The Nile Basin

Climate change, water and future cooperation

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Research Paper | April 2025

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Acknowledgements

The authors are very grateful to those interviewees who kindly offered their views on the issues covered in this report. They would also like to thank the expert reviewers of the draft report, Sarah Finch for her valuable editing work and Chris Aylett of Chatham House for his unflinching support throughout the process of producing this report.

This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 821010.

Acronyms and abbreviations

BCM: billion cubic metres

BCM/yr: billion cubic metres per year

CFA: Cooperative Framework Agreement

COMESA: Common Market for Eastern and Southern Africa

DoP: Declaration of Principles

ETO: evapotranspiration

EU: European Union

GERD: Grand Ethiopian Renaissance Dam

HAD: High Aswan Dam

GRACE: Gravity Recovery and Climate Experiment

kWh: kilowatt-hour

IGAD: Inter-Governmental Authority on Development

masl: metres above sea level

NBI: Nile Basin Initiative

NRBC: Nile River Basin Commission

NWRP: National Water Resources Plan 2017–2030–2037 (Egypt)

TWh: terawatt-hour

UAE: United Arab Emirates

UNSC: UN Security Council

Definitions

Live or active storage: The volume of water in a reservoir that can be used to meet the objectives of the reservoir, whether that is hydropower generation, supplying water downstream or flood control.

Riparian countries: the countries that share the Nile Basin.

Disclaimer

Greg Shapland is currently serving as a Senior Research Fellow on the Political Economy of Water in the Middle East and North Africa in the Foreign, Commonwealth and Development Office (FCDO). However, this report does not necessarily reflect the views of the FCDO.

Executive Summary

The future impact of climate change on rainfall and hence river flows in the Nile Basin is very unclear. Projections indicate a wide range of possible outcomes by mid-century: most show an increase in rainfall (although to very varying degrees) while a few suggest a slight decrease.

Temperature projections are much more consistent and indicate higher temperatures across the Basin. This will cause more evaporation from bodies of water and across the landscape, reducing water availability. There are direct implications for farming: crops will need more water per tonne of output.

All those who live in the Nile Basin will be affected in some way by climate change and especially by the extreme weather events which it will bring. Agricultural sectors, important in economic and social (employment) terms, are likely to be hard hit by climate impacts. Egypt faces an additional challenge: the effect of sea-level rise on the populous and productive Nile Delta.

Population growth will certainly mean less water per person. It will also mean increased dependence on imported food, even if climate change does bring more rain to the Basin.

Egypt, Ethiopia and Sudan share the waters of the Eastern Nile Basin. Ethiopia is by far the largest source of Nile water and Egypt by far the largest user – and the most heavily dependent on the river. Egypt and Sudan signed a treaty in 1959 which allocates the resource between them but provides no water quotas for the upstream users, who neither recognize nor are bound by it. Negotiations aimed at reaching a legal and institutional agreement covering the whole Nile Basin – the Cooperative Framework Agreement (CFA) – stalled in 2010 over Egypt's concerns about existing uses of the Nile waters. Technical cooperation among the Nile Basin countries has continued, primarily within the framework of the Nile Basin Initiative (NBI), a partnership among 10 countries.

Since 2011, the focus of the disagreement has been on the filling of the reservoir impounded by the Grand Ethiopian Renaissance Dam (GERD) and the future operation of the dam. Increased water storage in the Basin could help downstream countries better manage the risks of climate change. However, uncoordinated operations during, and particularly following, a multi-year drought could exacerbate already severe economic and social difficulties in both Egypt and Sudan. Furthermore, a lack of proper coordination during periods of exceptionally high flows could result in potentially disastrous downstream flooding in Sudan. Both issues are critical for the countries to address before such situations arise. However, the long-standing distrust between Egypt and Ethiopia and the continuing armed conflicts in Sudan and Ethiopia remain major obstacles to transboundary planning and coordination. Negotiations over the pressing issues raised by the GERD have come to a halt.

For the EU, the main consequences of a failure to resolve disagreements between Egypt, Ethiopia and Sudan in order to deal effectively with the impacts of climate change in the Nile Basin would be felt in the areas of regional instability, migration and lost opportunities for economic cooperation.

Summary of recommendations for EU policymakers

The EU could offer three forms of support to the Nile Basin: technical, financial and diplomatic.

- The EU could offer technical support to the NBI, as it has in the past, and should consider offering support to the Nile River Basin Commission (NRBC) which is expected to replace the NBI in the near future now that the CFA has been signed and ratified by six countries. The EU should also be ready to provide support for technical cooperation regarding the GERD, should the three Eastern Nile Basin countries request it.
- As well as technical support, the EU should extend financial assistance to the multilateral cooperation process within the NBI framework.
- Diplomatically, the EU should use its convening power to persuade Egypt, Ethiopia and Sudan to return to talks about how to advance transboundary cooperation. Rather than launching an independent initiative, the EU should do this in partnership with others such as the US and the Gulf countries.
- The EU could also offer its 'good offices' to both Sudan and Ethiopia in an attempt to mitigate their internal conflicts. By continuing to provide food aid to the two countries, the EU could help to reduce the humanitarian and political effects of the climate and conflict crises, thereby lessening collateral impacts on the dispute over the Nile waters.

When considering policy options regarding the Eastern Nile Basin, the unstable situations in Sudan and Ethiopia cannot be ignored. It may be a long time – probably several years and perhaps even longer – before there is a single, cohesive regime in Khartoum that controls the whole of the Nile Valley within Sudan. Some of the recommendations made above may have to wait until the conflict ends. Similar considerations apply to Ethiopia, although perhaps with somewhat less force.

A fuller elaboration of what the EU and its member states might do is set out in the final section of this paper.

Introduction

This report is part of the EU Cascades project.[1] It examines how climate risks could affect the environment, economies, societies and politics of the countries of the Nile Basin and the political relations between them, and the implications of this for the EU. The authors were guided by the Cascades framework for the Nile Basin elaborated in an earlier report in the series.[2]

However, they also recognized that a range of factors unrelated to climate risks – such as population growth, the expansion of irrigation and the political relationships among Basin states – could affect these questions as well, with equal if not greater force.

The report assesses external attempts to resolve the dispute over water between Egypt, Ethiopia and Sudan. It then looks at the consequences of climate impacts in the Nile Basin for the EU should the dispute remain unresolved. Finally, the report makes recommendations for EU policymakers that the authors believe to be realistic rather than utopian.

The Nile Basin covers around a tenth of Africa's land mass. Eleven countries – Burundi, Democratic Republic of the Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania and Uganda – share the Basin. This report focuses essentially on Egypt, Ethiopia and Sudan, since Ethiopia is by far the largest source of Nile water and Egypt by far the largest user and the country most heavily dependent on the Nile, with Sudan occupying a mid-stream position between them. This triad of countries also exhibits the tensest political relationships, a matter of significant international concern. However, the countries upstream of the White Nile and around the Equatorial Lakes are also considered, as necessary.

At the time of writing, both Sudan and Ethiopia are suffering extreme political instability, including internal armed civil conflicts. Egypt – although in many ways a much stronger state than either Ethiopia or Sudan and at least superficially stable – is going through a severe economic crisis and widespread popular discontent. While none of these situations will inevitably endure over coming decades, the current turbulence in Ethiopia and Sudan, alongside the possibility of future unrest in Egypt, make forecasts especially difficult.

The report adopts the middle of this century as its time horizon, for two reasons. First, water demands and climate impacts can be projected with greater confidence than they can for more distant time horizons. Projections looking beyond 2050 will nonetheless be referenced where they are helpful. Second, this is a sensible period for the purposes of policy planning: beyond 2050, the possibility of radically changed conditions (political and economic, as well as climatic) means that such planning becomes much more uncertain.

The methodology used in preparing this report consists of a critical literature review, interviews and points from a workshop held by Chatham House in 2021.

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[1] Cascades, 'Cascading climate risks: towards adaptive and resilient European societies', https://www.cascades.eu/.

[2] Lahn, G. and Shapland, G. (2022), *Cascading climate risks and options for resilience and adaptation in the Middle East and North Africa*, Report, London: Royal Institute of International Affairs, https://www.cascades.eu/wp-content/uploads/2023/03/CASJ9418-MENA-Report-220614.pdf

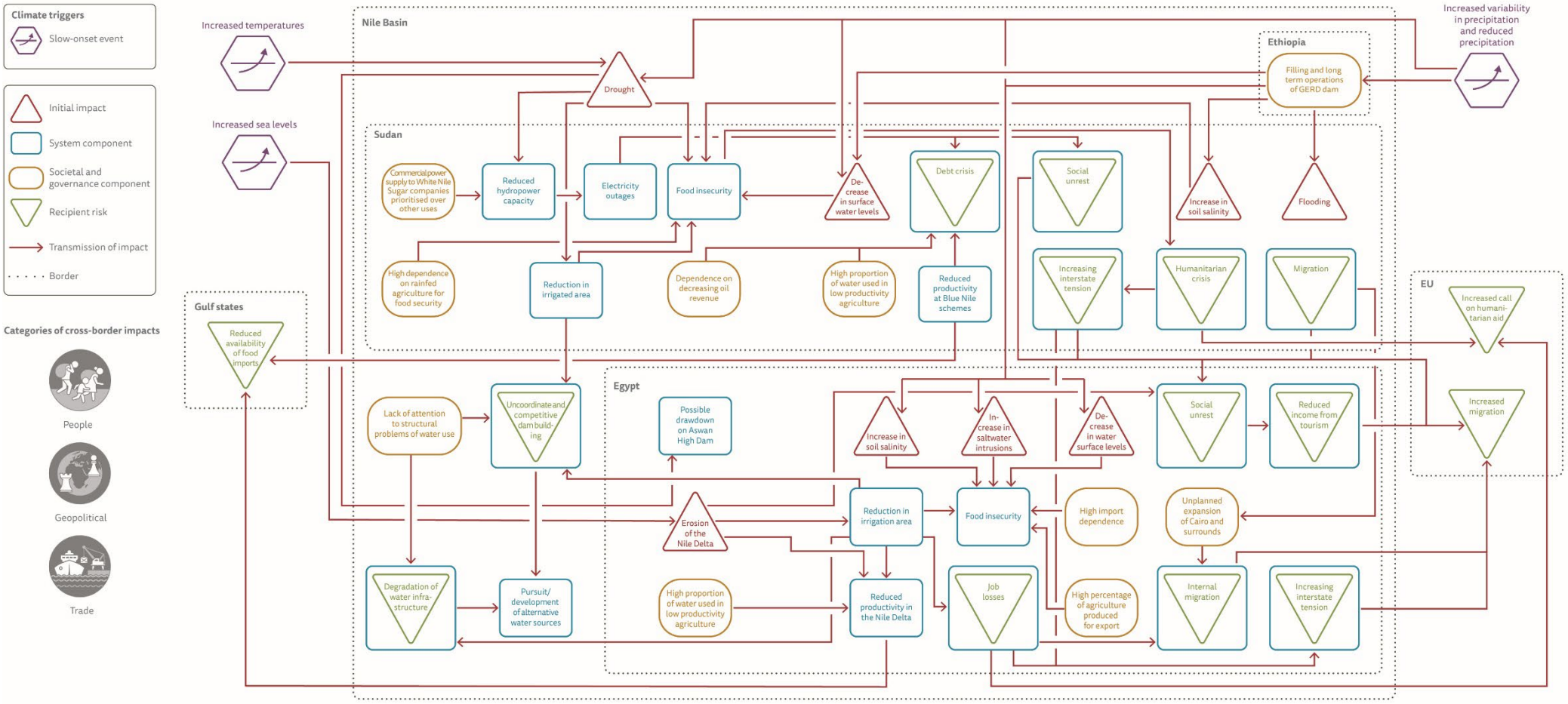

Figure 1. Climate risk cascade for the Nile Basin. (Source: Lahn, G. and Shapland, G. (2022), *Cascading climate risks and options for resilience and adaptation in the Middle East and North Africa*, Report, London: Royal Institute of International Affairs, https://www.cascades.eu/wp-content/uploads/2023/03/CASJ9418-MENA-Report-220614.pdf.)

The Nile Basin: hydrological characteristics

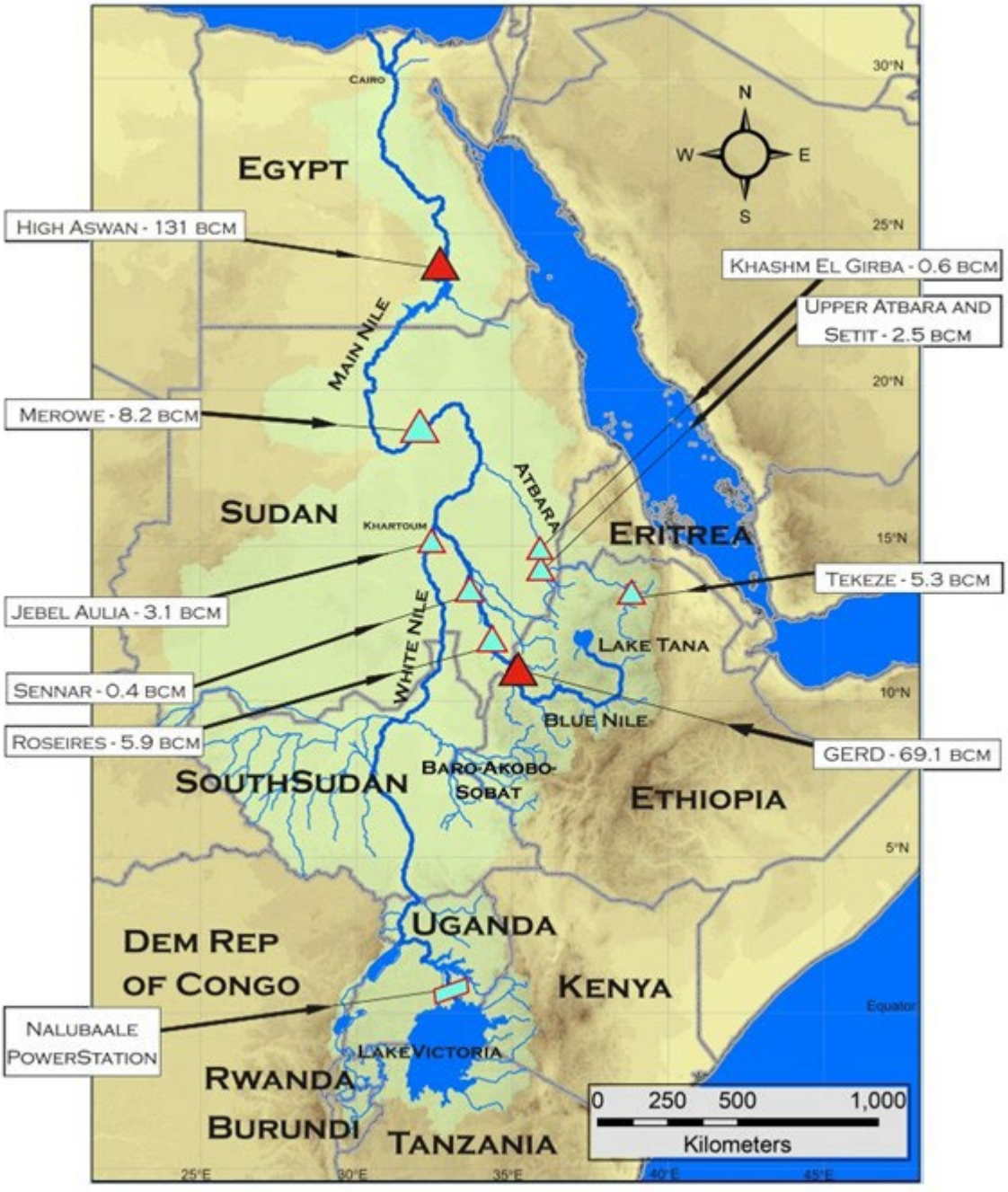

Figure 2. Map of the Nile Basin with major infrastructure. Active reservoir storage volumes are shown for each location in billion cubic metres, including the maximum range for the Grand Ethiopian Renaissance Dam and High Aswan Dam. (Source: Adapted from Wheeler, K. G., et al. (2020), 'Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam', *Nature Communications*, 11(1): 5222, https://doi.org/10.1038/s41467-020-19089-x.

The rivers of the Nile Basin and their natural (pre-dam) flows

The Nile is the world's longest river, draining water from lands within 11 countries across Eastern Africa (Figure 2). Two major tributaries, the Blue Nile (known as the Abbay in Ethiopia) and the White Nile, provide the majority of the flows.

The origins of the Blue and White Niles are geographically and climatologically distant from each other. The Blue Nile has its source in the highlands of Ethiopia, pouring from Lake Tana and descending through steep gorges until the channel flattens upstream of the Sudanese border and continues northwest to Sudan's capital, Khartoum. The White Nile originates from rainfall in the Equatorial Lakes region and accumulates runoff from parts of Burundi, Kenya, Rwanda, Tanzania, Uganda and the Democratic Republic of the Congo. Often labelled the Victoria Nile at this point, it flows out of Lake Victoria in Uganda into the Sudd wetlands of South Sudan, where approximately half of the volume is lost to evapotranspiration. The discharge from the Sudd, which includes runoff from the Bahr el Ghazal, joins outflow from the Sobat River and then flows north as the White Nile to meet the Blue Nile in Khartoum. The combined river then flows northward through the Nubian Desert, collecting runoff from the Atbara River (known as the Tekeze upstream in Ethiopia), which also flows from Ethiopia and Eritrea before joining the Nile in Sudan. The Nile continues into Egypt, traversing its entire length until it reaches the Mediterranean Sea.

The Nile is one of the most studied rivers in the world. Records of floods date back to 3000 BC and flood elevations have been recorded regularly since 641 AD. Systematic measurement of flow volumes began in 1869 with gauging at Aswan and Khartoum, allowing scientific assessment of the quantity of water available. Extreme hydrologic variability characterizes the Nile, both in terms of variations from one year to the next (Figure 3) and from month to month (Figure 4). Based on measurements taken between 1870 and 2015, an average annual 'natural' volume (without evaporation and regulation from man-made reservoirs and upstream abstractions) of 91 billion cubic metres per year (BCM/yr) would have flowed past the Egyptian city of Aswan.[3,4] However, the minimum estimated volume during a water year (1 July to 30 June) was a mere 42 BCM in 1913 and the maximum was 145 BCM in 1897, demonstrating the wide range of annual flows. Ancient civilizations along the Nile and modern mathematicians have long recognized that years of low flows tend to occur consecutively, with the same true for years of high flow (Figure 3).[5]

[3] Hurst, H. E. and Phillips, P. (1933), *The Nile Basin: Volume 4 and subsequent supplements. Ten-day mean and monthly mean discharges of the Nile and its tributaries*, Cairo, Government Press.

[4] van der Krogt, W. and Ogink, H. (2013), 'Development of the Eastern Nile Water SIMULATION ModelRep. 1206020–000-VEB-0010.', Delft, Deltares, (unpublished report prepared for the NBI).

[5] Mandelbrot, B. B. and Wallis, J. R. (1968), 'Noah, Joseph, and Operational Hydrology', *Water Resources Research*, 4(5), pp. 909-918, https://doi.org/10.1029/WR004i005p00909

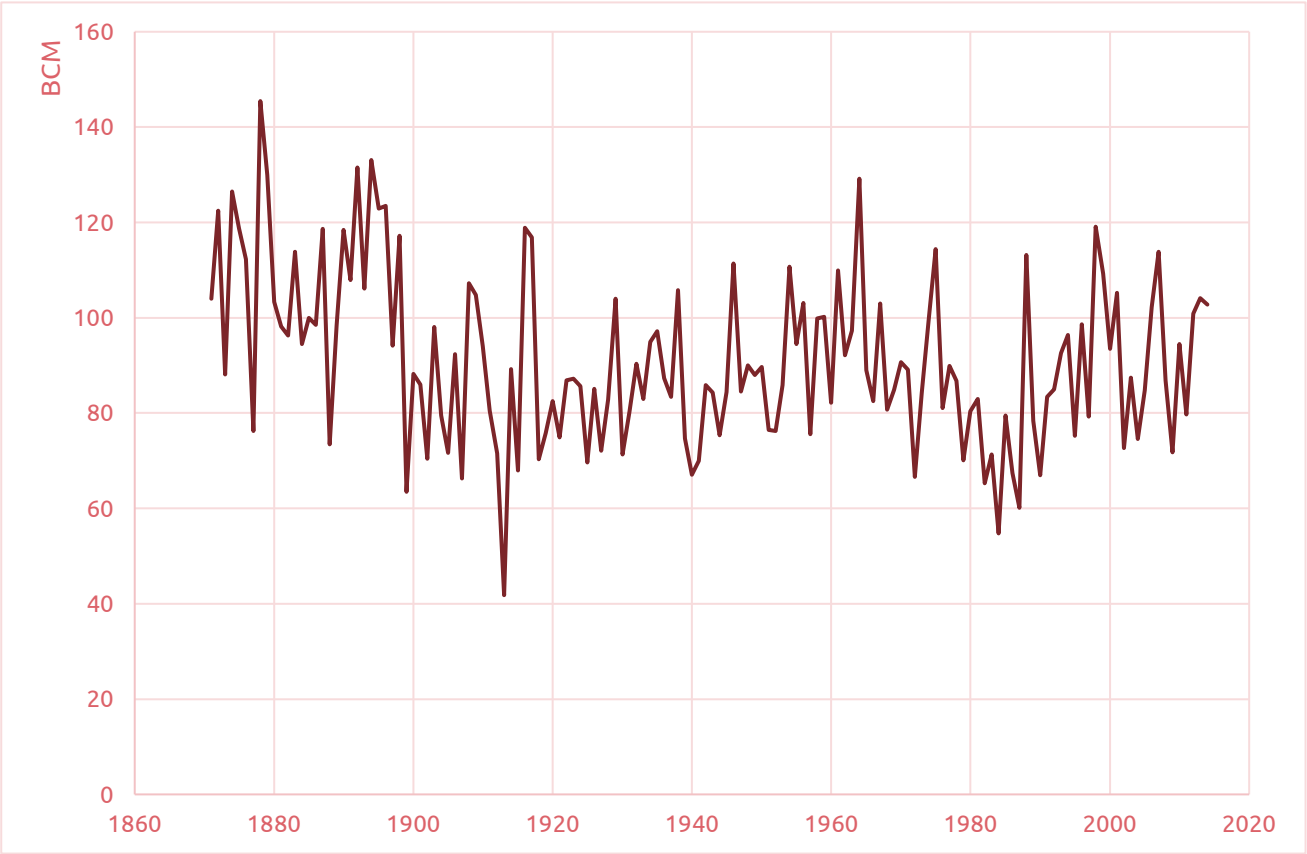

Figure 3. Naturalized flows at Aswan from 1871 to 2015 during a water year (1 July–30 June). Values estimate what would have occurred in the absence of upstream diversions and management. (Source: Hurst, H. E. and Phillips, P. (1933), *The Nile Basin: Volume 4 and subsequent supplements. Ten-day mean and monthly mean discharges of the Nile and its tributaries*, Cairo, Government Press.)

Long-term trends can also be seen. A recent study estimating total water storage capacity using GRACE (Gravity Recovery and Climate Experiment: Earth-monitoring from space using a microwave ranging system), in association with precipitation, temperature records and standard drought indicators, suggests there was an increase in the combined surface and groundwater in the Nile Basin from 1901 to 2002, suggesting a ~17% increase during the wet season and ~28% recovery during the dry season. The study noted that the period from 2002 to 2020 witnessed a substantial transition to wetter conditions but also suggests the potential for future reductions in total water storage.

There is no significant correlation between annual variations in the flow of the two major tributaries, since the catchments of the Blue Nile and White Nile occupy different climatic zones. Furthermore, the inter-annual variability of the natural flows of the Nile also varies substantially (Figure 4) primarily due to the Blue Nile and Atbara/Tekeze rivers producing a large flood from July to October and comparatively low baseflows throughout the rest of

the year.[6] Meanwhile, the bi-modal rainfall seasons that fall over the Equatorial Lakes provide a smaller but steadier flow after it is buffered through the Sudd wetlands.[7]

The Blue Nile and the Atbara/Tekeze contribute around 57% and 13% respectively of the natural flow of the Nile as measured at Aswan (Figure 4). The remaining 30% of the flow comes from the White Nile. Approximately 14% of the flow of the Nile comes from the Sobat and its tributaries, most of which rise in Ethiopia and join the White Nile in Sudan, making Ethiopia the source of around 84% of the total flow of the Nile at Aswan. Egypt's contribution to the flow of the Nile is negligible. Contributions to the Nile from Sudan are highly variable and often come in brief localized rainfall events that are discharged through ephemeral *wadis* (channels that are dry except in the rainy season) but generally do not provide a reliable water supply.

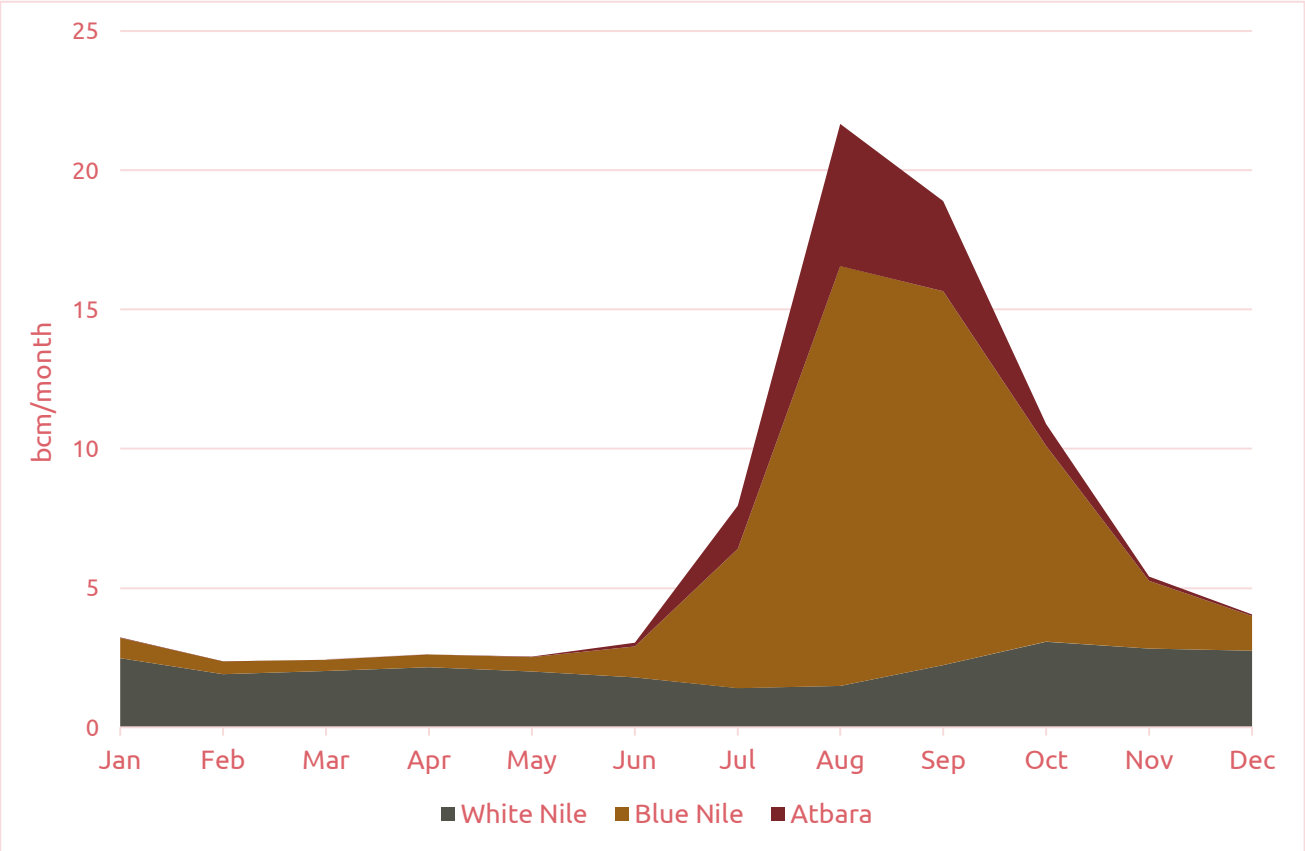

Figure 4. Seasonal pattern of major Nile tributaries (Source: Available gauge data from Atbara at Kilo 3, Blue Nile at Khartoum Soba, and White Nile at Mogren, in Hurst and Phillips, *The Nile Basin: Volume 4 and subsequent supplements.*)

[6] Siam, M. S., Guiling, W., Demory, M.-E. and Eltahir, E. A. B., 'Role of the Indian Ocean Sea Surface Temperature in Shaping the Natural Variability in the Flow of Nile River', *Climate Dynamics,* 43, no. 3–4 (April 17, 2014), pp. 1011–1023, https://dspace.mit.edu/handlfe/1721.1/107175

[7] Palmer, P. I., et al. (2023), 'Drivers and impacts of Eastern African rainfall variability', *Nature Reviews Earth & Environment,* 4(4), pp. 254-270, https://www.nature.com/articles/s43017-023-00397-x

Dams and diversion works and their effect on flows

Water is captured, diverted and used throughout the Nile Basin at vastly different scales.

In the upstream reaches of the Blue Nile, most farming relies on rainfed agriculture. Short periods of intense precipitation, combined with deforestation, result in soil instability and losses. Steep slopes limit the feasibility of substantial agricultural diversions from the river. Ethiopia currently diverts less than 1 BCM/yr from the Blue Nile, primarily for small-scale farming.[8]

This contrasts starkly with diversions downstream in Sudan and Egypt, where the topography is flatter and more conducive to irrigation canals feeding large areas. According to Khalifa et al., recent Sudanese withdrawals are somewhere between 16.0 ± 2.2 BCM/yr and 17.8 ± 1.3 BCM/yr, depending on the calculation method used.[9] These withdrawals are made primarily to supply water to large irrigation schemes near and between the Blue Nile and White Nile tributaries.

At these volumes, and considering evaporation losses in a warming climate, Sudan may be approaching or even exceeding the annual maximum of 18.5 BCM/yr agreed in a 1959 bilateral agreement between Sudan and Egypt.[10] Under the same agreement, Egypt is entitled to 55.5 BCM/yr, although Egyptian use has significantly exceeded this in certain years.[11] Egypt's consumption of Nile water has been estimated at 61.5 BCM on average from 1988 to 2017, with flow to the Mediterranean adding around 2–4 BCM/yr.[12] However, the lack of data transparency in Egypt limits independent verification of these figures.

The flows of the Nile are regulated by several dam structures. Some of these provide the means to divert water into canals. The majority, though, only alter the timing of flows to enable hydropower generation and provide steady releases for downstream irrigation. All existing dams in Sudan – the Roseires and Sennar on the Blue Nile, the Khashm El Girba and the Upper Atbara and Setit dual-dam complex on the Atbara/Tekeze, and the Merowe Dam on the main Nile – retain relatively small volumes of water compared to the annual flows. They therefore have only localized effects on the river system. Similarly, Ethiopia's Finchaa dam in the Blue Nile basin and the Tekeze Dam on the Tekeze (the major tributary to the Atbara) only capture a small volume of the total basin flow.

The largest dam by far is the High Aswan Dam (HAD) in Egypt, which was completed in 1970. The HAD reservoir (known in Egypt as Lake Nasser and in Sudan as Lake Nubia) can store up to 131 BCM of water (volume between elevations 147 and 182 metres above sea level or masl), which is over 1.4 years of average annual flow. Its main functions are to provide water for irrigation and to prevent flooding. It concurrently loses 12–15 BCM/yr due to

[8] Nile Basin Initiative (2014), *Eastern Nile Multi-Sectoral Investment Opportunities Analysis*, Addis Ababa, https://nilebasin.org/sites/default/files/2023-09/EN-MSIOA_Inception_Report.pdf.

[9] Khalifa, M., Woods, N. E. and Eltahir, E. A.B. (2023), 'Estimates of Sudan's historical water withdrawals from the Nile', *Journal of Hydrology*, 624, 129858 https://doi.org/10.1016/j.jhydrol.2023.129858.

[10] UN Treaty Collection (1959), 'United Arab Republic [Egypt] and Sudan Agreement (with annexes) for the full utilization of the Nile waters", No. 6519 https://treaties.un.org/doc/Publication/UNTS/Volume%20453/volume-453-I-6519-English.pdf

[11] Brichieri-Colombi, S. (2022), 'Egypt's water balancing act', *Water International*, 47(6), pp. 912–933, https://doi.org/10.1080/02508060.2022.2118372.

[12] Nikiel, C.A. and Eltahir, E.A.B. (2021), 'Past and future trends of Egypt's water consumption and its sources', *Nature Communications,* 12, 4508, https://doi.org/10.1038/s41467-021-24747-9.

evaporation.[13] It also generates approximately 7.2 TWh electricity a year on average,[14] worth approximately US$ 173 million/year.[15] However, the relative importance of this function has progressively declined with the development of other sources of power: in the mid-1970s, the dam produced half of Egypt's electricity; by 2023 this had fallen to around 3.3%.[16] Most importantly, the HAD has enabled Egypt to cope with long periods of low flows, as occurred during the 1980s.[17]

The only structure in the Nile Basin comparable to the HAD is the Grand Ethiopian Renaissance Dam (GERD), located on the Blue Nile at a site about 15 km upstream of the Ethiopia/Sudan border. This new dam will retain up to 74 BCM, with a maximum active, or live, storage of 69.1 BCM (volume between 565 and 640 masl), which also equates to 1.4 years of the average annual flow at the dam site. No other major river in the world has two reservoirs of this size relative to the average annual flow with no coordination between the operation of the dams which impound them.

The GERD is a large dam by any standards. Its main purpose is to generate electricity. It is planned to have installed power generation capacity of 5.15 Gigawatts, over twice that of the HAD and the largest in Africa. As a hydropower dam, it will not consume water. There will, however, be a loss to evaporation of around 1.2 to 1.7 BCM/yr from the reservoir. Most notably, the GERD will change the seasonal pattern of flow in the Blue Nile.[18]

Because of its size, the filling of the GERD reservoir has taken place over five years (2020–2024), during the rainy season in the Ethiopian highlands. This process began on 13 July 2020 and effectively ended as of 9 September 2024. Each year from 2020, the reservoir impounded water during the flood season (with net retention of 3.0 BCM in 2020, 4.5 BCM in 2021, 14.0 BCM in 2022, 21.0 BCM in 2023, and 6.8 BCM in 2024) to reach the annual flood control elevation of 625 masl or approximately 49.3 BCM of total storage. Although the maximum elevation of the GERD reservoir is 640 masl (74 BCM), the reservoir is expected to be lowered to 625 masl by 30 June each year to allow sufficient space to manage the incoming flood season. Therefore, according to Ethiopian statements, there will be no net water retention during a typical year. However, additional retention may occur if the reservoir level is lowered below 625 masl for hydropower purposes or to support downstream countries and raised again in subsequent years. Now that both the GERD and HAD reservoirs are full, and despite downstream concerns, the normal operation of GERD is

[13] Elsawwaf, M., Willems, P., Pagano, A. and Berlamont, J. (2010), 'Evaporation estimates from Nasser Lake, Egypt, based on three floating station data and Bowen ratio energy budget', *Theoretical and Applied Climatology,* 100, pp. 439–465, https://doi.org/10.1007/s00704-009-0168-z.

[14] Murgatroyd, A., Wheeler, K., Hall, J. W. W. and Whittington, D. (2024), 'The implications of further reservoir development on the Blue Nile in Ethiopia: trade-offs between hydropower, irrigation and transboundary water security', *Environmental Research Letters,* 19(9), https://doi.org/10.1088/1748-9326/ad6887.

[15] Heggy, E., et al. (2024), 'Grand Ethiopian Renaissance Dam can generate sustainable hydropower while minimizing downstream water deficit during prolonged droughts', *Communications Earth & Environment,* 5(1), Article no. 757, https://www.nature.com/articles/s43247-024-01821-w.

[16] Our World in Data, 'Share of primary energy consumption that comes from hydropower, Egypt'https://ourworldindata.org/grapher/hydro-share-energy?tab=chart&country=~EGY , (accessed 17 Dec. 2024).

[17] Abu-Zeid, M. A. and El-Shibini, F. Z. (1997), 'Egypt's High Aswan Dam', *International Journal of Water Resources Development*, 13(2), pp. 209-218, https://www.tandfonline.com/doi/abs/10.1080/07900629749836.

[18] Wheeler, K. G., et al. (2020), 'Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam', *Nature Communications*, 11(1): 5222, https://doi.org/10.1038/s41467-020-19089-x.

unlikely to cause significant water shortages in Egypt beyond what would occur anyway during drought conditions.[19]

What do the Eastern Nile Basin countries use Nile water for?

In Egypt, irrigated agriculture is by far the largest user of water, at 80–85%.[20,21] There is hardly any un-irrigated agriculture in Egypt, because of the country's low rainfall. Sudan uses some 96% of its water resources on agriculture, although not all of this comes from the Nile and its tributaries.[22]

To date, Ethiopia's use of Nile water has been slight. According to the Nile Basin Initiative (NBI), small-scale traditional irrigators use approximately 0.4 BCM/yr from the Blue Nile to irrigate 57,000 hectares, while the Finchaa and Koga irrigation schemes use 0.08 and 0.05 BCM/yr respectively.[23] Small-scale traditional Ethiopian irrigators use approximately 0.28 BCM/yr from the Atbara/Tekeze sub-basin to irrigate 40,000 hectares.

Agriculture (irrigated and otherwise) is a major contributor to the economies of all three Eastern Nile Basin countries and a significant provider of employment. In Egypt, however, the country's relatively high level of industrialization and its highly-developed tourist industry mean that agriculture is less dominant than it is in the other two countries, contributing 11.4% of GDP and providing up to 23.3% of employment.[24] In Sudan, in the period preceding the outbreak of civil war in April 2023, agriculture provided a third of GDP, half of foreign exchange earnings and 65% of citizens' livelihoods.[25] In Ethiopia, agriculture

[19] Whittington, D., Hall, J., Murgatroyd, A. and Wheeler, K. G. (2025), 'Should Egypt be afraid of the Grand Ethiopian Renaissance Dam? The consequences of adversarial water policy on the Blue Nile', *Water Policy*, 27 (1), pp. 104–11, https://doi.org/10.2166/wp.2024.257.

[20] Source for 80%: Abbas Sharaki, professor of geology and water resources at Cairo University, quoted by al-Kady, B., 'Egypt officially enters state of water poverty', *Al-Monitor*, 25 January 2021,

https://www.al-monitor.com/originals/2022/01/egypt-officially-enters-state-water-poverty.

[21] Source for 85%: US International Trade Administration (2022), 'Egypt Country Commercial Guide: Water and Environment', last published date: 8 August 2022, https://www.trade.gov/country-commercial-guides/egypt-water-and-environment.

[22] Figure derived from 2011 statistics in Aquastat (Food and Agriculture Organisation of the United Nations) (2019), 'Country Fact Sheet, Sudan', https://storage.googleapis.com/fao-aquastat.appspot.com/countries_regions/factsheets/summary_statistics/en/SDN-CF.pdf (accessed 21 September 2024).

[23] Nile Basin Initiative (2014), *Eastern Nile Multi-Sectoral Investment Opportunities Analysis*.

[24] PreventionWeb, 'Egypt scales up climate adaptation actions of its agriculture, water and agrifood sectors', 5 September 2022, https://www.preventionweb.net/news/egypt-scales-climate-adaptation-actions-its-agriculture-water-and-agrifood-sectors.

[25] Siddig, K., et al. (2020), 'Climate change and agriculture in the Sudan: Impact pathways beyond changes in mean rainfall and temperature', *Ecological Economics*, Volume 169, 106566, https://www.sciencedirect.com/science/article/pii/S0921800918316458 , quoting Central Bank of the Sudan (2016), *The 56th Annual Report of the Central Bank of the Sudan*.

(mainly rainfed) accounts for 43% of GDP, 45% of export earnings and 75% of employment.[26,27]

Important though agriculture is in the three economies, internal production is not able to provide all the food they need. This is most obviously the case in Egypt. Since the 1970s, Egypt has been importing ever-larger quantities of food, particularly grains and meat products.[28] 'Imports account for more than 40% of Egypt's calorie consumption, and the country is the world's largest importer of wheat, with about 85% coming from Russia and Ukraine before the war began', according to Abay et al.[29] These imports have been termed 'virtual water', as the water used to grow crops in other countries is embedded in them. Egypt imported the equivalent of 40 BCM/yr of water in the 2010s and virtual water is expected to exceed the water Egypt uses from the Nile in the 2020s.[30] Egypt also imports large quantities of meat from countries such as Brazil and Argentina. For Ethiopia and Sudan, food imports (or virtual water) mostly arrive in the form of food aid. Ethiopia has long been one of the world's most aid-dependent countries.[31] In Sudan's case, according to the Food and Agriculture Organization of the United Nations, 'In 2014–2015, despite a record production of over 7.84 million tons of cereals, 20 percent of the cereals balance relied on imports, mostly for wheat.'[32] Since then, the need for food aid has grown still further. In December 2023, 17.7 million people in Sudan were in a state of acute food insecurity because of armed conflict and continued economic decline.[33]

One significant use of water not related to domestic food needs derives from the investment in large-scale commercial farms by Gulf Cooperation Council states, China, Turkey and other countries. All these projects employ irrigation, although how much water they use is not in the public domain. These ventures have usually produced cash crops for export, such as fodder, flowers, biofuel, sugarcane and rice. They do not therefore directly contribute to the food security of the Eastern Nile Basin countries. They may help indirectly, by generating foreign currency earnings that can be used to import food.

[26] Kassie Y. A., Yimam A. Y., Assefa, T. T. and Belay S. A. (2022), 'Evaluating land suitability and water availability for surface irrigation in the Abbay basin of Ethiopia', *Royal Society Open Science,* 9: 220674, https://doi.org/10.1098/rsos.220674.

[27] Yimere, A. and Assefa, E., 'Current and future irrigation water requirement and potential in the Abbay River Basin, Ethiopia', *Air, Soil and Water Research*, 2022; 15, https://journals.sagepub.com/doi/full/10.1177/11786221221097929.

[28] Allan, T. (1992), 'Fortunately there are substitutes for water: otherwise our hydropolitical futures would be impossible', in Overseas Development Administration (1992), *Proceedings of the Conference on Priorities for Water Resources Allocation and Management* https://www.ircwash.org/sites/default/files/210-93PR-11967.pdf.

[29] Abay, K., Karachiwalla, N., Sikandra, K. and Salama, Y. (2023), 'Food price shocks and diets among poor households in Egypt', *IFPRI-Egypt*,

https://egyptssp.ifpri.info/2023/01/03/food-price-shocks-and-diets-among-poor-households-in-egypt/.

[30] Nikiel and Eltahir (2021), 'Past and future trends of Egypt's water consumption and its sources'.

[31] Pereira, A., (2021), 'Does international aid lead to dependency? The case of Ethiopia', Statecraft, 16 June 2021,
https://www.statecraft.co.in/article/does-international-aid-lead-to-dependency-the-case-of-ethiopia.

[32] Food and Agriculture Organisation of the United Nations (2015), 'Country profile: Sudan', https://www.fao.org/3/I9808EN/i9808en.pdf.

[33] IPC Global Support Unit (2023), *Sudan, Acute Food Insecurity Analysis, October 2023 – February 2024*, https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_Sudan_Acute_Food_Insecurity_Oct2023_Feb2024_Report.pdf.

The same considerations apply to the substantial quantities of food (inevitably grown with Nile water) which Egypt exports to the EU. In 2023, the value of these exports was €1,937 million.[34]

The effect of abstraction and pollution on water quality

Human activity along the Nile inevitably results in pollution entering the river. This is amplified by the withdrawal of water from the river: for any given quantity of pollutants, the less water there is, the higher the concentration of pollutants. According to the NBI, 'Pollution is a rapidly increasing threat to water-related ecosystems in the Nile Basin. Discharge of untreated wastewater and sludge, fertilizer and pesticides from farming, and sediments from land degradation comprise the prime pollutants.'[35] Heavy metals from industrial production are also becoming a significant pollutant, particularly in the Egyptian Delta.[36]

Agricultural wastes and sewage create a significant environmental problem for the Nile.[37] The low level of industrialization in Sudan and Ethiopia means that pollution from non-agricultural sources in these countries is relatively limited (except for Khartoum, a city of over six million people). The pollution of the Nile increases substantially in Egypt, mainly as a result of activities within the country itself.[38] Downstream from the HAD, the salinity of the water increases as a result of runoff from agricultural land, as well as pesticides and nutrients from fertilizers. Irrigation water is often re-used several times, successively increasing concentrations of pollutants.

Heavy metals from industry are also discharged into the river, almost entirely from Egyptian sources. Domestic waste (especially from Cairo) and storm water runoff are emptied into the river as well. As Abdel-Satar et al. put it, 'The quality of Nile water is a matter of serious concern'.[39] This is expected to grow unless significant efforts are made to tackle the problem.

In recent years, before the GERD filling began in 2020, Egypt released more water from the HAD than the quantity specified in the 1959 Agreement, with objectives of dilution and flushing pollutants out to the Mediterranean Sea. However, with the subsequent filling of the GERD and concerns about water scarcity, these excess releases have been scaled back.

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[34] European Commission (2024), *Monitoring EU Agri-Food Trade, Developments in 2023*, https://agriculture.ec.europa.eu/document/download/b2e5ee02-4a25-4a6b-9663-92dbee9eb211_en .

[35] Nile Basin Initiative (2022), *State of the River Nile Basin Report, 2021: Water Security in the Nile Basin, 2021*, Entebbe: Nile Basin Initiative Secretariat, p. xxi, https://adelphi.de/en/publications/state-of-the-river-nile-basin-report-2021. This refers to the whole Nile Basin not just the Eastern Nile Basin.

[36] Abotalib, A. Z., et al. (2023), 'Irreversible and large-scale heavy metal pollution arising from increased damming and untreated water reuse in the Nile Delta', *Earth's Future*, 11(3): e2022EF002987, https://doi.org/10.1029/2022EF002987.

[37] El-Sheekh, M. M. (2016), 'Impact of water quality on ecosystems of the Nile River', in: Negm, A. M. (ed.) (2016), *The Nile River (The Handbook of Environmental Chemistry)*, Vol. 56, Springer Nature Link. Agricultural wastes consist of fertilisers, pesticides and herbicides.

[38] Abdel-Satar, A. M., Ali, M. H. and Goher, M. E. (2017), 'Indices of water quality and metal pollution of Nile River, Egypt', *The Egyptian Journal of Aquatic Research*, 43(1), pp. 21-29, https://doi.org/10.1016/j.ejar.2016.12.006.

[39] Ibid.

Future climate change impacts on the Eastern Nile Basin countries

Climate change is projected to affect the environment in the Eastern Nile Basin countries in three main ways:

1. Changes in spatial and temporal rainfall patterns will affect the flow of the Nile and its tributaries, although the direction and magnitude of these changes are not clear.
2. Higher temperatures will result in higher rates of evaporation from reservoirs and other bodies of water and higher rates of evapotranspiration (ETO) from plants.
3. Sea-level rise will cause the intrusion of salt water into the Nile Delta and possibly the flooding of some areas.

These factors are often linked in confounding ways. For example, if changes in precipitation result in lower flows throughout the Basin and lower releases from the HAD that reach the Nile Delta, there will be less resistance to the ingress of seawater, resulting in greater salinization of agricultural lands. Furthermore, higher temperatures will result in higher rates of ETO, resulting in the need for greater quantities of irrigation water for the same level of crop production. However, increased demand for energy for air conditioning will also increase the value of hydropower, resulting in crop production downstream of dams becoming more economically sustainable than upstream irrigated crops, at least from a Basin-wide perspective. Such interlinkages are numerous and complex, leading to significant uncertainties about how climate impacts will affect management decisions.

One should note, however, that factors unrelated to climate will affect the situation of the three countries as much as, or perhaps even more than, climate change. These will be addressed in a later section (see p. 26).

Rainfall and hydrological changes

Projecting river flows into the future requires modelling of projected changes to both rainfall and temperature.

There is a high degree of uncertainty regarding the impact of climate change on rainfall in the Nile Basin. This is partly because the Basin covers 12 climatic zones, according to the Köppen Climate Classification System, and partly because there is a great deal of variation in the projections which emerge from the various models employed for those regions. Scholars have long cautioned against developing water management policies based on

singular or specific climate projections. However, an understanding of past changes and acknowledgement of future uncertainties can lead to better water management.[40,41]

Historical evidence reveals increases in rainfall and runoff from the Blue Nile and Atbara/Tekeze tributaries since the 1960s, primarily during the months of June through to October.[42] Changes to flows in the White Nile have been more complex. Climatic patterns over Eastern Africa have shown a decrease in rainfall in the months of March, April and May (often termed the 'Long Rains') and an increase during the months of October, November and December (the 'Short Rains'). Anomalous high rainfall and flooding around Lake Victoria from 2019 to 2020 followed by intense drought conditions in early 2022 demonstrate the hydro-meteorological extremes recently faced in the Equatorial Lakes and downstream in South Sudan's Sudd wetlands.[43]

Most regional climate change projections suggest that increases in rainfall will continue. It is important to note, however, that the largest increases in precipitation in Ethiopia are projected to occur towards the eastern side of the country, while the projected increases in the Blue Nile Basin are smaller.

Although most projections indicate wetter conditions across most of the region, a decline in duration of the Long Rains has been noted in the Horn of Africa (primarily outside the Nile Basin) from the 1980s to the 2000s. This phenomenon has been termed the 'Eastern African climate paradox'.[44] While scientists seek to unpack why historical rainfall patterns do not align with projections from climate models, these complexities reveal the challenges in understanding how changing rainfall patterns may affect water availability in the future.

After considering the implications of rainfall changes and increased temperatures and ETO, Gebrechorkos et al. conclude, 'the annual streamflow in the largest rivers [in Ethiopia] such as Awash [which is not part of the Nile Basin], Tekeze, Abbay, and Baro Akobo will increase by more than 5% throughout the 21 century'.[45] In the Nile Basin, streamflow will be higher in all basins of Ethiopia in July, August and September, which is when the bulk of flows in the Blue Nile already occur. Therefore, according to these projections, the result will be wetter summers and drier winters.

The trend of increasing flows is supported by Roth et al. who, using three general circulation models, suggest that flows entering Sudan from Ethiopia are likely to increase significantly (by 27%) by mid-century compared with the baseline 1988–2004. They differ greatly in their projections for the end of the century.[46]

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[40] Di Baldassarre, G., et al. (2011), 'Future hydrology and climate in the River Nile basin: a review.' *Hydrological Sciences Journal*, 56(2), pp. 199–211, https://www.tandfonline.com/doi/full/10.1080/02626667.2011.557378.

[41] Nikiel and Eltahir (2021), 'Past and future trends of Egypt's water consumption and its sources'.

[42] Siam, M. S. and Eltahir, E. A. B. (2017), 'Climate change enhances interannual variability of the Nile river flow', *Nature Climate Change* 7, pp. 350–354, https://doi.org/10.1038/nclimate3273.

[43] Pavur, G. and Lakshmi, V. (2023), 'Observing the recent floods and drought in the Lake Victoria Basin using Earth observations and hydrological anomalies', *Journal of Hydrology: Regional Studies*, Vol. 46, 101347, https://www.sciencedirect.com/science/article/pii/S2214581823000344.

[44] Baxter, A. J., et al. (2023), 'Reversed Holocene temperature–moisture relationship in the Horn of Africa', *Nature,* 620, pp. 336-343, https://doi.org/10.1038/s41586-023-06272-5.

[45] Gebrechorkos, S. H. et al. (2023), 'Future changes in climate and hydroclimate extremes in East Africa', *Earth's Future,* 11(2), https://doi.org/10.1029/2022EF003011.

[46] Brichieri-Colombi (2018), 'Egypt's water balancing act', citing Roth, V. et al. (2018), 'Effects of climate change on water resources in the upper Blue Nile Basin of Ethiopia', *Heliyon*, 4(9), e00771. https://doi.org/10.1016/j.heliyon.2018.e00771.

Another recent study takes a pragmatic approach by developing 20 climate projections derived from a wide range of models.[47] Given that all these projections suggest a wetter future, the authors then develop another nine 'drier' projections by removing the general wetting trend. The result is an analysis of possible changes to Nile streamflow ranging from a 13% reduction to a 90% increase, noting that 'both the sign and magnitude of potential changes in naturalized streamflow of the Nile in 2021–2050 are highly uncertain'.

Higher average annual rainfall would bring higher river flows, which (other things being equal) would be positive in terms of the availability of water. In the Eastern Nile Basin, such variations would potentially provide additional supplies. However, these additional supplies must not be considered a reliable new source for future development lest an extended drought occur as it did in the 1980s. Such a recurrence would inevitably be more severe in the future than it was in the past given the increased demands in Sudan since that severe drought.[48] Furthermore, evidence suggests that increased variability – both more frequent flooding and more severe droughts – is likely, despite the greater overall water availability.[49]

Across East Africa, higher peak streamflow and the risk of flooding could pose significant threats.[50] The GERD will provide a significant opportunity to regulate the flow of the Blue Nile and reduce the risk of flooding in Sudan.[51] However, the GERD reservoir is likely to be operated to reach its annual capacity each year, initially due to insufficient turbine capacity, transmission lines and power purchase agreements, and later to maximize hydropower generation efficiency. The annual drawdown of the reservoir will be a critical factor to manage downstream flooding and thus coordination with Sudan's Roseires reservoir immediately downstream of the GERD will be essential. For Egypt, the HAD reservoir has been elevated above its normal operation zone during the filling process of the GERD reservoir, presenting an additional risk of flooding. However, if normal operations resume, and with the Toshka spillway to redirect water, Egypt remains at minimal risk from downstream flooding. However, coordination among all reservoirs will still be critical under extreme flooding or drought events.

The bottom line from the published studies of streamflow in the Nile Basin is that there is a very wide range of projections. Most studies agree that there are 'trends towards more severe hydrological extremes, in both high and low streamflow directions'.[52] Furthermore, some speculate that 'an overall increase in high and low streamflows is expected, prompting a reduction in drought events for the 2050s and 2080s'.[53] Others are cautious to suggest a reduced occurrence of droughts, lest projections are wrong.[54] It is also worth remembering that changes in land use and vegetation cover will interact with climate impacts to affect streamflows.

[47] Basheer, M. et al. (2023), 'Negotiating Nile infrastructure management should consider climate change uncertainties', *Nature Climate Change,* 13, pp. 17–19, https://doi.org/10.1038/s41558-022-01557-5.

[48] Wheeler, et al. (2020), 'Understanding and managing new risks on the Nile'.

[49] Siam and Eltahir (2017), 'Climate change enhances interannual variability of the Nile river flow'.

[50] Gebrechorkos et al. (2023), 'Future changes in climate and hydroclimate extremes in East Africa'.

[51] Basheer, M. (2021), 'Cooperative operation of the Grand Ethiopian Renaissance Dam reduces Nile riverine floods', *River Research and Applications*, 37(6), 805-814, https://doi.org/10.1002/rra.3799

[52] Taye, M. T., Willems, P. and Block, P. (2015), 'Implications of climate change on hydrological extremes in the Blue Nile basin: A review', *Journal of Hydrology: Regional Studies*, Vol. 4, Part B, pp. 280-293, https://doi.org/10.1016/j.ejrh.2015.07.001.

[53] Ibid.

[54] Siam and Eltahir (2017), 'Climate change enhances interannual variability of the Nile river flow'.

Higher temperatures

Temperature projections for the Nile Basin can be made with a greater degree of confidence than is the case with rainfall. Temperatures are unequivocally projected to be higher across the region, although not dramatically so in the period to 2050. With respect to Ethiopia, Kenya, Uganda and Tanzania, Gebrechorkos et al. note that 'The projected changes for Tmax [annual average maximum temperature] and Tmin [annual average minimum temperature] for the 2050s are below 2°C for both scenarios while for the 2080s and SSP585 scenario it is projected to be higher than 3°C.'[55]

Some authors suggest that '[h]igher temperatures will offset much of any gain in water availability'.[56] Others emphasize that, in the Upper Nile Basin including Ethiopia, 'hot and dry years have been more frequent in recent decades, driven by increasing regional temperatures. This trend is likely to continue despite climate model projections of increasing regional precipitation.'[57] This study concludes by arguing that the combination of increased hot and dry years, along with increased water demands, will result in increased water scarcity despite any increases in rainfall.

One certain effect of climate change is that higher temperatures will result in increased evaporation from lakes and reservoirs. According to an Egyptian professor of engineering, 12 BCM/yr was lost to evaporation from the HAD reservoir between 1981 and 2021 (rather than the 10 BCM/yr for which allowance was made in the 1959 Egypt–Sudan agreement). In a worst-case scenario, higher temperatures resulting from climate change could lead to additional losses of 8 BCM/yr.[58]

Moreover, increased evapotranspiration (ETO) from crops will mean more water is required per unit of crop yield, or a decrease in yield would be expected without irrigation improvements or changes to cropping technology.[59] Across the entire region of Ethiopia, Kenya, Uganda and Tanzania, a maximum 6% annual increase in ETO is projected. This is highly variable, however, and decreases in ETO (up to –2%) in the western part of Ethiopia are projected until the 2050s and 2080s.[60] In Sudan, where ETO from wheat crops poses significant potential to drive increased water demand, the government has been planning for warming of 1.5 to 4.2°C.[61] In Egypt, potential ETO from crops is projected to increase by

[55] Gebrechorkos et al. (2023), 'Future changes in climate and hydroclimate extremes in East Africa'.

"In this study, SSP245 and SSP585 were used. SSP245 represent the medium challenges to mitigation and adaptation as well as fossil-fueled development world while SSP585 represents the high challenges to mitigation and low challenges to adaptation to climate change." (2.2. Climate and Hydrological Data). SSP = Shared Socioeconomic Paths

[56] Brichieri-Colombi (2022), 'Egypt's water balancing act'.

[57] Coffel, E. D. (2019), 'Future hot and dry years worsen [Upper] Nile Basin water scarcity despite projected precipitation increases', *Earth's Future,* 7(8), pp. 967–977, https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019EF001247

[58] Prof. Hany Abd-Elhamid of Zagazig University in Egypt, speaking at Cairo Water Week on 2 November 2023.

[59] Nile Basin Initiative (2022), 'State of the River Nile Basin Report', p. xxiii.

[60] Gebrechorkos et al. (2023), 'Future changes in climate and hydroclimate extremes in East Africa'.

[61] Iizumi, T., et al. (2021), 'Rising temperatures and increasing demand challenge wheat supply in Sudan', *Nature Food*, 2(1), pp. 19–27, https://www.nature.com/articles/s43016-020-00214-4.

5–21%.[62] Food crop yields are projected to decline by 10% on average, as a result of heat stress, water stress and increased salinity.[63]

The impact of climate change on the Nile Delta

The impact of climate change and increased Basin-wide abstractions could have important implications for Egypt's economy and society, particularly in the Nile Delta. The Delta makes up two-thirds of Egypt's agricultural land[64] and its 10 governorates, including Alexandria (Egypt's second city), are home to over 48 million people.[65]

Because of its coastal position, the Nile Delta is exposed to climate impacts deriving from sea-level rise that are distinct from those affecting other parts of the Basin. However, quantifying the extent and impacts of sea-level rise in the Delta is challenging. This is because of the variability in projections, the uncertain accuracy of digital land-surface mapping in a topographically flat region, and geologically dynamic land surfaces.

According to Prof. Ibrahim Elshinnawy of the National Water Research Centre in Cairo, there may be nearly 25 centimetres of sea-level rise by 2050. This means that, combined with a possible 1.1 metre surge, there could be a temporary 1.35 metre rise in sea level during extreme events.[66]

Whatever its eventual extent, sea-level rise could have two main effects on the Delta. First, a strip of land along the coast could be permanently submerged, with storm surges bringing seawater further inland. Second, seawater could intrude into the aquifer beneath the Delta, rendering the groundwater it contains unsuitable for irrigating crops and other purposes.

How much freshwater reaches the Delta is one factor that will determine the degree of saltwater intrusion. The more freshwater that flows into the Delta from the Nile, the stronger the resistance to that intrusion will be. As noted earlier, Egypt has for many years released water from the HAD in excess of its allocation of 55.5 BCM/yr to flush salinity from the waterways and manage the freshwater/saltwater interface.[67] With increased abstractions throughout the basin and greater ETO, Egypt will inevitably not be able to release as much water each year, exacerbating the implications of sea-level rise.

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[62] Perez, N. et al (2021), *Climate-Resilience Policies And Investments For Egypt's Agriculture Sector: Sustaining Productivity And Food Security*, CGIAR, p. 39, https://cgspace.cgiar.org/items/d22329cc-b4f4-4291-9d91-8c6cae63bab5.

[63] Ibid., p. 22.

[64] Molle, F., Gaafar, I., El-Agha, D. A. and Rap, E. (2018), 'The Nile delta's water and salt balances and implications for management' *Agricultural Water Management*, 197,

pp. 110–121, https://www.sciencedirect.com/science/article/pii/S037837741730375X.

[65] Total population of Egypt as of 2022, by governorate, Statista website, https://www.statista.com/statistics/1229759/total-population-of-egypt-by-governorate, accessed 13 Jan. 2024.

[66] Interview with Prof. Elshinnawy, Cairo, 31 October 2023.

[67] Brichieri-Colombi (2022), 'Egypt's water balancing act'.

Governmental preparedness to respond to climate impacts

The three countries of the Eastern Nile Basin vary in terms of their preparedness to respond to water-related climate impacts. In general, they appear to be not well prepared, although Egypt is somewhat better prepared than Ethiopia and much better prepared than Sudan. The Notre Dame Global Adaptation Initiative Index ranks Egypt 102nd out of 187 countries, with Ethiopia ranking 155th and Sudan 183rd.[68] In light of the disruption caused by their respective internal conflicts, both Ethiopia and Sudan would presumably now be ranked even lower.

Egypt

Because of the HAD and the Toshka spillway, Egypt is unlikely to suffer from flooding. The HAD cannot, however, wholly protect the country from a multi-year drought. Coordination with Ethiopia's GERD would certainly help Egypt, and the lack of coordination could potentially be harmful. Regardless of whether this coordination materializes, Egypt does face the risk of shortages, and this is likely to increase with climate change and upstream development.

In anticipation of the rare, but inevitable, occurrence of a multi-year drought, less Nile water will arrive at the HAD reservoir, and the volume of water it stores will decline if Egypt maintains its expected release of 55.5 BCM/yr. Egypt has a drought management policy that reduces releases from the HAD by 5%, 10% and 15% as the storage falls below 60, 55 and 50 BCM respectively.[69] The implications and sufficiency of this policy are uncertain and the Egyptian authorities will need to re-evaluate them periodically as the impacts of climate change become clearer and upstream water use increases. Regardless of whether the current plan or an adapted plan is implemented in the future, a deeper understanding of where reductions in use can be most reasonably made will become increasingly important. As well as frequently highlighting their concerns about upstream development, Egyptian officials are aware of the need to reduce water use.[70]

How reductions would be allocated to water users within Egypt is not clear but economic logic suggests they would mainly affect the agricultural sector.[71] Domestic and industrial consumers would probably not be affected due to the high value of those sectors, large return flows and low volumes of use compared to agriculture. Following an exceptionally low seasonal flood in 2015, the HAD reservoir declined significantly in 2016, when, according to the National Water Resources Plan 2017–2030–2037 (NWRP), the country 'faced water shortage due to drought in the upper catchment of the River Nile'. Although

[68] The scores are for 2022. ND-GAIN (Notre Dame University Global Adaptation Country Index), 'Country rankings', , https://gain.nd.edu/our-work/country-index/rankings/, accessed 22 Feb. 2025.

[69] Moussa, A. M. A. (2018), 'Dynamic operation rules of multi-purpose reservoir for better flood management', *Alexandria Engineering Journal*, 57(3), pp. 1665–1679, https://doi.org/10.1016/j.aej.2017.03.012.

[70] AbuZeid, K. M. (2020), 'Existing and Recommended Water Policies in Egypt', in: Zekri, S. (ed.) (2020), *Water Policies in MENA Countries*, Global Issues in Water Policy, Vol. 23, Cham: Springer, , pp. 47–62, https://doi.org/10.1007/978-3-030-29274-4_3.

[71] Boehlert, B., Strzepek, K. M. and Robinson S. (2017), 'Analysing the economy-wide impacts on Egypt of alternative GERD filling policies. The Grand Ethiopian Renaissance Dam and the Nile Basin', in Yihdego, Z., Rieu-Clarke, A. and Cascão, A. E. (eds) (2017), *The Grand Ethiopian Renaissance Dam and the Nile Basin: Implications for Transboundary Water Cooperation* (1st ed.), London: Routledge, https://doi.org/10.4324/9781315160122 .

the HAD reservoir storage levels only fell to 112 BCM, far from the 60 BCM that would trigger their drought management policy, water for irrigation 'was rationed strictly and the ceiling on the cultivation of water-thirsty crops was resolutely enforced'.[72] Rice production has been the most targeted crop, and there are ongoing, and controversial, efforts to restrict the area cultivated for rice.

The imposition of the drought management policy might cause the loss of farming livelihoods, especially if it happened over consecutive years. Some workers in the sector could be driven to leave the land and migrate to the cities. Abrupt changes to water availability could cause reduced production, higher prices, and short-term impacts on Egypt's food supplies. However, modest reductions in the availability of irrigation water will have a limited impact on long-term food security due to the significant and ever-increasing dependence on food imports. Further increases in imports are likely to compensate for modest reductions in water availability.

As far as the Delta is concerned, physical counter-measures should be able to prevent seawater from flooding extensive tracts of land in the period up to 2050. According to Prof. Elshinnawy, saltwater intrusion will not produce a substantial effect in the near future (2050) but will affect the agricultural environment over time. He argues that the expected level of sea-level rise plus storm surge up to 2050 should not threaten Alexandria, because of the height of the corniche.[73] The combination of torrential flooding events, rapid urban growth and the lack of sediment replenishing the delta primarily due to the HAD reservoir, however, significantly increases Egyptian coastal vulnerability.[74]

Ethiopia

The present government, in power since 2018, has launched several climate-related campaigns under its Green Legacy initiative, such as the planting of billions of trees.[75] The implementation of these programmes on the ground has not matched the government's declared aspirations. The causes include the diversity of climate-related problems throughout the country, poor governance at both federal and regional levels, armed conflicts, and increasing environmental challenges.[76] Hirpha et al. observe what appears to be 'weak integration among the different institutions working on climate change'.[77]

One major area in which Ethiopia is deficient is water storage. More water storage would prevent or at least mitigate floods and would retain water against years of drought. The government would benefit from external assistance in this area. It is important to recognize that, due to its downstream location, the GERD does not buffer the effects of climate change on Ethiopian agriculture uses.

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[72] Arab Republic of Egypt, Ministry of Water Resources and Irrigation (2005), *Water for the Future: National Water Resources Plan, 2017* ', Executive Summary, p. viii, https://andp.unescwa.org/plans/1343.

[73] Interview with Prof. Elshinnawy, Cairo, 31 October 2023.

[74] Hzami, A., et al. (2021), 'Alarming coastal vulnerability of the deltaic and sandy beaches of North Africa', *Scientific Reports,* 11(1), 2320, https://www.nature.com/articles/s41598-020-77926-x.

[75] Government of Ethiopia, Office of the Prime Minister (undated), *Green Legacy Initiative,* https://sdgs.un.org/partnerships/green-legacy-initiative.

[76] Dove, M. (2022), *Climate Risk Country Profile: Ethiopia*, Washington, DC: World Bank, https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099432006152216345/p171116024fa790c50b4ae091dd929c683b.

[77] Hirpha, H. H., et al. (2021), 'Assessing the integration of climate change adaptation and mitigation into national development planning of Ethiopia', *International Journal of Climate Change Strategies and Management*, 13 (3), pp. 339–351, https://doi.org/10.1108/IJCCSM-07-2020-0082.

According to Zegeye, Ethiopia 'has in general low adaptive capacity to the impacts of climate change'.[78] Without improved performance in implementing its plans and creating additional water-management infrastructure, Ethiopia's food security will probably continue to depend heavily on external food aid for the foreseeable future.

Sudan

Sudan is highly vulnerable to climate variability in the Nile basins (the Blue Nile and the Atbara–Tekeze and Baro–Akobo–Sobat White Nile basins). In past decades, in the absence of adequate storage capacities within the country or upstream in Ethiopia, Sudan has frequently suffered from severe flooding. Sudan's dams on the Blue Nile (Roseires and Sennar) and main Nile (Merowe) provide only limited protection against droughts and floods, due to their limited active storage volumes. Therefore, Sudan has not been able to deal with the variation in flow of the Blue Nile, as demonstrated during the very damaging floods of 2020, for example.[79] The GERD could bring benefits to Sudan in terms of flood control, as was shown during the filling process. In the post-filling period, the GERD, if operated to provide a steady baseload of hydropower, will significantly reduce the flood risk to Sudan. It will also reduce the flow of sediment into Sudan, so protecting the storage capacities of Sudanese reservoirs.

However, if the operations of the GERD do not consider the management of the Sudanese reservoirs, or occur without adequate exchange of information, or if GERD operations do not properly adapt to increased climate variability, the risks to Sudan will increase. How well technical staff from Ethiopia and Sudan communicate in real time will be critical in mitigating flood risks in Sudan. In the absence of a trilateral agreement on the GERD, Sudanese and Ethiopian Heads of State met in Addis Ababa on 26 April 2023 (just 11 days after the Sudanese civil war started) and reportedly agreed on a bilateral approach to sharing information about water releases from the GERD. The language used was ambiguous, with Sudan and Ethiopia stating they are 'aligned and in agreement *on all issues* [authors' emphasis] regarding GERD'. [80] The present status of this 'agreement' is unknown.

The ongoing civil war has changed the picture dramatically. The majority of Sudanese water experts have fled the country and it is not clear to what extent the Ministry of Water Resources and Irrigation is currently functioning or can continue to do so. Moreover, during the course of the war, the Sudanese Armed Forces have lost control of several areas in the Blue Nile, White Nile and Gezira states, where most of the developed and potential irrigated agriculture is located, to the Rapid Support Forces. Accounts of the encirclement and threats to the Sennar Dam and attacks on the Jebel Aulia Dam show how hydraulic infrastructure

[78] Zegeye, H. (2018) , 'Climate change in Ethiopia: impacts, mitigation and adaptation', *International Journal of Research in Environmental Studies (IJRES)*, 5, pp. 18–35, https://www.academia.edu/42827784/Climate_change_in_Ethiopia_impacts_mitigation_and_adaptation.

[79] Reliefweb, 'Sudan floods: Blue Nile state governor warns for a disaster', 15 September 2020, https://reliefweb.int/report/sudan/sudan-floods-blue-nile-state-governor-warns-disaster.

[80] *Al-Ahram* (2023) (citing AFP), 'Burhan says Sudan "in agreement" with Ethiopia on controversial dam', 26 April 2023, https://english.ahram.org.eg/News/484993.aspx.

can be weaponized.[81,82,83] The battle for territorial control between the two belligerent forces means that there is limited national-level control over water issues.

Both forces continue to fight along the Nile banks, seriously jeopardizing Sudan's capacities to manage the water resources on its territory. There seems little prospect of peace returning in the short or medium term.[84] Even when it does, the restoration of Sudan's water-management capability will be a protracted process. Until that happens, Sudan will have little capacity to deal with extreme climate events or any potentially negative effects of the GERD. Meanwhile, Sudan could become even more exposed to food insecurity (which has already reached famine conditions in most parts of the country) and even more dependent on food aid.[85]

The impact of non-climate factors: population and the expansion of irrigation

The most important factor in determining the future per-capita availability of water in the Eastern Nile Basin countries is demographic growth. The population of the three countries is projected to grow apace. According to the 'medium variant' of UN projections, Egypt, Ethiopia and Sudan will together have 467 million people in 2050, compared to 302 million today.[86]

As Coffel et al. put it, 'climate conditions (such as hot and dry occurrence) are not the only, nor even the most important, factor determining future water stress. A rapidly rising population is likely to dramatically increase water stress in the Nile Basin as measured by per-capita runoff supply, irrespective of climate change.'[87] More people will naturally mean greater demand for water for human uses such as drinking and hygiene. Economic development over coming decades will also translate into higher demand in key economic sectors. Moreover, rising living standards mean that this demand is likely to grow at a rate faster than a linear projection of population numbers would suggest.

More food will be required to feed growing populations. As already noted, much of the food consumed in Egypt, Ethiopia and Sudan is imported, whether on commercial terms or as food aid, and this will continue to be the case. Nevertheless, the governments of these countries

[81] Alnaser, H., Idris, M., Alagra M. and al-Faroug, O., 'Sudan Nashra: Ongoing RSF incursion in Sennar, Military secures gains in Omdurman, Central Sudan faces famine risk', *Mada*, 5 July 2024, https://www.madamasr.com/en/2024/07/05/news/u/sudan-nashra-ongoing-rsf-incursion-in-sennar-military-secures-gains-in-omdurman-central-sudan-faces-famine-risk/.

[82] *Sudan Tribune,* 'White Nile floodwaters engulf new areas, RSF blames army', 23 December 2024, https://sudantribune.com/article295013/.

[83] Basheer, M. and Elagib, N. A. (2024), 'Armed conflict as a catalyst for increasing flood risk', *Environmental Research Letters*, 19(10), 104034, https://iopscience.iop.org/article/10.1088/1748-9326/ad6fb6.

[84] *ACLED,* 'Foreign meddling and fragmentation fuel the war in Sudan', 12 December 2024, https://acleddata.com/conflict-watchlist-2025/sudan/.

[85] IPC, 'Sudan: Acute Food Insecurity Situation – Updated Projections and FRC conclusions for October 2024 to May 2025', https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1159433/.

[86] United Nations Department of Economic and Social Affairs, Population Division, World Population Prospects, https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used.

Figures for current populations are from World Population, Worldometer, accessed 24 January 2025, https://www.worldometers.info/world-population/.

[87] Coffel et al. (2019), 'Future hot and dry years worsen [Upper] Nile Basin water scarcity despite projected precipitation increases'.

will want to minimize imports when possible and maintain a degree of food security by growing some of their food within national boundaries. Irrigation is therefore likely to be the most important factor creating higher demand for Nile water.

One likely driver of the expansion of irrigated agriculture not related to domestic food needs is the further investment in large-scale commercial farms in all three countries by agri-businesses based outside the Basin, in particular from the Gulf countries (see p. 16). As neither the quantities of water presently being used nor the agri-businesses' investment plans are in the public domain, it is extremely difficult to estimate how much water they might use in future.

The factors influencing the future demand for water will be different in all three countries.

Egypt

Egypt currently has 118 million people but is projected to have 160 million in 2050.[88] The added population will put pressure on water resources. Egypt's NWRP recognizes this: 'The first and foremost driver for the increasing demand [for water] is Egypt's expected population growth.'[89] Another driver of increased demand for water is the country's need for foreign exchange, which has led to a focus on agricultural exports. In 2023, for example, Egypt's exports of food to the EU were 41% greater than in the previous year.[90]

Even though Egypt is more than fully using the water allocated to it under the 1959 Agreement with Sudan, it has plans for agricultural expansion. The NWRP suggests that the allocation of water to agriculture will moderately increase by 2037, primarily by 'increasing the fresh water supplies and limiting allocations to the municipal water sector'.[91] Such a conservation effort will be difficult to achieve with a growing urban population. Plans suggest that Egypt may seek to consume up to 11 BCM of additional water by 2050.[92] This could only be achieved by heavy investments in desalination plants, groundwater-extraction facilities, wastewater treatment plants and technologies for the reuse of treated water. It is most likely, however, that such investments will not produce the savings required.

If Egypt is not able to save enough water to greatly expand its irrigated area, it will soon be importing more water embedded in food than it takes directly from the Nile.[93] The near inevitability of this outcome may not, however, keep Egypt from trying to expand its agricultural lands to grow more food domestically.

[88] World Population Prospects, Population Division, UN Department of Economic and Social Affairs, median projection https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used. The figure for the current population is from World Population, Worldometer, https://www.worldometers.info/world-population/, accessed 24 January 2025 .

[89] Arab Republic of Egypt, Ministry of Water Resources and Irrigation (2005), *Water for the Future*: National Water Resources Plan, 2017', p. 23, https://andp.unescwa.org/plans/1343.

[90] European Commission (2024), *Monitoring EU Agri-Food Trade, Developments in 2023*.

[91] Arab Republic of Egypt, Ministry of Water Resources and Irrigation (2005), *Water for the Future: National Water Resources Plan, 2017*, Table 2.6, p. 18.

[92] Multsch, S., et al. (2017), 'Improving irrigation efficiency will be insufficient to meet future water demand in the Nile Basin', *Journal of Hydrology: Regional Studies*, 12, pp. 315–330, https://www.sciencedirect.com/science/article/pii/S2214581816301331.

[93] Nikiel and Eltahir (2021), 'Past and future trends of Egypt's water consumption and its sources'.

Ethiopia

Ethiopia's population is projected to reach 213 million in 2050, up from today's 134 million.[94]

Ethiopia has a history of extreme food insecurity. Droughts in the 1970s and 1980s caused famines that cost many lives.[95] Against this background, a rapidly growing population (as well as even greater climate variability than the country has experienced to date) naturally makes food security a priority for the government. Substantial improvements in rainfed agriculture and expansion of irrigation are part of the Ethiopian government's strategy. The main manifestation of this for the present decade is the Ten-Years Perspective Development Plan (2021–2030).[96]

The Blue Nile Basin is considered an important part of this overall endeavour, as it has 50% of the country's surface water resources and accounts for over 40% of the nation's agricultural output.[97] The government has designated it 'a growth corridor for economic development'.[98] It has plans to promote irrigated agriculture within the basin which, according to an NBI estimate, could see an additional 5.6 BCM being abstracted in the Blue Nile sub-basin.[99] Multsch et al. estimate that 10 BCM in total could be used by 2050 and Alemu and Seleshi estimate 15 BCM is possible under full irrigation development.[100,101] Such a wide range of projections suggests that the upper values are aspirational yet they frame the contentious negotiations among the countries.

An expansion of water use of these orders of magnitude would surely constitute a substantial reduction in the flow of the Blue Nile, which is, on average, 49 BCM/yr as it approaches the border with Sudan. Irrigation would therefore be in competition with hydropower within Ethiopia. For Addis Ababa, hydropower would likely be a higher priority than irrigation, as the economic value of generating hydropower at the GERD exceeds that of the output from irrigated crops.[102]

Moreover, for the foreseeable future, the Ethiopian government may find it difficult to implement irrigation projects in the Blue Nile basin, given the lack of security in the states where the potential for irrigation exists (Amhara and eastern parts of Oromia). Indeed, the expansion of large-scale farming is presently taking place in other regions, such as the southern and western parts of Oromia. It is impossible to predict how long the insecurity in

[94] World Population Prospects, Population Division, UN Department of Economic and Social Affairs, median projection https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used . The figure for the current population is from World Population, Worldometer, https://www.worldometers.info/world-population/ , accessed 24 Jan. 2025.

[95] Moloo, Z. (undated), 'Ethiopia's unforgettable famines: Here's why they really happen', CBC Documentary Channel, https://www.cbc.ca/documentarychannel/features/ethiopias-unforgettable-famines-heres-why-they-really-happen.

[96] Government of Ethiopia (undated), 'Ethiopia 2030: The Pathway to Prosperity: Ten Years Perspective Development Plan (2021 – 2030)'), https://climate-laws.org/documents/10-year-development-plan-2020-21-2029-30_18f4?id=10-year-development-plan-2020-21-2029-30_8dc1.

[97] Kassie, Y.A., et al. (2022), 'Evaluating land suitability and water availability for surface irrigation in the Abbay basin of Ethiopia'.

[98] Ibid.

[99] Nile Basin Initiative (2014), *Eastern Nile Multi-Sectoral Analysis of Investment Opportunities Report*.

[100] Multsch et al. (2017), 'Improving irrigation efficiency'.

[101] Alemu, A. M. and Seleshi, Y. (2024) 'Trade-off and synergy analysis between hydropower generation and irrigation development in the Abbay River Basin, Ethiopia', *Journal of Hydrology: Regional Studies,* 52, 101723, https://doi.org/10.1016/j.ejrh.2024.101723.

[102] Murgatroyd, A., et al. (2024), 'The implications of further reservoir development on the Blue Nile in Ethiopia'.

the Blue Nile/Abbay basin will last and the government is likely at some point to be able to press ahead with its plans to develop irrigated agriculture there.

Sudan

Before the beginning of the civil war, Sudan had 48 million people. However, as of November 2024, over 3 million people had fled the country. Pre-civil war projections indicated that Sudan would have 84 million people in 2050.[103]

Like Ethiopia, although to a lesser extent, Sudan has opportunities for increasing the output of rainfed farming. However, Sudan has long had ambitious plans for the expansion of irrigated agriculture. Indeed, the rate of development was rapid (mainly for agri-business development) in the years before the outbreak of the civil war, leading to an increasing trend in water abstraction. Had this trend been maintained, it would easily have taken Sudan's withdrawals above the 18.5 BCM/yr allocated to it under the 1959 Agreement with Egypt.[104]

According to an NBI technical report, 'Sudan's policy on irrigation development is likely to move toward expansion', in part driven by a need to compensate for the loss of oil income which followed the secession of South Sudan in 2011.[105] Steady flows released by the GERD may present significant opportunities for Sudan to implement long-awaited irrigation plans. Another NBI report estimates that the 1.4 million hectares of planned irrigation in Sudan could use an additional 12.6 BCM/yr of water from the Blue Nile.[106] According to another study, 'there is great potential for irrigated agriculture, especially in the southeast, where large irrigation schemes already exist … The calculated irrigation water demand [assuming full development of irrigable land] is 33.5 BCM/year, which is 19.5 BCM/year additionally compared to 2017.'[107]

However, as noted in the preceding section, the civil war has put all such plans on hold. Indeed, it may be several years, even once stability is restored, before the country's water sector is again functioning as well as it was in the pre-war period. Moreover, while some irrigation expansion will probably occur at some point, it seems highly unlikely that Sudan would be able to take such large additional volumes of water from the Nile. Water consumption on this scale would require a renegotiation of the 1959 Agreement with Egypt. While the agreement provides for such a renegotiation, Egypt would almost certainly not accept Sudanese use in excess of 18.5 BCM/year.

[103] World Population Prospects, Population Division, UN Department of Economic and Social Affairs, median projection https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used. The figure for the current population is from World Population, Worldometer, https://www.worldometers.info/world-population/, accessed 5 Dec. 2023.

[104] Khalifa, Woods and Eltahir (2023), 'Estimates of Sudan's historical water withdrawals from the Nile'.

[105] Haileslassie, A. and Moges, S. A. (2022), *Irrigation Development Projection in the Nile Basin Countries: Scenario-based Methodology*, Nile Basin Initiative p. 6, https://nilebasin.org/node/11947.

[106] Nile Basin Initiative (2014), *Eastern Nile Multi-Sectoral Analysis of Investment Opportunities.*

[107] Kau, A. S., Gramlich, R. and Sewilam, H. (2023), 'Modelling land suitability to evaluate the potential for irrigated agriculture in the Nile region in Sudan', *Sustainable Water Resources Management,* 9(10), https://doi.org/10.1007/s40899-022-00773-3.

The states of the Basin and their relationships over the waters of the Nile

The legal and institutional framework

One of the main obstacles to cooperation among the countries that share the Nile basin (called 'Nile riparians') relates to legal agreements and the interpretation of the principles of international water law. The major points of contention concern the 1959 bilateral agreement between Egypt and Sudan (where specific water allocations were made to both countries but not to the remaining riparians) and the 2011 Cooperative Framework Agreement which includes, but is not agreed by, all Nile riparians. The two agreements are of a different nature but, for political rather than legal reasons, they continue to be a source of conflict between upstream and downstream countries. A third agreement, the 2015 Declaration of Principles, was designed to guide negotiations specific to the GERD but proved to be insufficient due to different interpretations. These three legal instruments are considered below.

The 1959 Agreement between Egypt and Sudan

The Agreement between the United Arab Republic [Egypt] and the Republic Of Sudan for the Full Utilization Of The Nile Waters, signed in 1959, divides the entire flow of the Nile between the two countries, based on an assumed average flow of 84 BCM/yr.[108] The agreement allocated 18.5 BCM/yr to Sudan and 55.5 BCM/yr to Egypt (including any flows to the Mediterranean); the remaining 10 BCM/yr represented the expected losses to evaporation from the HAD reservoir. Today, we know that both the actual flows and evaporation losses are higher.[109,110] The former phenomenon may bode well for the basin, but the latter increases contestation by upstream countries as it forecloses even further their potential development.[111]

The upstream states do not recognize the 1959 Agreement. Regardless, Egypt and Sudan insist it is the baseline for any discussions with the upstream countries. It forms one of the main bases of Egypt's diplomatic position in all forums, including the GERD negotiations which have been taking place since 2011.

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[108] United Nations Treaty Collection (1959), 'United Arab Republic [Egypt] and Sudan Agreement (with annexes) for the full utilization of the Nile waters'.

[109] Wheeler et al. (2020), 'Understanding and managing new risks on the Nile'.

[110] Abou El-Magd, I. H. and Ali, E. M. (2012). 'Estimation of the evaporative losses from Lake Nasser, Egypt using optical satellite imagery', *International Journal of Digital Earth*, 5(2), pp. 133–146, https://www.researchgate.net/publication/220473208_Estimation_of_the_evaporative_losses_from_Lake_Nasser_Egypt_using_optical_satellite_imagery.

[111] Salman, S. M. A. (2010), 'Downstream riparians can also harm upstream riparians: the concept of foreclosure of future uses', *Water International,* 35(4), pp. 350–364, https://colab.ws/articles/10.1080%2F02508060.2010.508160.

The 2011 Cooperative Framework Agreement

The 2011 Cooperative Framework Agreement (CFA) was the outcome of negotiations among all Nile riparians (including Egypt and Sudan) between 1997 to 2010.[112] The negotiations were a parallel track to technical cooperation under the NBI. The CFA is the most comprehensive agreement on the Nile but does not deal with Basin-wide cooperation. Its first section sets out the legal principles that guide transboundary relations. The second section defines the mandate and functions of the Nile River Basin Commission (NRBC), a permanent body to be established following the entry into force of the CFA.

The CFA is based on the principles of international water law as embodied in the 1997 UN Convention on the Law of Non-Navigational Uses of International Watercourses and was negotiated with the support of international legal experts who were involved in drafting that Convention.[113] The central principle of the Convention is that water resources should be utilized 'in an equitable and reasonable manner'.[114] It also addresses the other main legal principle of 'not causing significant harm'.

The inclusion in the CFA of these two principles means it should – at least in theory – cover the concerns of all the Nile riparians. However, Egypt wanted more explicit language than that proposed by other states regarding the protection of 'the water security and current uses and rights' of riparians. These divergent positions led to the inclusion of two alternative versions of one Article, Art. 14(b). With no apparent prospect of the acceptance of its preferred wording, Egypt withdrew from further negotiations. Since then, Egypt has argued that the CFA is not a complete agreement, as it does not take into account Egyptian reservations. According to Cairo, it should not be regarded as valid or be supported by external parties.

Nevertheless, on 13 October 2024, the CFA entered into force, following its ratification by six countries and the deposition of that ratification with the African Union. This development established the legal basis for the NRBC to replace the NBI in due course. Egypt has forcefully condemned this move.

The Declaration of Principles

The Declaration of Principles (DoP) on the GERD, a trilateral declaration rather than a legally-binding agreement, was signed in 2015 by the heads of government of Egypt, Ethiopia and Sudan.[115] This was the first time that the three countries had signed a joint document on the Nile. The DoP confines itself to issues relating to the GERD and comprises 10 articles covering general principles of cooperation, the filling and operation of the GERD, and the settlement of disputes. Ambiguities in the text mean the DoP has not helped to ease tensions or advance negotiations – and sometimes rather the opposite. From 2015 onwards,

[112] Nile Basin Initiative (2011), *Agreement on the Nile River Basin Cooperative Framework*, https://nilebasin.org/sites/default/files/attachments/CFA%20-%20English%20FrenchVersion.pdf.

[113] United Nations Treaty Collection (1997), 'Convention on the Law of the Non-Navigational Uses of International Watercourses.

[114] United Nations Treaty Collection (1997), 'Convention on the Law of the Non-Navigational Uses of International Watercourses', PART II. GENERAL PRINCIPLES, Article 5, Equitable and reasonable utilization and participation', https://legal.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf.

[115] United Nations Environment Programme (UNEP) (2015), 'Agreement on Declaration of Principles between The Arab Republic of Egypt, The Federal Democratic Republic of Ethiopia And The Republic of the Sudan On The Grand Ethiopian Renaissance Dam Project (GERDP)', 5 March 2015, https://leap.unep.org/sites/default/files/treaty/TRE160043.pdf.

numerous rounds of negotiations have taken place among the three states, with and without the involvement of external parties including the US, the World Bank, the African Union and the United Arab Emirates (UAE). A decade after the DoP was signed, construction of the GERD is essentially finalized and Ethiopia has completed the reservoir filling process.

While all Nile Basin states assert that international water law should be respected, none has ratified two key UN Conventions: the 1992 UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes and the 1997 Convention on the Law of Non-Navigational Uses of International Watercourses.[116] This does not mean, however, that the principles on which these Conventions are founded are not applicable to the Nile Basin. Moreover, both the CFA and DoP embody the two central principles of the 1997 Convention, as mentioned above. Further, in 2021, Sudan accepted the 1997 Convention as codifying 'the basic principles of customary international water law which must be adhered to in order to resolve the remaining differences on the GERD'.[117]

However, the three Eastern Nile Basin states have so far not explicitly embraced the Conventions as a framework within which they could reach agreement on the use of the river.

In sum, while the Nile riparians invoke international water law as guidance for transboundary cooperation, and even reflect it in the recent agreements, the interpretations of the legal principles are extremely politicized. This conclusion suggests that solutions for the Nile disputes must be political rather than legal.

Political relationships among the Nile basin states

As already noted, Ethiopia is by far the largest source of Nile water in the Eastern Nile Basin and Egypt by far the largest user and the most heavily dependent on the river. This is the baseline for the dispute which has dominated hydro-political relations between the two countries over the past century. In the absence of inclusive agreements, diplomatic disputation has so far been the norm.

This situation need not endure indefinitely. The uncertainties of climate change projections, together with the *fait accompli* that is the GERD, could make Eastern Nile Basin capitals realize the benefits of cooperation – and the need to make compromises to achieve it.

Egypt: the first to develop major infrastructure works on the Nile

During the colonial period of the early 20th century, infrastructure was built in Egypt and Sudan that was intended to extend the growing season in the Nile Valley and Delta and develop the new Gezira irrigation scheme in Sudan. Following independence, and by signing the 1959 Agreement with Sudan, Egypt was able to significantly increase its use of the Nile

[116] United Nations Economic Commission for Europe (1992), 'Convention on the Protection and Use of Transboundary Watercourses and International Lakes', https://unece.org/DAM/env/water/pdf/watercon.pdf. While originally devised for Europe, the Convention does not exclude non-European countries, witness Iraq's accession in March 2023:

'UNECE (UN Economic Commission for Europe), Iraq's accession to UN Water Convention opens new opportunities to strengthen transboundary water cooperation in the Middle East', 24 March 2023, https://unece.org/media/environment/Water-Convention/press/377056.

[117] United Nations Digital Library, 'Letter dated 12 April 2021 from the Chargé d'affaires a.i. of the Permanent Mission of the Sudan to the United Nations addressed to the President of the Security Council', https://digitallibrary.un.org/record/3923983?ln=en.

by constructing the HAD as *over-year* storage, or storage that could capture more than the average annual flow. The objective was for sufficient water to be stored in the HAD reservoir in years of high flow to allow economic activity (mainly irrigated agriculture) to continue in years of low flow. As noted above, the agreement gave Sudan a far smaller share of water than Egypt. Nonetheless, it enabled Khartoum to construct its much smaller dams (the Roseires Dam on the Blue Nile and Khashm El Girba Dam on the Atbara/Tekeze) and expand the Gezira Scheme.

Ethiopia did not accept the development of the HAD. Indeed, in 1956, Ethiopia formally voiced its opposition to the Egyptian–Sudanese talks which led to the signature of the 1959 Agreement.[118]

For its part, Egypt objected vociferously to any suggestion that Ethiopia might embark on water projects on the Blue Nile that could reduce the total flow of the river. Egypt used its international weight (generally, and within international institutions such as the World Bank) to prevent Ethiopia and other upstream states from regulating the river in ways that would, in Egypt's view, have posed a threat. For many years, this blocking strategy was a success.

Ethiopia: multilateral cooperation and unilateral action

From the mid-1990s, and despite the sharp difference of opinion between Egypt and Ethiopia, the countries of the Nile Basin embarked on a multilateral initiative that aimed to replace conflict with regional cooperation.[119] International donors and organizations supported them in this endeavour. This process had two parallel tracks: first, legal and institutional cooperation, and second, technical cooperation within the framework of the NBI.

From the late 1990s until 2010–11, Ethiopia engaged in diplomatic efforts aimed at reaching a multilateral Nile agreement and securing the cooperation of other Nile Basin states (including Egypt) for large-scale projects to be built in Ethiopia. The other upstream states welcomed the idea of a new Nile agreement and hoped that the CFA would be that agreement. The CFA has now entered into force, and decisions about the future permanent Commission are taking place. However, it currently seems unlikely that this development will lead to investment in transboundary infrastructure projects, at least within the foreseeable future. This is because Egypt has rejected the creation of the NRBC under present conditions and is likely to oppose any such projects, both those that were in the pipeline and any new ones.

In the absence of an agreement acceptable to all riparians, initiatives aimed at instituting multilateral cooperation have had only limited success. Instead, upstream countries have turned to unilateral development. The prime example of this was, of course, the GERD, announced by then Prime Minister of Ethiopia Meles Zenawi in April 2011. External trade and support to Ethiopia's budget from China and other investors, together with the rapid growth of the country's economy, meant that Egypt's financial blocking strategy could no longer prevent Addis Ababa from proceeding with the GERD. This was a game-changer, with Egypt implicitly recognizing that it was futile to try to stop the project from going ahead. Egypt switched to a damage limitation approach, as embodied most notably in the trilateral DoP of 2015.

[118] Whittington, D. (2024), 'The long shadow of the 1959 Nile Waters Agreement', *Water Policy,* 26(9), pp. 859–874, https://doi.org/10.2166/wp.2024.035.

[119] Cascão, A. E. and Nicol. A. (2016), 'GERD: new norms of cooperation in the Nile Basin?', *Water International*, 41(4), pp. 550–573, https://www.tandfonline.com/doi/full/10.1080/02508060.2016.1180763.

Egypt, Ethiopia and Sudan: lack of trust

Egypt, Ethiopia and Sudan could not, however, agree on specific issues within the DoP. The most prominent of these concerned the period over which the GERD reservoir was to be filled and the way in which it was to be operated thereafter.[120] The dispute therefore ostensibly became one about technical issues.[121] The National Independent Scientific Research Group, an independent expert panel restricted to experts from the three countries, was convened in 2017 and 2018. Most of the technical issues were reported to have been resolved in this forum. However, agreement over how to handle drought conditions remained elusive.[122]

The enduring lack of trust among the three countries stood in the way of agreement on the outstanding technical issues, as well as the legal and political ones. Egyptian officials maintain that the interests of Egypt and Ethiopia are not mutually exclusive and a balanced and equitable agreement on the GERD is attainable.[123] They assert that Egypt has offered Ethiopia 'everything it could' over the last 12 years. This included a proposal to establish a trilateral commission (with Sudan) at head-of-state level, with a fund to pay for trilateral projects.[124]

For its part, Ethiopia has formally stated that 'Ethiopia will abide by and faithfully implement the guidelines and rules on the annual operation of the GERD once an agreement is reached. However, it will not constrain its right to use the Nile waters for future development by the guidelines and rules or the quantified obligations contained therein.'[125] Egypt argues that such guidelines would not provide adequate guarantees, which is why it is insisting on a binding agreement.[126]

Another issue that has made reaching agreement among the Nile Basin countries more difficult is the fact that the Nile is by far the most significant issue that connects Egypt to the upstream countries (Sudan excepted). As a result, the opportunities for cooperation through issue linkages and negotiated trade-offs in other economic, political and diplomatic areas are very restricted.

Previous studies on cooperation over the GERD (and dam cascades in the Blue Nile) and potential trade-offs have highlighted the potential for Egypt to buy energy generated by the GERD.[127] This could, perhaps, act as an incentive for all countries to cooperate. The idea

[120] Wheeler, K. G., et al. (2016), 'Cooperative filling approaches for the Grand Ethiopian Renaissance Dam', *Water International,* 41(4), pp. 611–634., http://doi.org/10.1080/02508060.2016.1177698.

[121] Gebreluel, G. (2023), 'Ideology, grand strategy and the rise and decline of Ethiopia's regional status', *International Affairs*, (99)3, pp. 1127–1147, https://doi.org/10.1093/ia/iiad111.

[122] Roussi, A. (2019), 'Gigantic Nile dam prompts clash between Egypt and Ethiopia', Nature, 7 October 2019, https://doi.org/10.1038/d41586-019-02987-6.

[123] Helal, M. and Bekhit, H. M. (2023), 'So near, yet so far: an Egyptian perspective on the US-facilitated negotiations on the Grand Ethiopian Renaissance Dam', *Water International,* 48(5), pp. 580–614, https://www.tandfonline.com/doi/full/10.1080/02508060.2023.2230851.

[124] Ahmed Sharief, Minister Plenipotentiary and Deputy Director, Cabinet of the Minister of Foreign Affairs, speaking during a plenary session at Cairo Water Week, 29 October 2023.

[125] United Nations Security Council, 'Ethiopian letter to the President of the UNSC of 22 Jun 2020: A letter from Ethiopia updating the Council on development regarding the Grand Ethiopian Renaissance Dam in response to the 19 June letter from Egypt, S/2020/567', https://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/S_2020_567Ethiopia%20letter%20of%2022%20June.pdf.

[126] Face-to-face interview with diplomat who preferred to remain anonymous, Cairo, November 2023.

[127] Etichia, M., et al. (2024), 'Energy trade tempers Nile water conflict', *Nature Water*, Vol. 2, pp. 337–349, https://doi.org/10.1038/s44221-024-00222-9.

has come up throughout the negotiations but without eliciting enthusiastic engagement from any of the parties. Addis Ababa appears to see Kenya, Tanzania and Djibouti as the main markets outside Ethiopia for electricity from the GERD, as well as expanding its existing power trade with Sudan (pre-war) and South Sudan.[128]

Public opinion in all three countries has been another constraint on negotiators, with the public space and social media acting as a channel for views that are often nationalistic and uncompromising, frequently informed by misleading science.[129,130,131] For example, the DoP was strongly criticized in Egypt where, according to one expert, 'the people' see the government as the 'guardian of the Nile'.[132] Many vocal media and political analysts in Egypt saw the recognition of the GERD in the DoP as 'giving in' to Ethiopia, although it is not clear how widely this view was shared by the public at large. In Ethiopia, many people consider it a diplomatic victory, as Egypt's president was tacitly recognizing the GERD as a *fait accompli.*

Sudan: alliances downstream and upstream

Because of the 1959 Agreement with Egypt, Khartoum's position has historically been to align with Cairo on most Nile-related issues. This support has not been steadfast, however, as Khartoum often recognizes the potential benefits of the GERD for Sudan. This is primarily because of the GERD's capacity to retain significantly more water than Sudan's much smaller dams, thus both decreasing the risk of flooding and increasing the availability of water for agricultural development. Nevertheless, at times, Khartoum has expressed significant concerns that Ethiopia might, in years of high flow, release more water than Sudan's dams could control, leading to unexpected flooding or damage to their own infrastructure. Furthermore, Sudan fears that the GERD might, in years of low flow, retain water that Sudan needs to irrigate its crops.

Sudanese concerns rose following an unexpected 10-day drop in flows during the first filling in 2020, followed by a rapid increase in flows when the first filling was completed. This prompted the Sudanese Ministry of Irrigation and Water Resources to develop a method to help predict the timing of subsequent GERD filling stages in the event that Ethiopia did not share critical information.[133] In February 2021, the Sudanese government stated that any unilateral filling by Ethiopia would represent a threat to Sudan's national security.[134] In recent years, some information exchange has reportedly taken place between Ethiopia and

[128] Wheeler, K. G. (2024), 'Energy trade is the future of water management for the Nile', *Nature Water*, 2(4), pp. 303–305, https://doi.org/10.1038/s44221-024-00230-9.

[129] Elsoufy, A. M. (2024), 'Media bias through collocations: a corpus-based study of Egyptian and Ethiopian news coverage of the Grand Ethiopian Renaissance Dam', *Humanities and Social Sciences Communications*, 11, 680, https://doi.org/10.1057/s41599-024-03145-8.

[130] Wheeler, K. G. and Hussein, H. (2021), 'Water research and nationalism in the post-truth era', *Water International*, 46(7–8), pp. 1216–1223, https://www.tandfonline.com/doi/full/10.1080/02508060.2021.1986942.

[131] Wheeler, K. G., et al. (2022), 'Comment on 'Egypt's water budget deficit and suggested mitigation policies for the Grand Ethiopian Renaissance Dam filling scenarios', *Environmental Research Letters*, 17(8), https://doi.org/10.1088/1748-9326/ac7e5e.

[132] Face-to-face interview with expert who preferred to remain anonymous, Cairo, October 2023.

[133] Hassan, M. A., Hassan, M. F., Mohamed, Y. A. and Awad, W. A. (2023), 'Dam operation using satellite data and hydrological models: the case of Roseires dam and Grand Ethiopian Renaissance Dam in the Blue Nile River', *Water International*, 48(8), pp. 975–999, https://doi.org/10.1080/02508060.2023.2286412.

[134] BBC News (2021), 'Gerd: Sudan talks tough with Ethiopia over River Nile dam', 22 April 2021, https://www.bbc.co.uk/news/world-africa-56799672.

Sudan regarding the filling process, easing tensions and allowing Sudanese dam operators to better manage their own critical infrastructure, despite the ongoing conflict in Sudan.

The GERD and sharpening of focus in the negotiations

The emphasis on the GERD signalled a major shift in the discussions over use of the Nile waters. In the 1990s and 2000s, the emphasis was on multilateral cooperation and the possibility of moving towards joint planning, including investment in infrastructure. From 2010–11, with the withdrawal of Egypt from the NBI programmes and a decrease in external financial support, the *modus operandi* significantly changed away from multilateral cooperation. Following Ethiopia's announcement of the GERD, the focus turned towards project-specific efforts and trilateral cooperation instead of basin management and development. In the GERD negotiations, rather than trying to have an agreement based on principles of international water law, the negotiations moved towards controversial issues such as water releases and water allocations – topics which had been avoided in the multilateral process. Furthermore, the negotiations began to factor in climate-related issues, be it natural variability or future climate events and extremes.

Now that the GERD reservoir has effectively reached its maximum storage volume without any appreciable impacts on Egypt or Sudan, and a 'new normal' has now become a reality, the issue for Egypt has increasingly turned to minimizing harm and 'the burden-sharing of drought'.[135] One immediate concern has been whether Ethiopia could operate the GERD in a way that would be intentionally harmful to downstream countries, such as forcing Egypt into a shortage state by filling the GERD quickly during or after a multi-year drought. However, conditions for adversarial operations would be rare, the magnitude of any additional harm would be limited, and such operations would significantly reduce the hydropower generation and financial productivity of the GERD.[136]

Regardless, a future multi-year drought is inevitable. An agreement on how water uses should be managed during a drought and reservoirs operated in a way that protects power production and downstream interests is therefore necessary.[137,138,139] Discussion is now refocused on protecting existing uses versus the development of future consumptive and non-consumptive uses.[140] Reaching an agreement during a drought situation will be extremely difficult and thus must be done before such a situation develops.

[135] Face-to-face interview with expert who preferred to remain anonymous, Cairo, October 2023.

[136] Whittington, Hall, Murgatroyd and Wheeler (2025), 'Should Egypt be afraid of the Grand Ethiopian Renaissance Dam?'

[137] Wheeler et al. (2020), 'Understanding and managing new risks on the Nile'.

[138] Etichia, M., et al. (2024), 'Energy trade tempers Nile water conflict'.

[139] Heggy, et al. (2024), 'Grand Ethiopian Renaissance Dam can generate sustainable hydropower'.

[140] Murgatroyd, et al. (2024), 'The implications of further reservoir development on the Blue Nile in Ethiopia'.

External involvement in the Nile waters question

The EU, and several individual EU countries, have long provided bilateral technical assistance on water, irrigation, environment and climate to Nile countries. The EU, US and other members of the international community have also provided valuable support for both the technical and political aspects of the multilateral processes which began in the mid-1990s (see p. 33). This support declined from 2010 because of Egypt's decision not to participate any longer in NBI meetings.

On the specific dispute over the GERD, several external parties have attempted to support Egypt, Ethiopia and Sudan to find a detailed agreement on the filling and operation of the dam and reservoir, rather than simply an agreement on legal international principles. The most striking of these attempts was made by the US over the winter of 2019–20, when the Trump administration brought the three countries together in Washington, DC. The stated goal was to reach a final agreement in less than three months, which was ambitious, given that the countries had not been able to reach agreement in a decade. Interestingly, this effort was led by the Department of the Treasury rather than the State Department. This endeavour failed when Ethiopia withdrew in February 2020, believing that pressure was being applied to sign an agreement that favoured Egypt.[141] Following the failure of these negotiations, Egypt continued to pursue an aggressive diplomatic strategy, taking the GERD file to the UN Security Council (UNSC). However, the Council declined to take up the issue but rather encouraged Egypt, Ethiopia and Sudan to resume negotiations under the auspices of the African Union.[142]

Egypt sent similar letters to the UNSC in 2021, 2022 and 2023. In September 2024, Egypt once again wrote to the UNSC complaining of Ethiopia's unilateral behaviour regarding the GERD.[143] Both Sudan and Ethiopia have also submitted letters to the UNSC. Ethiopia's response reiterated its view that Egypt was 'only interested in perpetuating its self-claimed monopoly' over the river.[144]

The Gulf states have potential influence with the Eastern Nile Basin governments but have not used it consistently or in a concerted fashion. The UAE, as a major trade partner of the three countries, has been the most active in terms of the GERD dispute and facilitated several trilateral talks starting in 2021. Although the UAE has the financial resources to influence the countries in pursuit of an agreement, its efforts came to an end in December 2023 without having produced the desired result. Since then, there have been no known attempts at external mediation in the GERD process.

[141] Shapland, G. (2021), 'Filling the GERD: Sudan's rising anxieties', Arab Digest, 16 February 2021, https://arabdigest.org/arab-digest-newsletter/filling-gerd-sudans-rising-anxieties/.

[142] United Nations Security Council, 'Statement by the President of the Security Council', 15 September 2021, https://documents-dds-ny.un.org/doc/UNDOC/GEN/N21/254/83/PDF/N2125483.pdf?OpenElement.

[143] United Nations Digital Library, 'Letter dated 1 September 2024 from the Permanent Representative of Egypt to the United Nations addressed to the President of the Security Council', https://digitallibrary.un.org/record/4060649.

[144] United Nations Digital Library, 'Letter dated 6 September 2024 from the Permanent Representative of Ethiopia to the United Nations addressed to the President of the Security Council', https://digitallibrary.un.org/record/4060831.

The stated priorities of the present Trump administration do not yet include the Nile; the failure of the 2019–20 efforts is likely to discourage a second attempt in the foreseeable future. Direct EU mediation is also not foreseeable, as Egypt considers the US the only external party able to put pressure on Ethiopia. For its part, Ethiopia has generally resisted external mediation and has insisted that negotiations should take place only at a trilateral level.

For the EU and other external actors, the main lesson from previous involvement in the Nile waters question in general and the GERD dispute in particular may be that no successful result can be obtained if engagement is not neutral and perceived to be so by all parties. In other words, an external actor would have to treat Egypt, Ethiopia and Sudan on equal terms. This would enable them to resume support for pathways towards positive and productive multilateral cooperation, as seemed to be achievable in the mid-1990s. This would be challenging, especially for the EU: maintaining good working relations with Egypt may outweigh any potential benefit from the promotion of cooperation among the Eastern Nile Basin countries and the countries of the Basin more widely.

Implications for EU interests

Because of the geopolitical and economic importance of the Eastern Nile region – globally and for the EU – ongoing changes in the Horn of Africa, the Red Sea and the Middle East are already affecting EU interests in these regions. Impacts of climate change – current and in the future – in the Nile region threaten to pose additional economic, political and security challenges for the EU. The EU should address these challenges in tandem with other interlinked foreign policy concerns, such as regional stability, migration, and economic cooperation.

Regional stability – within the Eastern Nile Basin and beyond

The political situation in the Eastern Nile region and its constituent countries is currently in a perilous state. Several factors not directly related to climate or the water issue are expected to have compound effects. A major civil war in the Tigray region of Ethiopia broke out in 2020. While a ceasefire agreement was reached in 2022, civil strife and political instability have flared up since then in several of the other regional states of Ethiopia. These internal conflicts have had repercussions on Ethiopia's relations with neighbouring countries such as Eritrea, Djibouti and Somalia, as well as Sudan. The possibility of proxy wars erupting cannot be excluded, this having been a historical pattern in the Horn of Africa region.

There has been a civil war in Sudan since April 2023. The fighting has caused massive casualties and the displacement of millions of people inside Sudan and into neighbouring countries, including Chad, South Sudan, Ethiopia and mainly Egypt. The impact of the civil war is also being felt on the strategic Red Sea coast, where many displaced Sudanese are waiting at Port Sudan for a chance to emigrate, in particular to the Gulf region. As in the case of Ethiopia, the war in Sudan is also having major regional spillover effects.

Egypt is going through a chronic and severe economic crisis with high levels of inflation and national indebtedness. These economic troubles have been exacerbated by the Israeli conflict with Hamas and the Houthis' attacks in the Red Sea. The latter have caused a decline in the trade passing through the Suez Canal and thus a substantial fall ($600 million per month) in Egypt's foreign exchange earnings from the Canal.[145] Moreover, as already mentioned, Egypt is currently hosting an influx of refugees from Sudan (as well as from other countries). The management of the Nile is therefore only one of several issues that could affect the negotiations over the GERD and the search for ways of adapting to climate impacts. In short, relations between Ethiopia, Sudan and Egypt (and adjacent regions) have become even more complex than they were during the last several decades.

The tensions between the three countries over the Nile waters, whether driven by climate impacts or other factors, are expected to increasingly interact with other ongoing geopolitical disputes and thus contribute to even greater regional instability. Such tensions might arise, for example, during a severe multi-year drought. It is therefore in the interests

[145] *Ahram Online* (2024), 'Egypt loses $8 bln over Suez Canal revenues decline amid regional tensions: FM Abdelatty at Rome MED', 25 November 2024, https://english.ahram.org.eg/NewsContent/1/1234/535872/Egypt/Foreign-Affairs/Egypt-loses--bln-over-Suez-Canal-revenues-decline-.aspx.

of the EU and other external partners that disagreements over the Nile should be addressed and mitigated prior to the onset of a drought of major dimensions. There has been no lack of attempts by external actors to resolve these disagreements but these have had limited success so far. However, that does not mean that these external actors might not be able to use windows of opportunity in future, if the Nile countries themselves are open to it.

At the same time, the relations between the three Eastern Nile countries do not operate in a political vacuum and can be affected by changes in the Middle East and North Africa, Gulf and Red Sea regions. The influx of refugees from Sudan, the Gaza war and the significant reduction in Red Sea trade could divert Egypt's attention from the Nile issues and climate concerns. Nevertheless, the continuing dialogue between Egypt and the EU is likely to remain focused on the question of irregular immigration to EU countries, whether the migrants are economic or climate refugees. As in previous circumstances, Egypt can always use the impacts of drought in the Nile Basin to raise concerns over future irregular migration.

On the other hand, the conceptualization of regional stability is changing rapidly. Gulf countries are increasingly being seen as guarantors of economic and political stability in the three Eastern Nile countries, because of their large investment in key economic areas. Besides, the Gulf countries – particularly the UAE – have shown growing interest in GERD issues, facilitating discussions on how to address future climate change in the Nile region. The EU should recognize that the convening power of the Gulf countries has grown, and work with them to address issues of regional stability that might arise from climate-related conflicts in the Nile Basin.

Migration from the Eastern Nile Basin region

The issue of migration to EU countries is multi-layered. There have been several drivers of migration over the past decade, including civil wars, social uprising, poverty and lack of economic opportunity. The number of migrants crossing the Mediterranean has increased dramatically, from countries in conflict such as Syria, Afghanistan and West African countries, for example. The civil war in Sudan has also led to an increase in the number of people looking for refuge in the EU.

Migration from Egypt to Europe has been on the rise too. In 2024, Egyptians were the fifth largest group in terms of nationality arriving in Europe.[146] Since the outbreak of the war in Ethiopia in 2018, many thousands of Ethiopians have also fled their country – mainly to the Gulf and US, rather than the EU. But the ongoing political instability – on top of economic crisis – in the country might lead more Ethiopians to try to reach Europe, despite the risks involved in, for example, crossing the Red or Mediterranean Seas by boat.

[146] United Nations Institute for Migration, 'Displacement Tracking Matrix, Migration Flow to Europe: Arrivals', https://dtm.iom.int/europe/arrivals, accessed 7 March 2024.

An Institute for Migration study from 2017 mentions climate impacts as a 'push factor' but other studies make no mention of climate impacts as drivers of migration.[147,148] With or without climate change, it is expected that population movements within and from Eastern Nile countries will increase. These movements could take the form of internal displacement, migration to a neighbouring country or migration to countries further afield.

Climate impacts could intensify those trends, although disentangling and quantifying the effect of those impacts is virtually impossible.[149] However, it is probable that extreme climate events will contribute to further displacement from regions affected by drought- or flood-related challenges to livelihoods, such as reduced access to water for domestic purposes, the deterioration of farmland and food security, a drop in the income of poor sectors of society, and rural-urban migration and resulting social pressures. This climate-induced displacement may first be internal and within national borders, but when left unresolved, may induce migration to other regions such as the EU or Middle East and North African countries.

Addressing climate and other challenges through closer regional economic cooperation

The Eastern Nile Basin countries, most notably Egypt, have close economic relations with the EU (both as a bloc and with some of its individual member states). These relations take the form of multilateral and bilateral trade agreements, investment opportunities, budget support and aid packages, and security and migration arrangements. The economic cooperation between the EU and Egypt is of great importance, not least because 40% of Europe's trade with Asia passes through the Suez Canal.[150] Egypt is also a major importer of food from EU countries, a fact that should be considered if Egypt faces future food shortages (directly or indirectly related to climate change).

The EU's economic links with Ethiopia and Sudan are not on the same scale. However, the EU is still a major economic partner for both countries, even though China, Turkey and the Gulf countries have to an extent reduced the EU's economic influence over the last decade.

To deal with climate impacts in the Eastern Nile Basin, economic cooperation within the region needs to be expanded and should increasingly feature climate change issues. All the three Eastern Nile Basin countries are part of COMESA (a regional economic bloc) and IGAD (a sub-regional body addressing drought issues in the Horn of Africa). Nile-related questions

[147] United Nations Institute for Migration (2017), Enabling a Better Understanding of Migration Flows (and its Root-Causes) from Ethiopia towards Europe, Desk-Review Report', Geneva: International Organization for Migration, p. 17 https://dtm.iom.int/sites/g/files/tmzbdl1461/files/reports/Desk%20Review%20Report%20-%20ETHIOPIA%20-MinBuZa%20%2802%29_0.pdf.

[148] For example, climate impacts are not mentioned as drivers of migration in either Adugna, G. (2021), Once Primarily an Origin for Refugees, Ethiopia Experiences Evolving Migration Patterns, Migration Policy Institute, 5 October 2021, https://www.migrationpolicy.org/article/ethiopia-origin-refugees-evolving-migration or Schewel, K. and Asmamaw, L. B. (2021), 'Migration and development in Ethiopia: Exploring the mechanisms behind an emerging mobility transition', Migration Studies, 9(4), pp. 1673–1707, https://doi.org/10.1093/migration/mnab036.

[149] Schewel, K. (2023), 'Who counts as a climate migrant?' *Migration Policy Institute*, 20 July 2023, https://www.migrationpolicy.org/article/who-is-a-climate-migrant.

[150] Sebastian Clapp (2024), 'Maritime security: Situation in the Red Sea and EU response', European Parliamentary Research Service, https://www.europarl.europa.eu/RegData/etudes/ATAG/2024/757606/EPRS_ATA(2024)757606_EN.pdf.

have been addressed to some extent in these bodies.[151,152] Hydropower development in Ethiopia presents economic opportunities for many of the Nile riparian countries, including Egypt. A regional energy market could be an entry point for increasing regional integration, within which the Eastern Nile Basin countries could find alternative ways of identifying infrastructure investments. Similar discussions have taken place under the IGAD umbrella.

The EU already supports these regional bodies technically and financially and has been pushing for climate to be addressed as a priority within them.

Greater intra-region economic cooperation will not only increase cross-border trade but will also enhance the opportunities for trade between the Nile countries and the EU. The framework for this future economic cooperation must address possible responses to climate change, basing itself on the numerous studies and policies that have been technically and financially supported by the EU in the recent past.

[151] COMESA: Common Market for Eastern and Southern Africa

[152] IGAD: Inter-Governmental Authority on Development

Recommendations for EU policymakers

The EU should build on its past support for cooperation in the Nile Basin region to offer three interlinked forms of support: technical, financial and diplomatic.

The EU should offer technical support to the NBI, continuing to support programmes dealing with data and information sharing and the computerized Decision Support System.[153] Additionally, it could support climate-related programmatic activities and the NBI Secretariat and its subsidiary programmes, the Eastern Nile Technical Regional Office (ENTRO) and the Nile Equatorial Lakes Subsidiary Action Programme (NELSAP). The EU should consider offering support to the forthcoming Nile River Basin Commission, which will be the first river basin commission in the history of the Nile Basin. EU policymakers will need to bear in mind the hostile attitude which Egypt has so far adopted towards the Commission, even though Egypt remains a member of the NBI.

The EU should also be ready to provide support for technical cooperation specific to the GERD, should the three Eastern Nile Basin countries request it. This support could take the form of studies, models or action plans addressed to specific aspects of climate impacts. One area in which the EU might consider assisting is a flood warning system for the Blue Nile valley in Sudan, including Khartoum, in case of the release of excessive volumes of water from the GERD which Sudan's dams would not be able to retain.

In addition to technical support, the EU should consider extending its financial assistance to the multilateral cooperation process within the NBI/NRBC framework, which is due to cease in 2025. This support should be programmatic and could be earmarked for climate-related work, which in general is less politicized than issues such as infrastructure development and water allocation issues.

Diplomatically, the EU should use its convening power to persuade Egypt, Ethiopia and Sudan to return to talks (informal and/or formal) about how to advance transboundary cooperation. The EU should do this in close partnership with others such as the Gulf countries, to which the three Eastern Nile Basin countries are increasingly connected in economic and diplomatic terms and which have also been involved as brokers in previous rounds of negotiations. The EU should refrain from launching its own independent initiative, which could be counter-productive.

The EU could also offer its 'good offices' to both Sudan and Ethiopia in an attempt to mitigate their internal wars and conflicts. The situation in both countries is complex and, in the short term at least, there seems to be no obvious solution that would bring an end to the wars, particularly in the case of Sudan. However, as one of the main economic, trade and aid partners of both countries, the EU does have some potential leverage to advance or support peace talks.

In short, when considering policy options regarding the Eastern Nile Basin, the unstable political situations in Sudan and Ethiopia cannot be ignored. It may be a long time – probably several years and perhaps even longer – before there is a cohesive and stable government in Sudan. Some of the recommendations made above may simply have to wait until the conflict ends. Similar considerations apply to Ethiopia, although perhaps with somewhat less force.

[153] Nile Basin Initiative (2015), 'The Nile Basin Decision Support System: Best National Application Cases 2015', https://nilebasin.org/sites/default/files/2023-09/DSS%2520Booklet_web.pdf.

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Greg's entire career has been focussed on the MENA region, whether as a commercial representative, university lecturer or government official (in the Ministry of Defence, Cabinet Office and FCO). From 1979 until 2015, he served in the MENA Research Group in the FCO. He was also Head of Research Analysts from July 2010 to July 2013. During his time with the FCO, Greg served in British Embassies in Saudi Arabia, Egypt and Tel Aviv and in the Consulate General in Jerusalem.

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The project has been funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821010

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