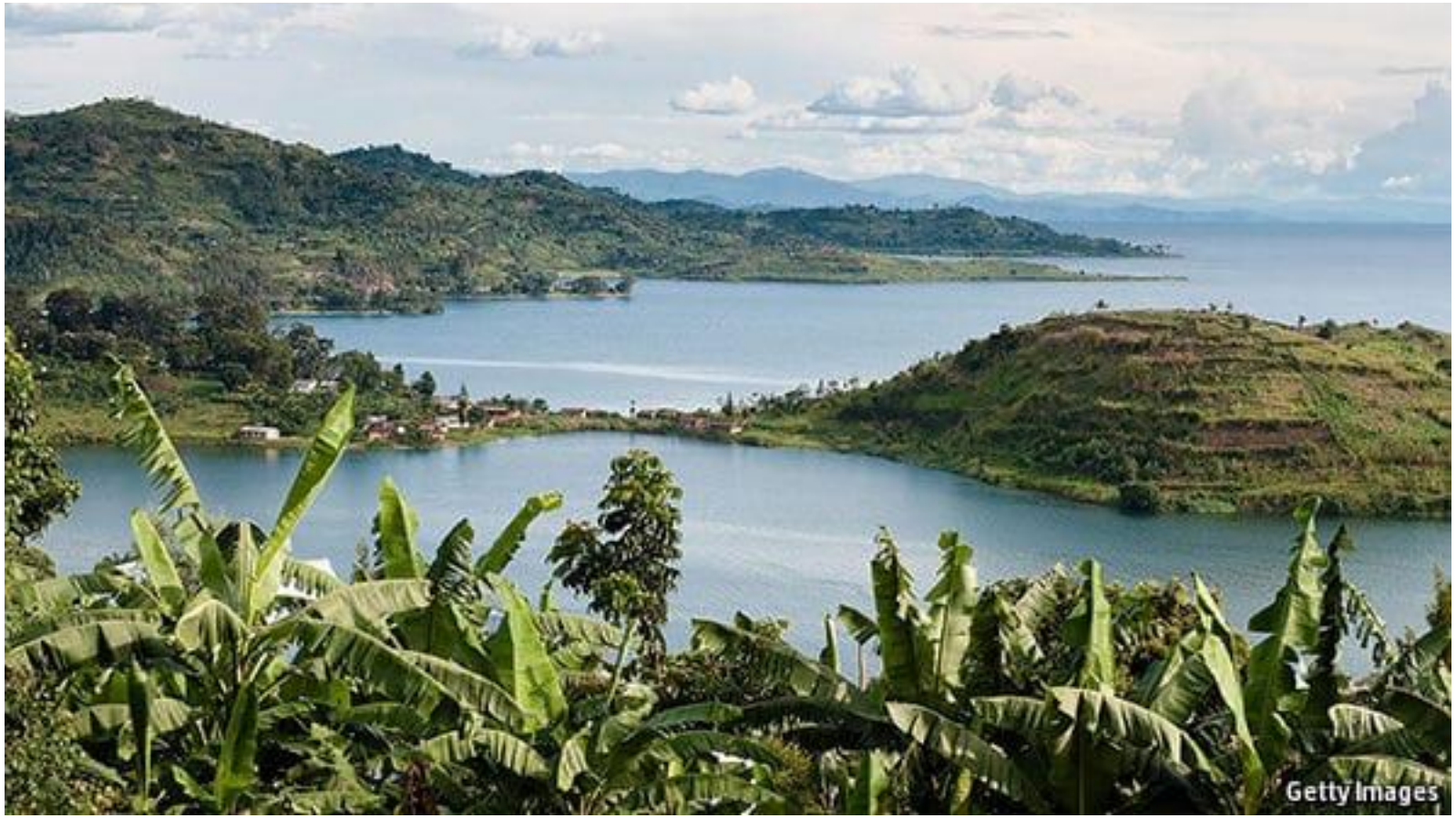
Rift lakes

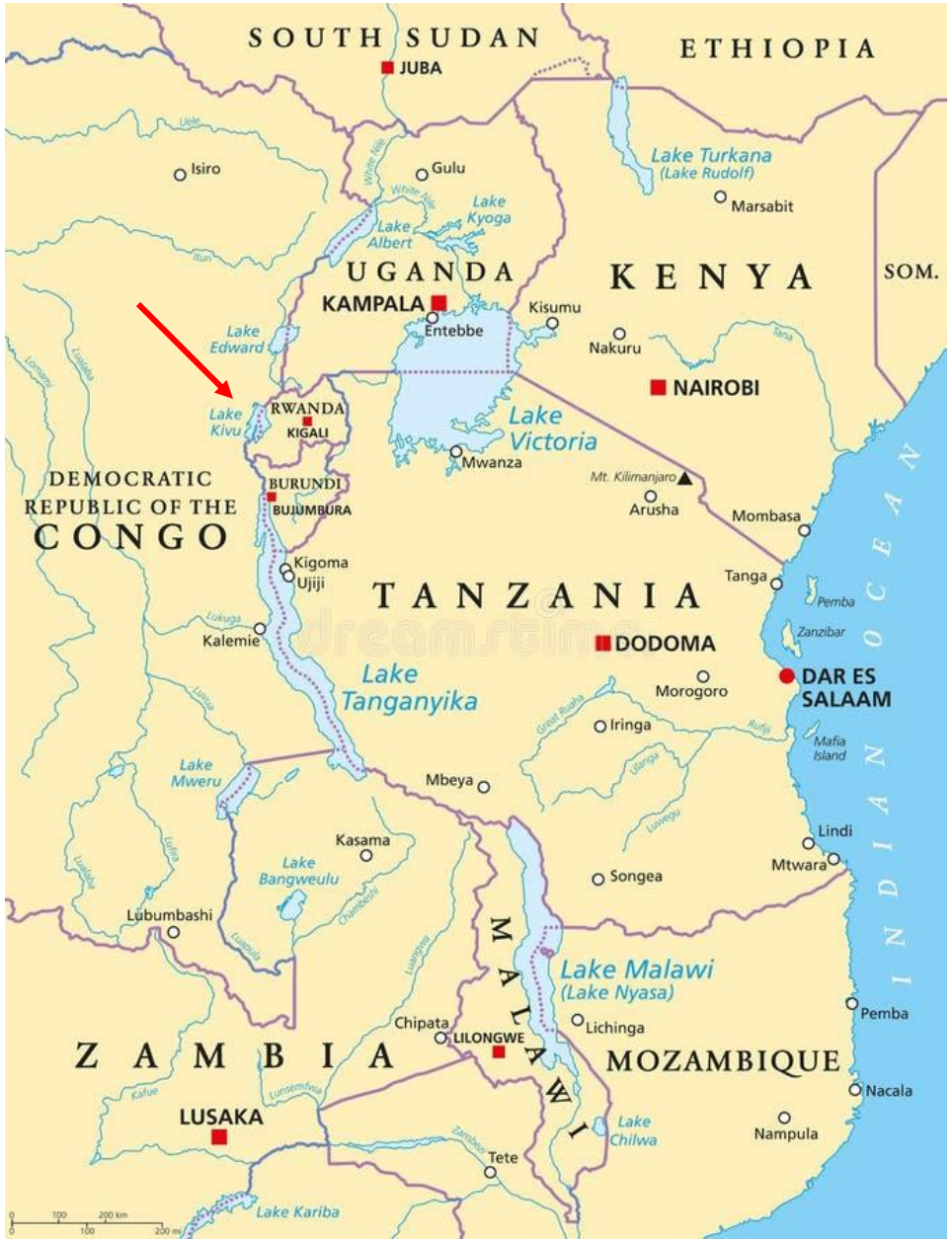
African Great Lakes

EPFL

Lake Kivu



Lake Kivu



The African Rift Valley

- Plate tectonics
- Increased volcanic activities

Large cracks have appeared in the ground caused by aftershocks from the weekend eruption

Lake Kivu

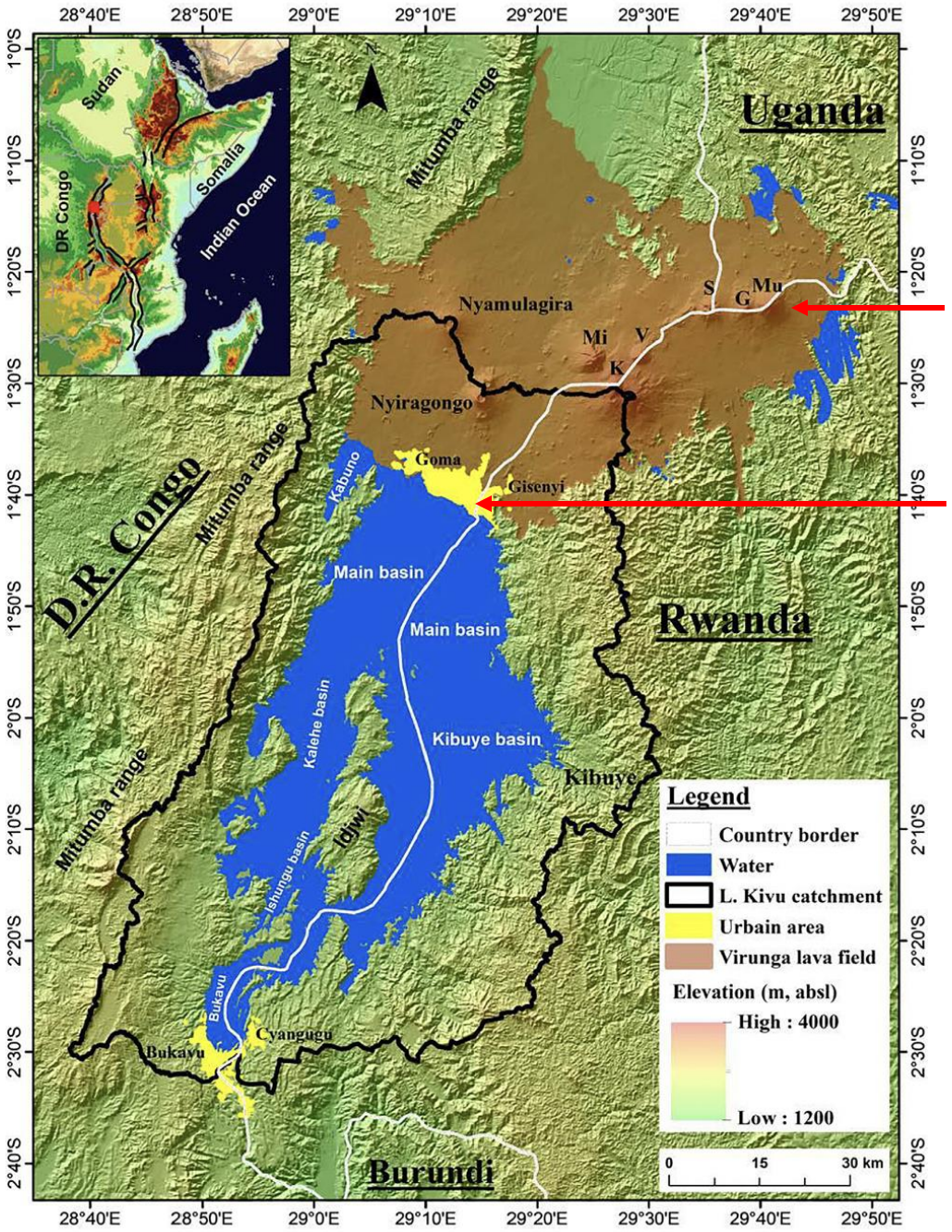


Fig. 1. Map of the Lake Kivu basin with the field of Virunga volcanoes shown to the North. The map presents a Digital Elevation Model in which the eight major volcanoes of the Virunga are shown to the north, aligned along the border of the DRC, Rwanda and Uganda: Nyiragongo, Nyamulagira, Mikeno (Mi), Karisimbi (K), Visoke (V), Sabinyo (S), Gahinga (G), and Muhabura (Mu). The black lines in the inset map indicate the East African Rift System boundaries, of which the western branch covers parts of the Democratic Republic of the Congo, Uganda, Rwanda, Burundi, and Tanzania.

Virunga lava fields - volcanoes
(*Please, watch Virunga on Netflix*)

Goma: Ca. 2M inhabitants

Lake Kivu

Area	2401 km²
Max. length	89 km
Max. width	48 km
Volume	500 km³
Max .depth	480 m
Average depth	237 m

Lake Geneva: 580 km^2

Lake Kivu is a most extraordinary lake

- With a maximum depth of ~485 m, the “classical” lake-water constituents, such as temperature, salinity, nutrients, as well as CO_2 and CH_4 all increase with depth.
- This peculiarity is caused by the inflow of warm, ion- and CO_2-rich water from deep subaquatic springs — related to volcanic activities.
- The high density of the intruding water leads to an unusually strong stratification which suppresses turbulence and reduces diffusion of dissolved substances out of the permanently anoxic deep-water.
- This sealing effect of the stratification, combined with the high rate of CH_4 formation, has resulted in the accumulation of ~65 km^3 of CH_4 and ~300 km^3 of CO_2 (at 0°C and 1.013 bar)

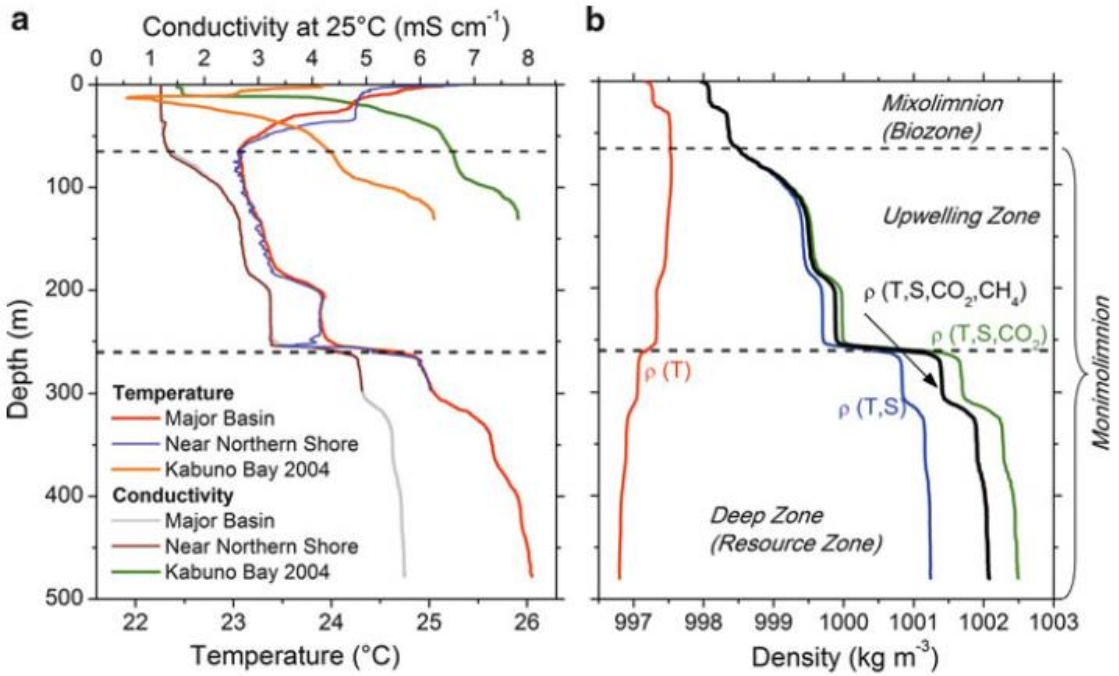


Fig. 2.2 (**a**) Temperature and conductivity κ_{25} (corrected to 25°C) profiles measured in Jan 2010 (Feb 2004 for the profile in Kabuno Bay) at the positions 4, 5 and 6 in Fig. 2.1. (**b**) Contributions of the different components to the average density profile in the main basin (Feb 2004, Schmid et al. 2004b)

Chapter 2
Stratification, Mixing and Transport Processes in Lake Kivu

Martin Schmid and Alfred Wüest

Lake Kivu is among a most extraordinary lake

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, G03006, doi:10.1029/2011JG001690, 2011

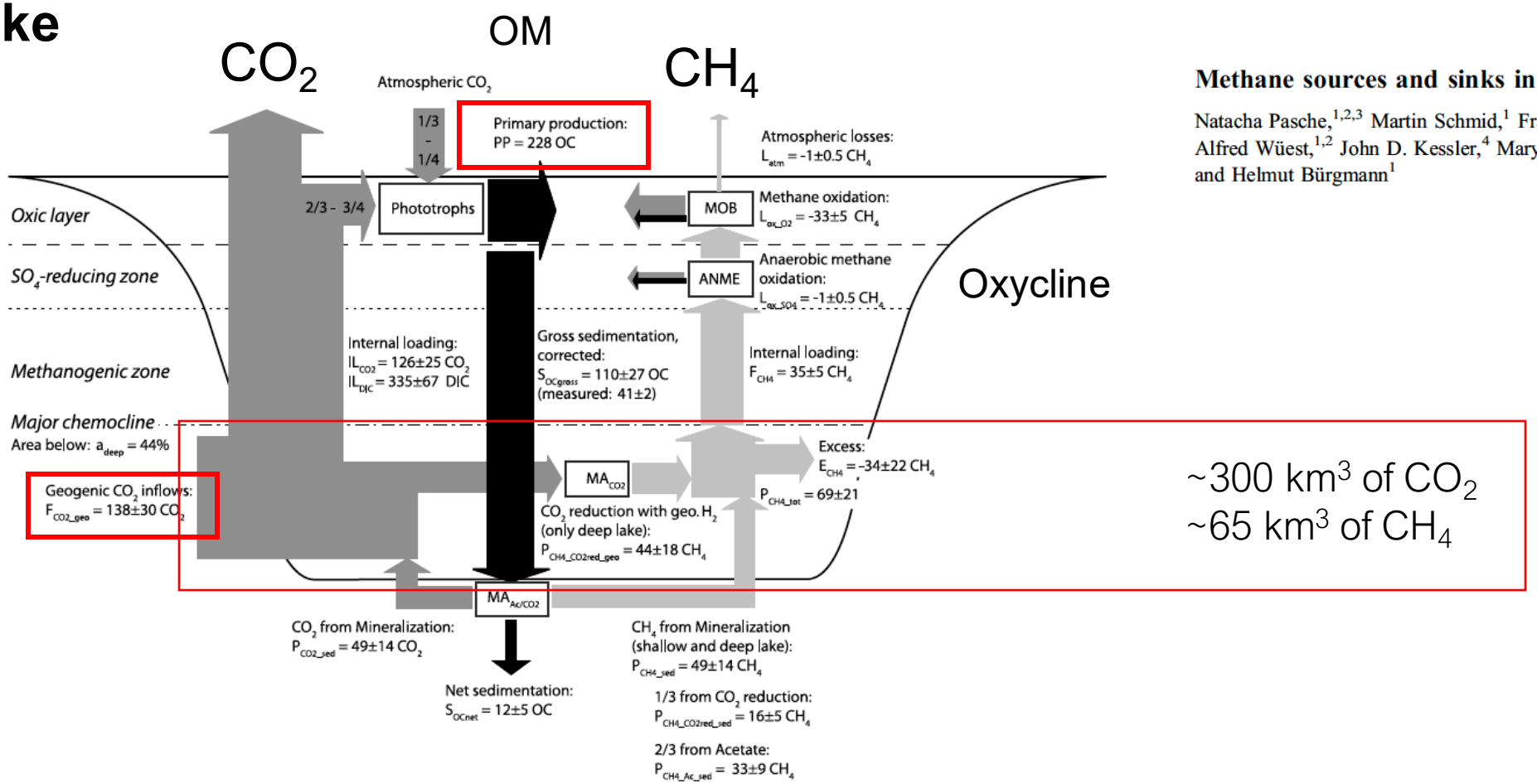


Figure 5. Overview of carbon cycling in Lake Kivu (for details, see section 4.3). CH_4 (light gray), CO_2 (dark gray), and OC (black) fluxes in g C m^{-2} yr^{-1} in Lake Kivu. The dashed line represents the oxycline, the dotted line is the lower boundary of the SO_4^{2-}-reducing zone and the dot-dashed line represents the major chemocline (255 to 262 m depth). All values are areal fluxes and thus do not always add up, as some of them relate to areas smaller than the lake surface. The abbreviations of the fluxes are explained in the text. Boxes indicate microbial populations involved in the process: MA_{Ac}, acetoclastic methanogenic archaea; MA_{CO2}, CO_2-reducing methanogenic archaea; ANME, anaerobic methane oxidizing archaea; MOB, methane oxidizing bacteria (aerobic).

Methane sources and sinks in Lake Kivu

Natacha Pasche,[1,2,3] Martin Schmid,[1] Francisco Vazquez,[1] Carsten J. Schubert,[1] Alfred Wüest,[1,2] John D. Kessler,[4] Mary A. Pack,[5] William S. Reeburgh,[5] and Helmut Bürgmann[1]

~300 km^3 of CO_2
~65 km^3 of CH_4

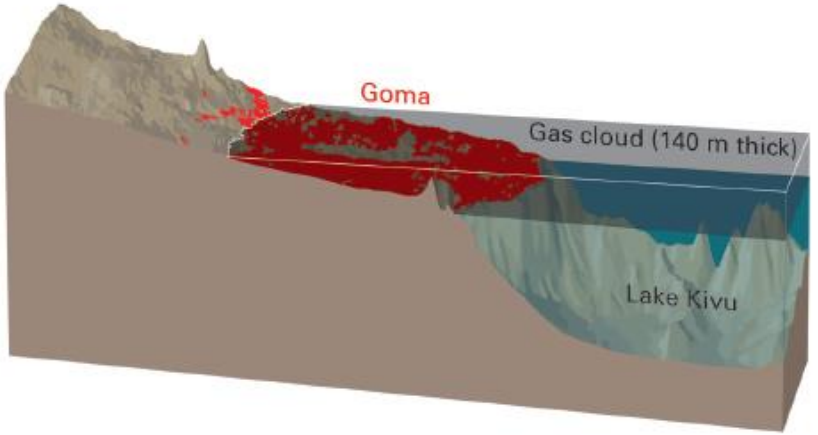
Catastrophic CH_4 cloud from from Lake Kivu

The total amount of gas in Lake Kivu corresponds to a gas cloud of about 140 m thickness above the lake.

As the gas mixture is heavier than air, the gas cloud would fill the valley , cover densely populated areas including most of the city of Goma, and asphyxiate people.

Such a gas eruption would therefore have catastrophic consequences.

Removing methane from the lake decreases the gas pressures and thus reduces the risk of a gas eruption.



Dead cattle surround compounds in Nyos village Sept. 3, 1986, almost two weeks after the lake's explosion.
PHOTO COURTESY U.S. GEOLOGICAL SURVEY

CO_2 eruption from Lake Nyos, Cameroon, September 1986
Killing and displacing thousands of inhabitants

Extracting CH_4 from Lake Kivu

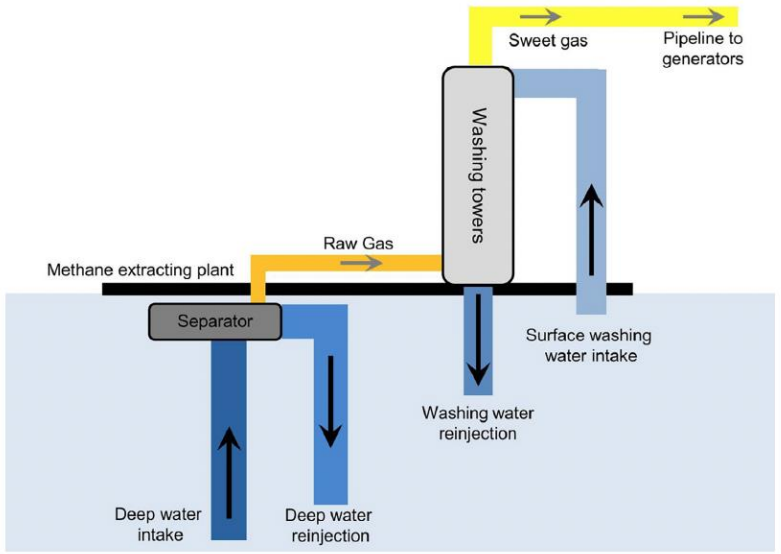
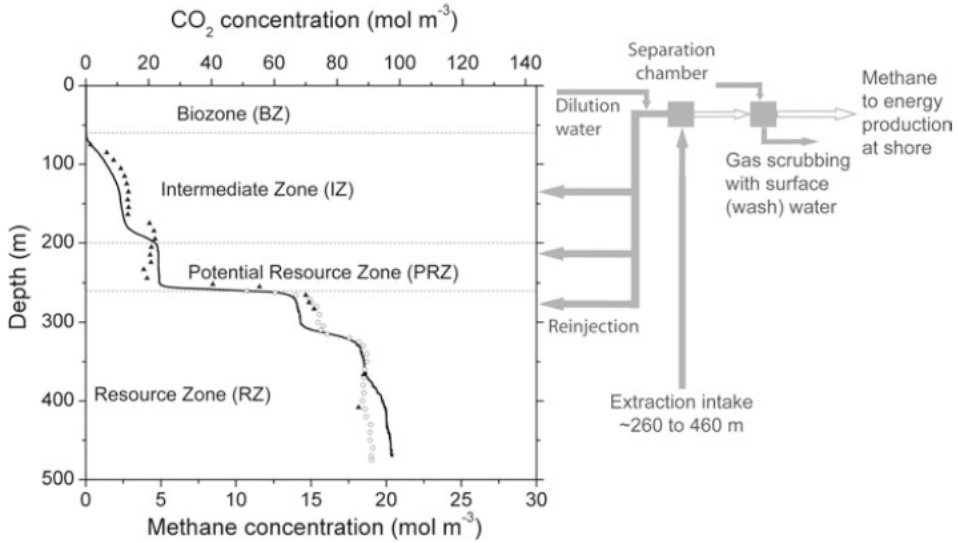


Fig. 8. Schematic view of the methane extracting process in Lake Kivu. The black arrows represent the raw water flow and the grey arrows the gas flow.



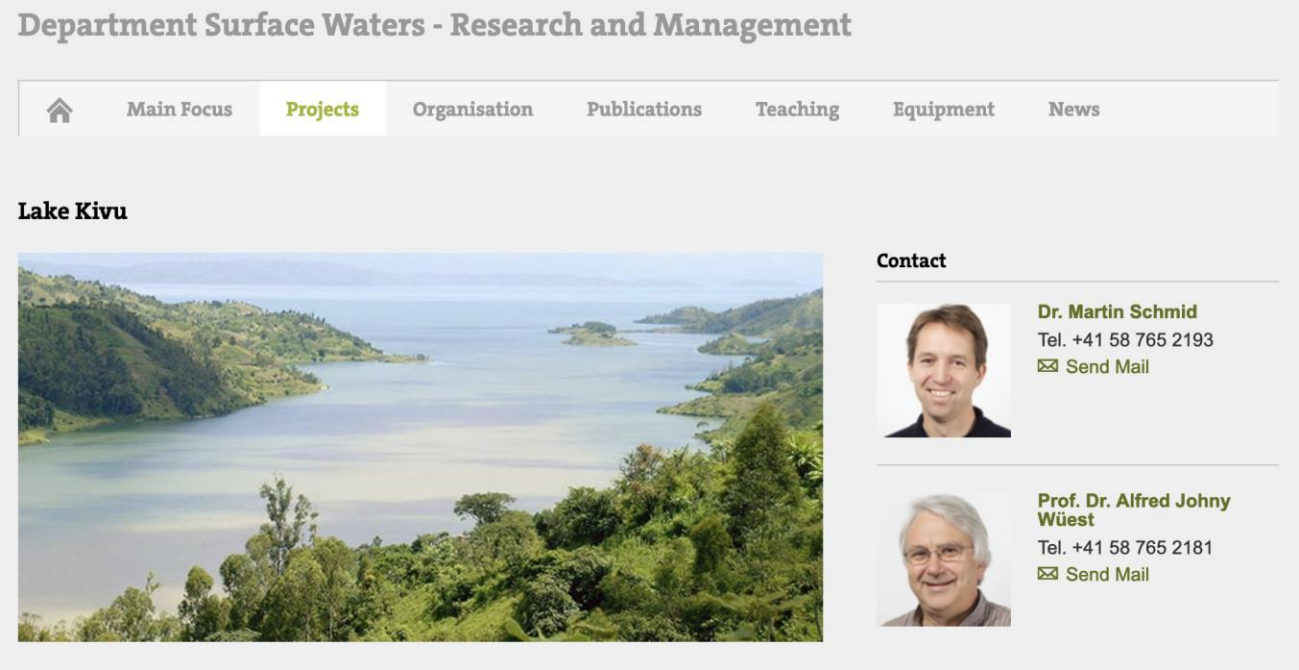
American company ContourGlobal, which owns KivuWatt, launched the Lake Kivu venture in 2015 and for a time considered expanding its capacity from 26 to 100 megawatts.

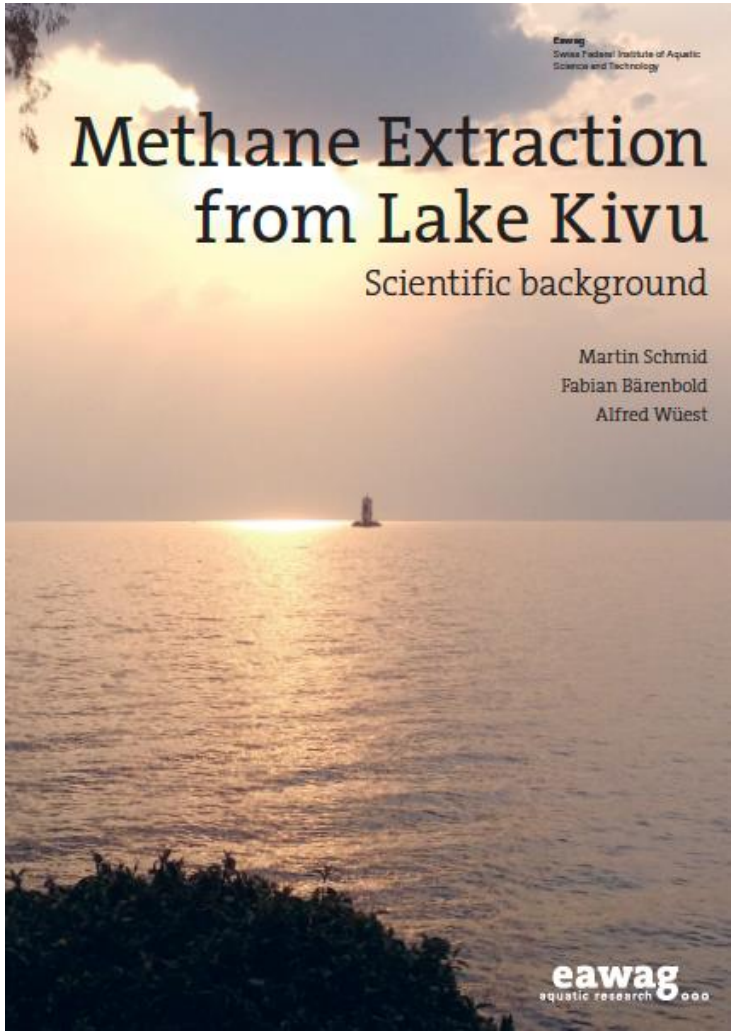
Another company is exploring the possibility of launching its own 56-megawatt gas extraction venture on the lake.

Initiating gas extraction enables the vital outcomes:

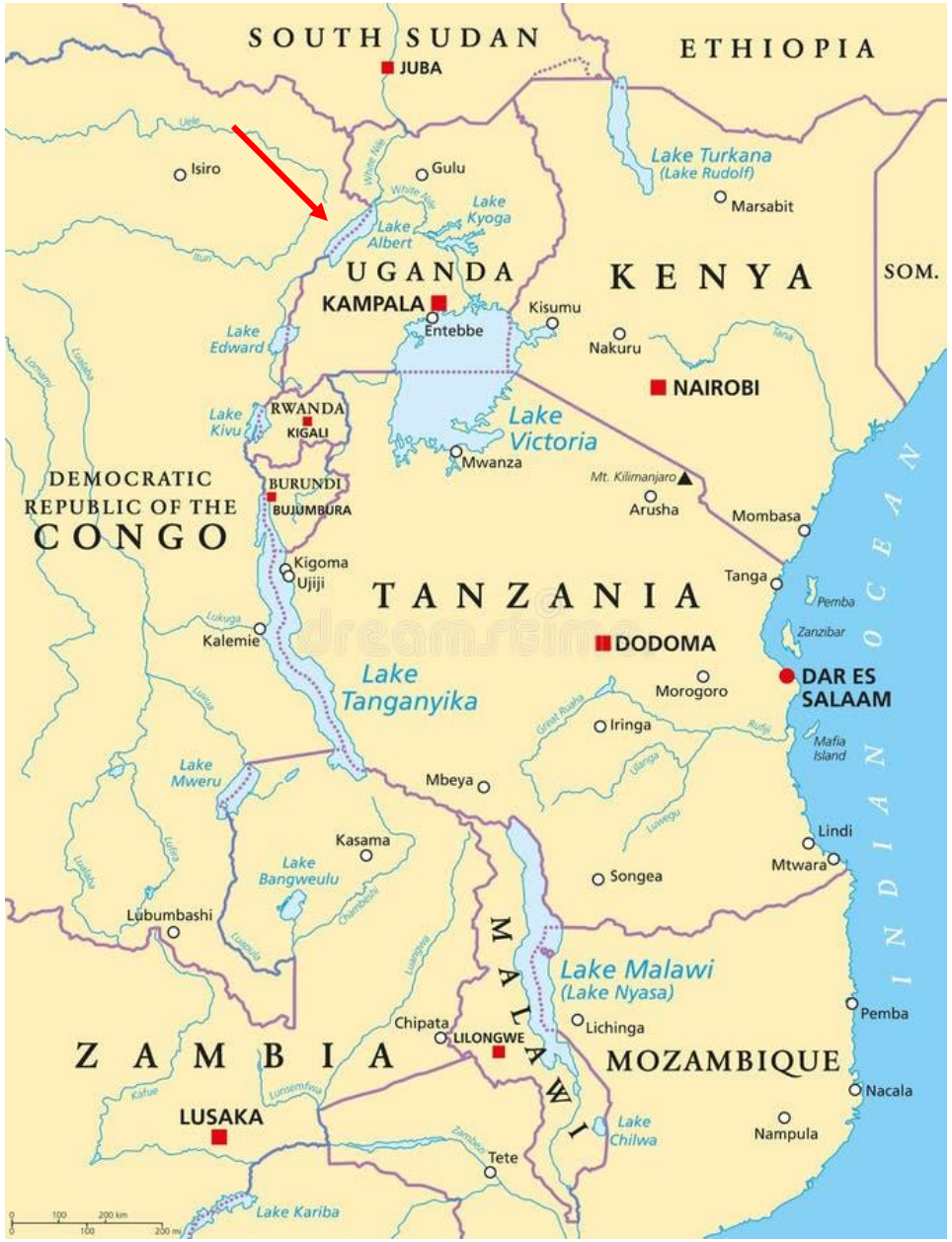
- Society can enforce extraction methods that
- ensure prevention of future disasters while,
- minimizing environmental impact,
- maximizing useful energy output
- developers pursuing economic projects.

The key to safety is management of the chemoclines while producing gas. Achieving safety and production needs the right specification of plant design.





Lake Edward



The African Rift Valley

- Plate tectonics
- Increased volcanic activities

Lake Edward

Organic-rich rocks of lake origin are the dominant source of hydrocarbons in many oil and gas provinces around the world.

Most of the world's long-lived extant lakes are affiliated with continental extensional basins.

Lake systems situated in the tropical latitudes commonly contain sediments that are exceptionally rich in organic matter because of a high biological productivity and, in some cases, prolonged bottom water anoxia

The basin has experienced a long-term change from a continuously open lake, possibly deep lake system in the Miocene (23 to 5 My) or early Pliocene (5 to 2.6 My), to an alternating shallow lake and fluvial system in the mid and late Pleistocene.

This history of basin evolution has led to the development of a rich hydrocarbon system.

Karp, Tobias, Christopher A. Scholz, and Michael M. McGlue, 2012, Structure and stratigraphy of the Lake Albert Rift, East Africa: Observations from seismic reflection and gravity data, *in* O. W. Baganz, Y. Bartov, K. Bohacs, and D. Nummedal, eds., Lacustrine sandstone reservoirs and hydrocarbon systems: AAPG Memoir 95, p. 299–318.

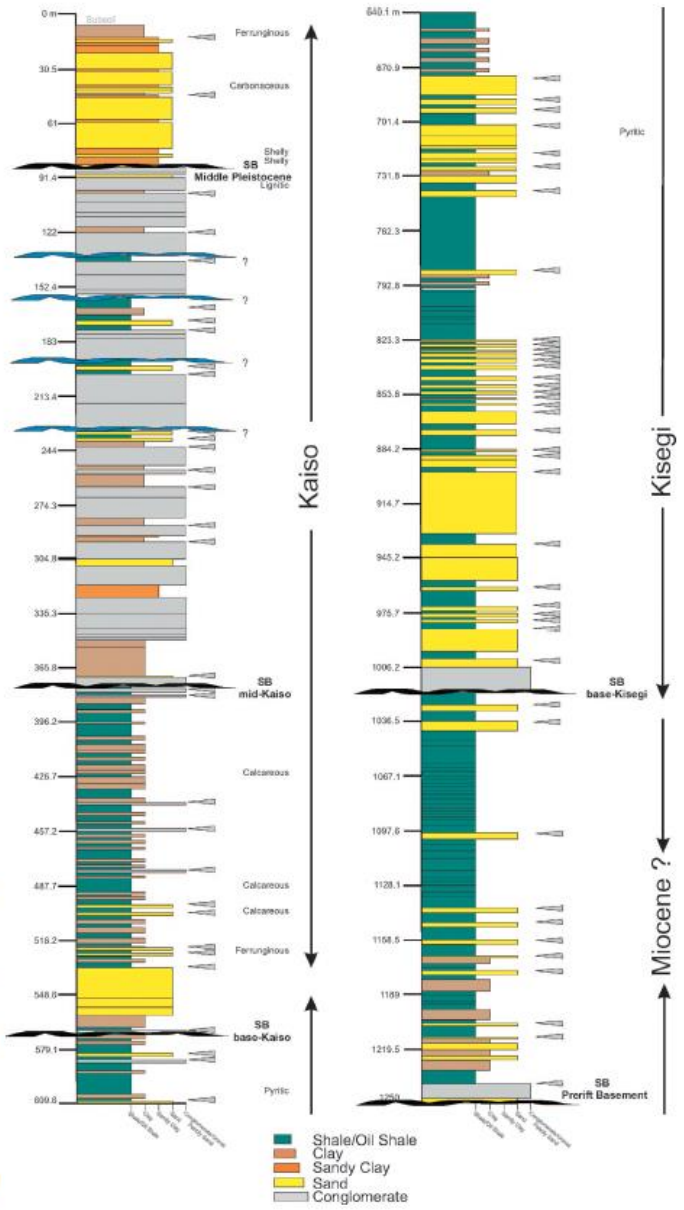
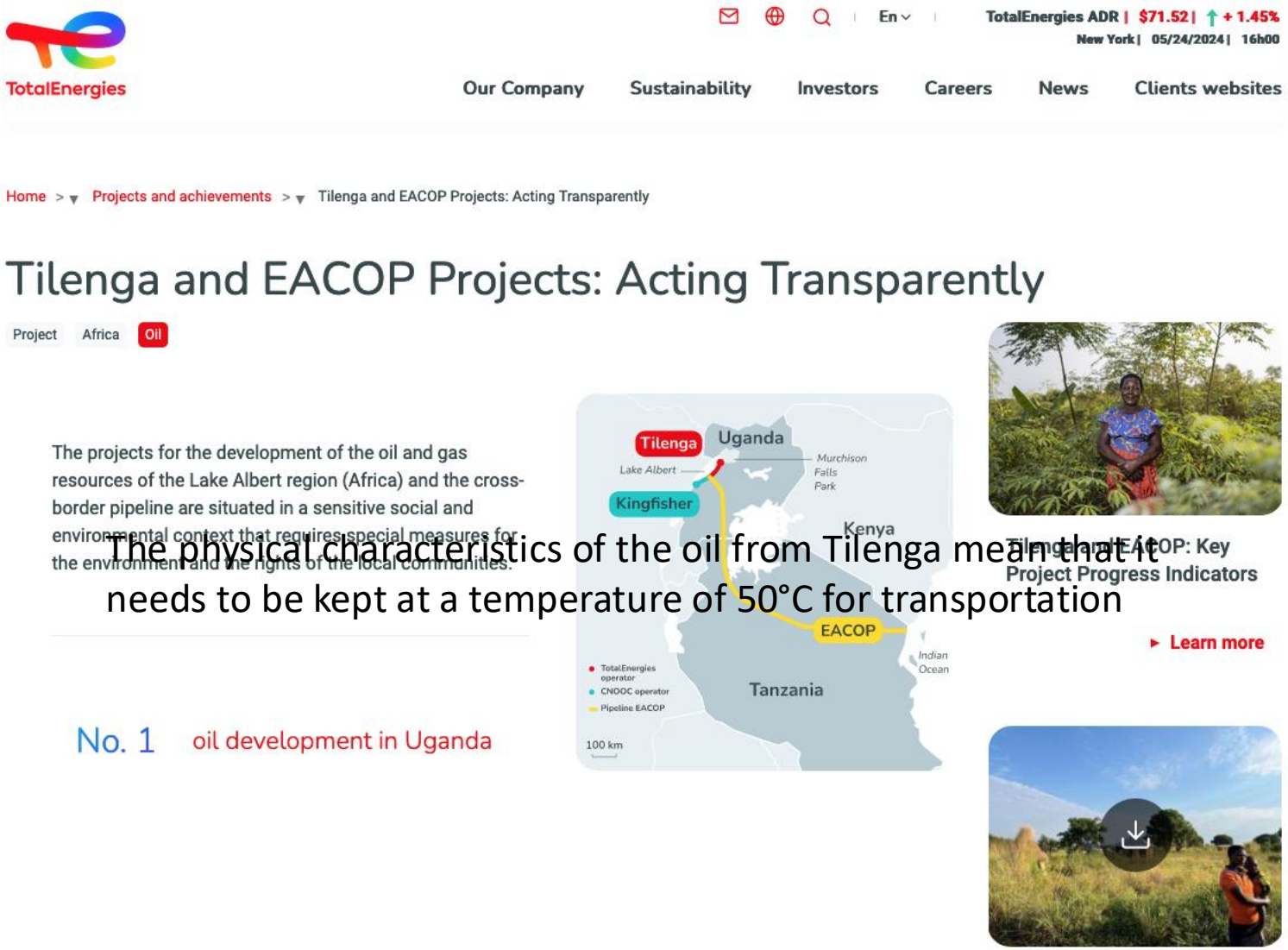


Figure 11. Detailed lithology log of the Waki-B1 well (modified from Harris et al., 1956). Depth increments are given in meters. Relative grain size is expressed by the length of horizontal beds (ranging from oil shale to conglomerate). The well is shown with sequence-stratigraphic interpretations. Small triangles mark the locations of interpreted parasequences boundaries or flooding surfaces. Ribbons mark the locations of interpreted sequences. The overall coarsening-upward trend in the well reflects major changes in lake hydrology since the Miocene, likely responding to changes in regional precipitation patterns. See text for explanation.



The physical characteristics of the oil from Tilenga mean that it needs to be kept at a temperature of 50°C for transportation

East African Crude Oil Company

https://totalenergies.com/projects/oil/tilenga-and-eacop-projects-acting-transparently

IFP REGIONAL COOPERATION ON NATURAL RESOURCES, ENVIRONMENT AND ECONOMY CLUSTER

PEACEBUILDING ACROSS LAKE ALBERT

Reinforcing environmental cooperation between Uganda and the Democratic Republic of Congo

Meike Westerkamp, Annabelle Houdret

February 2010

adelphi research

INITIATIVE FOR PEACEBUILDING

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ENERGY AND OIL

OVERVIEW

The eastern part of the DRC and Uganda heavily depend on Kenya for energy imports, which have proven to be irregular in supply and pricing. 'Eastern DRC [is] especially vulnerable, depending for transit on Uganda which in turn depends on Kenya'.[49] The Lake Albert region does not only depend on foreign energy supply, but suffers from energy shortages as well. On the Ugandan side of the lake, only three percent of the population has access

48 Nile Basin Initiative of the Democratic Republic of Congo (2009). *Local micro grants coordination Goma*. Monthly project follow up, September 2009. Unpublished report.
49 D. Johnson (2003). *Shifting sands: Oil exploration in the Rift Valley and the Congo conflict*. Goma, DR Congo: Pole Institute. p.7.

to electricity.[50] The people of Ituri receive even less electricity due to lack of infrastructure. Consequently, the main energy source in the region is firewood and imported petroleum.[51]

On the Ugandan shores of Lake Albert, exploration of oil reserves started in the last few years. The findings point to important quantities of oil compared to other sources in the Sub-Saharan region. The Ugandan soil alone holds two billion barrels of oil and estimates reach as high as six billion barrels.[52]

The prospect of oil production is intertwined with rapid changes, hopes and fears in economic, political, social and environmental dimensions. Economic expectations of the oil wealth are very high.

Locals and migrants hope for jobs and better living conditions, speculators and investors seek valuable land and the government envisions itself as independent of oil imports and as a regional supplier. Within Uganda, civil society groups massively mobilise against the production-sharing agreements the government signed with international oil companies and which are not made public. No concrete strategy for the use of the revenues from oil exploitation has been communicated so far by the Ugandan Government. The Ugandan CSO Greenwatch has petitioned the court, requiring the handing over of all contracts concluded between the Government and the international oil companies.[53] An oil refinery could cover Ugandan oil demands for 20–25 years, including export supplement to the Great Lakes Region.[54] This also explains the high political value of the resource, as Uganda could soon become a major regional player if it succeeds in exploiting and refining the oil to sell it to neighbouring countries.

Besides the chances of economic development, the oil findings pose environmental and socio-economic problems as well as security risks. Firstly, while Uganda is already planning oil exploitation and production in the near future, the DRC is still debating who they will give the concessions to. At the same time, the DRC fears Uganda will defraud it. One of the major DRC concerns is that Congolese oil could be extracted from Ugandan soil, thus "stolen" by its neighbour.[55] These fears are further supported by the fact that Uganda conducts oil test drillings directly on the lakeshore.

Secondly, the tense security situation in the Lake Albert region might worsen. The securitisation of the oil issue is linked to two main concerns of the government: potential involvement of rebel organisations and increasingly critical voices from the local level. Ugandan and Congolese rebel groups are suspected to launch attacks in the oil area, which will eventually be supported by local communities.[56] Mistrust of local communities and CSOs towards the Ugandan government is already growing. They fear a "second Niger Delta" in the Lake Albert region,[57] as a lack of transparency and insufficient involvement from local stakeholders exist pertaining to oil-related decisions, that is to say benefit sharing, environmental and social impact assessments and compensation measures.[58] Suspicion is further fuelled by the fact that the oil companies progress very quickly on the ground and are far

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ahead of local governmental officials, communities and CSOs in terms of technical know-how, financial and human capacities.[59]

Thirdly, neither Uganda nor the DRC are prepared for the socio-economic shifts that the communities in the Lake Albert region will face. Many villages struggle to cope with the influx of migrants and support measures for urban planning, housing, livelihoods and social infrastructure are lacking as well. As a result, tensions between ethnic groups are rising. Moreover, the increasing presence of UPDF in the border region may exacerbate political and social unrest.

Fourthly, due to oil extraction, water and land pollution may occur and place additional pressure on already stressed livelihoods.[60] Decreasing water quality and quantity (as water is needed for the extraction process) may negatively impact local communities and wildlife, including on the Congolese side. NEMA stated that 'the currently worrying status of fishery resources in the region would be greatly exacerbated by oil spills or pollution resulting from oil development activities'.[61]

Consequently, the extraction and refinery process in the Lake Albert region entails major environmental, political and socio-economic changes with probable negative effects on security at the local and the transboundary level.

"EACOP has been a disaster for the tens of thousands who have lost the land that provided food for their families and an income to send their children to school, and who received too little compensation from TotalEnergies," said Felix Horne, senior environment researcher at Human Rights Watch. "EACOP is also a disaster for the planet and the project should not be completed."

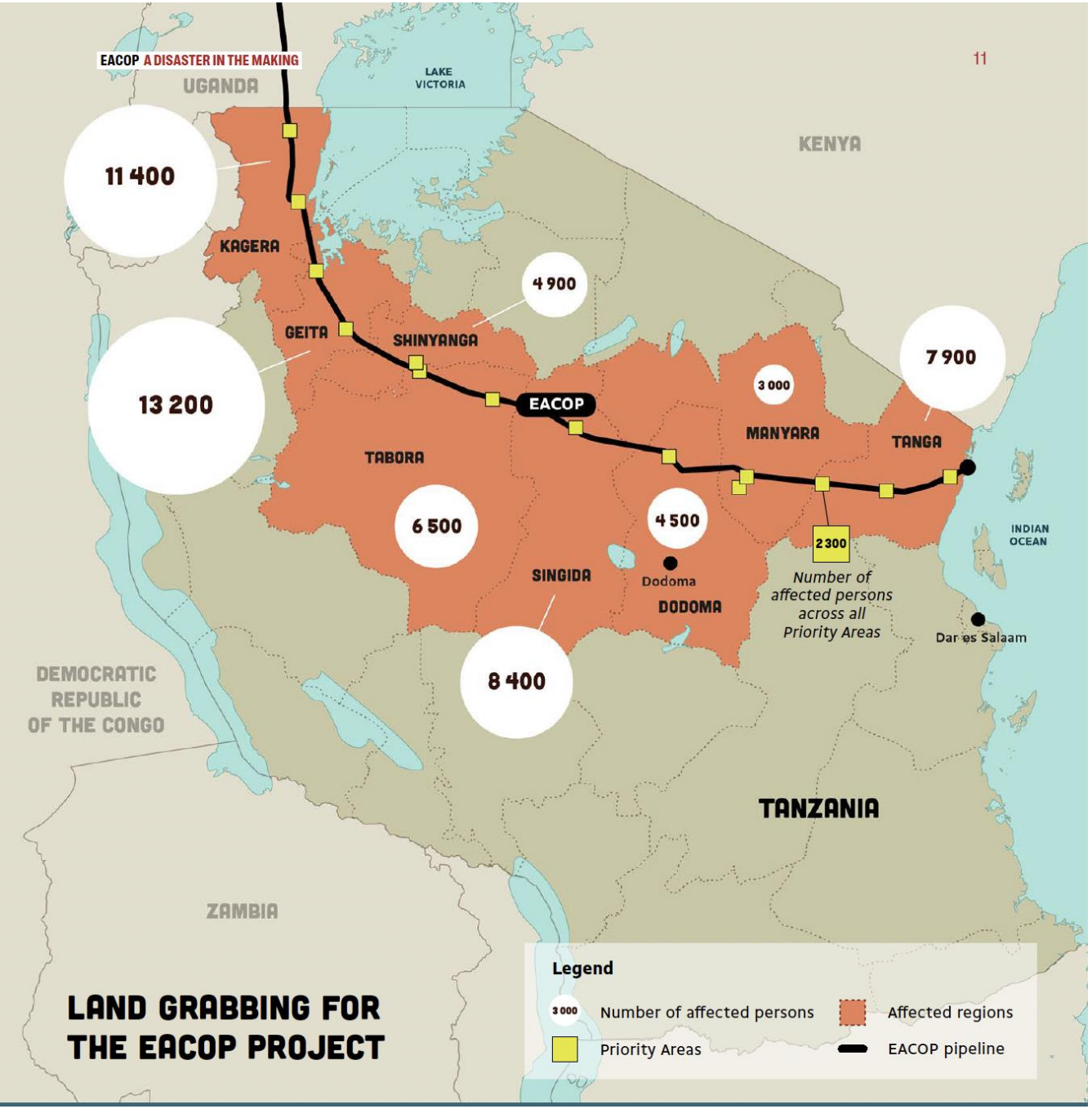
EACOP PROJECT: MAIN ECOSYSTEMS UNDER THREAT

LEGEND

- National borders
- Water bodies
- EACOP pipeline
- Ramsar wetlands
- Protected areas
- Conservation areas at risk
- Key biodiversity areas
- Water bodies at risk

Source : SEI/IGSD, East African Crude Oil Pipeline Risks, 2020.

- Protected ecosystems, wildlife & biodiversity
- Completely inadequate or non-existent preventive measures
- High seismic activity increasing the risk of oil spills and leakage
- Project's water needs prioritised over those of the local population



- Protected ecosystems, wildlife & biodiversity
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#STOPEACOP

ENGLISH SWAHILI FRANÇAIS

Take Action

Police officers detain a Ugandan activist during a demonstration on September 15, 2023, over plans to build the East African Crude Oil Pipeline (EACOP), in Kampala, Uganda [File: Abubaker Lubowa/Reuters]

FOR PEOPLE, FOR NATURE, FOR CLIMATE

French oil company Total and majority state-owned China National Offshore Oil Corporation (CNOOC) are on the cusp of building the world's longest heated oil pipeline right through the heart of Africa.

- People, society, politics
- Nature and natural heritage
- Climate change

https://www.stopeacop.net/why-stop-eacop

Ecology and Evolution of the African Great Lakes and Their Faunas

Walter Salzburger,[1] Bert Van Bocxlaer,[2,3,4] and Andrew S. Cohen[5]

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[5]Department of Geosciences, University of Arizona, Tucson, Arizona 85721; email: cohen@email.arizona.edu

Deforestation and watershed erosion are other factors that altered the sensitive littoral zone, particularly through high sedimentation rates, changed substrate composition, a subsequent loss of biodiversity, and altered species interactions (Alin et al. 1999, Cohen et al. 2005, Eggermont & Verschuren 2003, McIntyre et al. 2005). Most recently, intense exploration of hydrocarbons in the AGL has begun. Discovery wells near Lake Albert have already been developed, and intensive exploration is also under way in the Turkana Basin and at Lake Tanganyika. Beyond these indirect effects through ecosystem interactions, unsustainable resource exploitation (e.g., use of fishing nets with fine mesh sizes) has exhausted fish stocks directly (Lowe-McConnell 1993). The significance of these developments is moreover increased by the division of most AGL by national boundaries, and economic instability has hampered the development of transnational agreements, such that lake management and conservation infrastructure remain weak. Perhaps of even greater concern is the initially slower but increasing impact of global climate change, which is largely beyond the control of local authorities. The surface waters of at least some of the meromictic AGL are warming, which strengthens stratification and hence reduces the depth of oxygenation and the nutrient influx from deep waters to the epilimnion. This warming has changed primary productivity and the interactions between the pelagic and benthic ecosystems, and it has resulted in a loss of benthic habitat and diversity (Eggermont & Verschuren 2003, O'Reilly et al. 2003, Tierney et al. 2010, Van Bocxlaer et al. 2012b). Given the fragile limnological balance on which the extraordinary biodiversity of the AGL depends, much more ecosystem monitoring and conservation strategies are needed to preserve the AGL biota and the varied ecosystem services and resources that these fascinating ecosystems provide to society.

SUMMARY POINTS

1. The AGL are one of the most remarkable freshwater features on our planet, and their extraordinary ecosystems incorporate some of the most diverse and renowned radiations of freshwater biotas on earth. Marked differences in basin formation, tectonic activity, and climate regimes between basins have shaped the ecosystem characteristics and faunas of each lake differently.
2. The AGL are quasi eco-insular systems, and like oceanic islands, most of their biodiversity has evolved through evolutionary (adaptive) radiations, in which both ecological opportunity and intrinsic biological factors have played prominent roles. In addition to remarkable endemism, great morphological disparity is observed, and it is often strongly correlated with niche diversity.
3. In this phenomenal setting of quasi-replicate lake systems, much iterative evolution and morphological convergence are observed between and within lake basins.
4. The biodiversity of the AGL depends heavily on a delicate limnological balance and overall ecosystem stability: Larger and deeper lakes have a greater buffering capacity and more diverse species assemblages. In the more stable lakes, complex ecological interactions such as coevolution (e.g., predatory-prey arms race) and ecosystem engineering are noteworthy consequences.
5. Taxa of the more stable lakes often show remarkable phylogenetic structure related to past cycles of lake-level change. Other lakes that have undergone more ecosystem calamities harbor more species that are widespread and fewer species flocks that evolved within the lake (less endemism).

Hydropolitics in the MENA Region

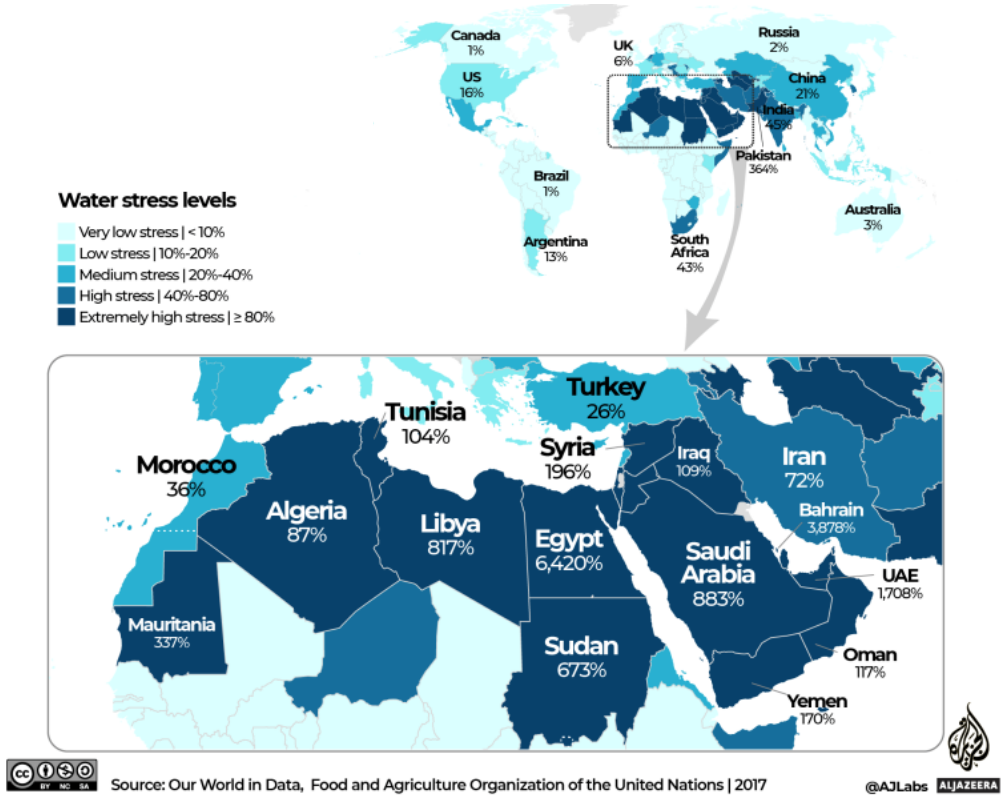
Filippo Menga

Associate Professor of Geography
University of Bergamo

At the global level there are 310 international river basins.

The MENA (Middle East and North Africa) region has a population of over 500 million people and it comprises, in its more recent definitions, the following 20 countries: Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, State of Palestine, Israel, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen.

Semi-arid or Mediterranean climate, vulnerable to climate change, whose impacts include an increase in drought conditions, heatwaves, and aridity.



Hydropolitics in the MENA Region

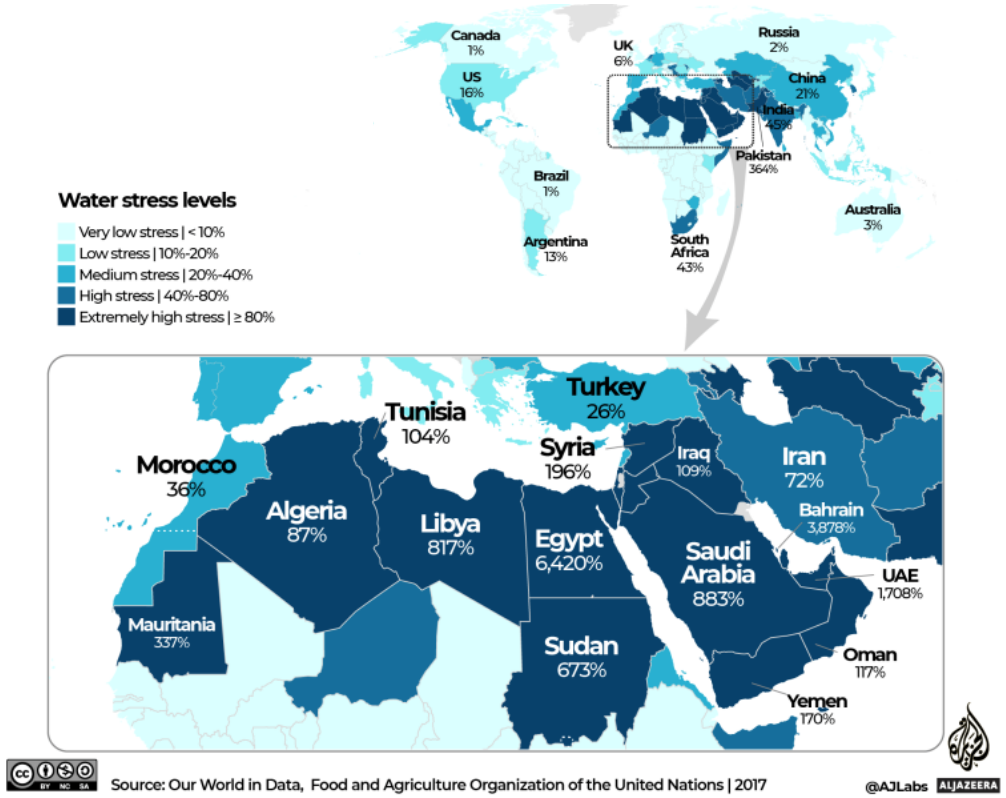
Filippo Menga

Associate Professor of Geography
University of Bergamo

Nile River

The most important conflict over the waters of the Nile has revolved around the Grand Ethiopian Renaissance Dam (GERD), a mega-dam currently under construction along the Blue Nile in Ethiopia

Once completed, it will be the largest dam in Africa, with a reservoir covering 1,875 km2 and a total installed capacity of 5150 MW, equivalent to that of five large nuclear power plants. In the past, Egypt had threatened to wage war if Ethiopia attempted to build dams on the Blue Nile.



Hydropolitics in the MENA Region

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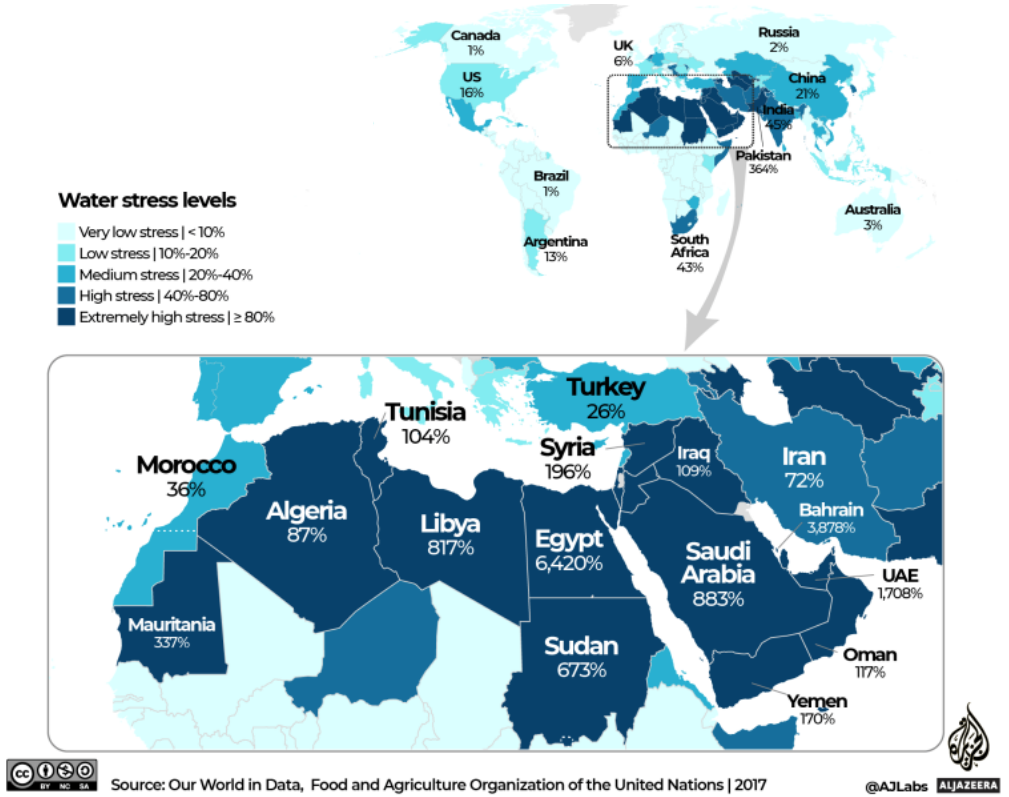
University of Bergamo

Jordan River

‘The Jordan River is probably the most conflictual river in the world, or at least, it is the river that is more frequently singled out as a key conflict hotspot worldwide…’

Since the construction of the National Water Carrier of Israel in 1964 and the Six-Day War of 1967 – when Israel seized the Golan Heights – Israel has de facto controlled water resources in the region. Subsequently, this control became increasingly evident, disproportionately affecting the State of Palestine and Palestinians residing in the Gaza Strip and the West Bank, who have experienced a relentless diminishment of their ability to access water resources. This inequality is exemplified by striking figures.



Hydropolitics in the MENA Region

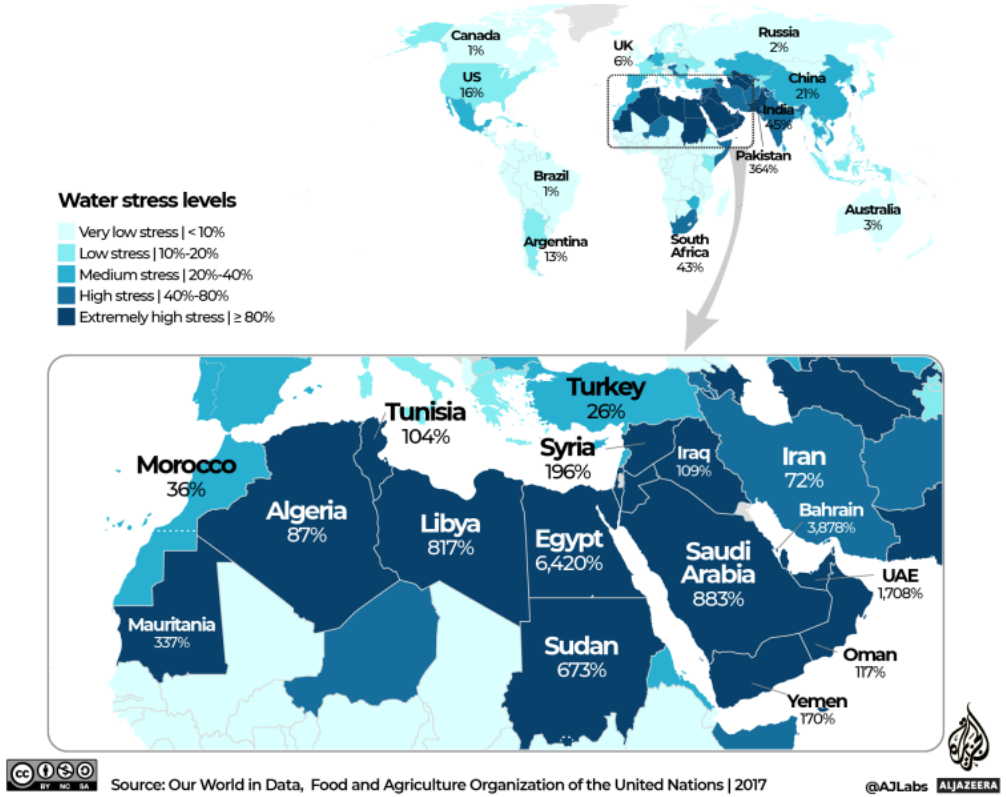
Filippo Menga

Associate Professor of Geography
University of Bergamo

Jordan River

While almost the entire population of Israel has access to running water and basic hydraulic infrastructure, the same applies to only 36% of all West Bank Palestinians. Furthermore, while the average daily water consumption per person in Israel is 247 litres (well above the World Health Organization's recommended minimum of 100 litres), West Bank Palestinians consume only a third of this amount (82 litres), and those not connected to the water grid receive only 26 litres per day.

The United Nations humanitarian agency, OCHA, reports that following the devastation of Gaza and the conflict in Israel, water availability for those living in the Gaza Strip has dropped to less than three litres per day per person.



Aquatic ecosystems

From lake formation to water and aquatic ecosystem properties, global carbon fluxes, and some critical thinking, hopefully.