SHOULD EGYPT BE AFRAID OF THE GRAND ETHIOPIAN RENAISSANCE DAM?—THE CONSEQUENCES OF ADVERSARIAL WATER POLICY ON THE BLUE NILE

2025 RiverWare User Group Meeting
6 Feb 2025

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UNIVERSITY OF OXFORD

WATER BALANCE CONSULTING

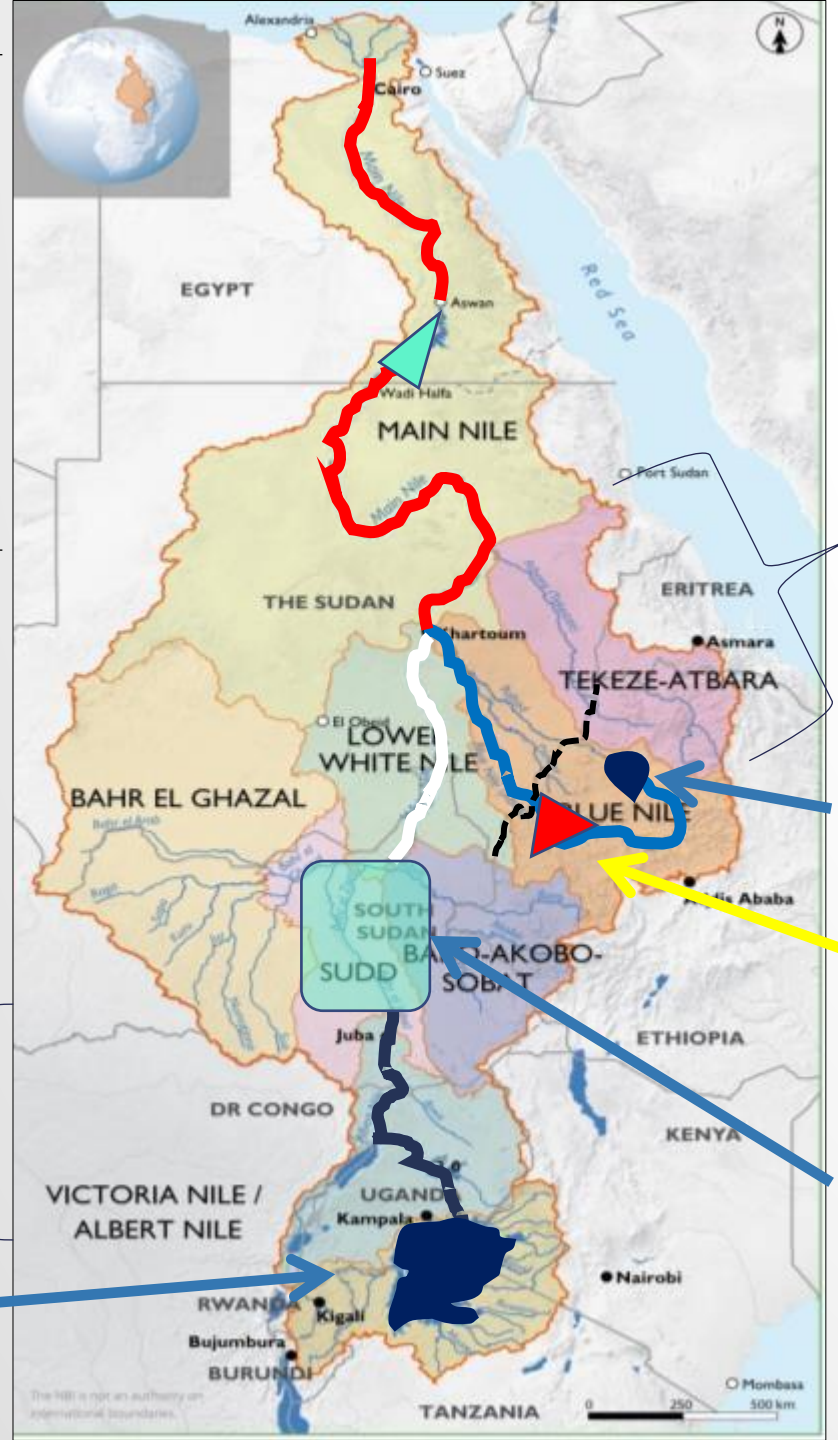
Nile River Basin

Main Nile

White Nile

Victoria/ Albert Nile

Lake Victoria

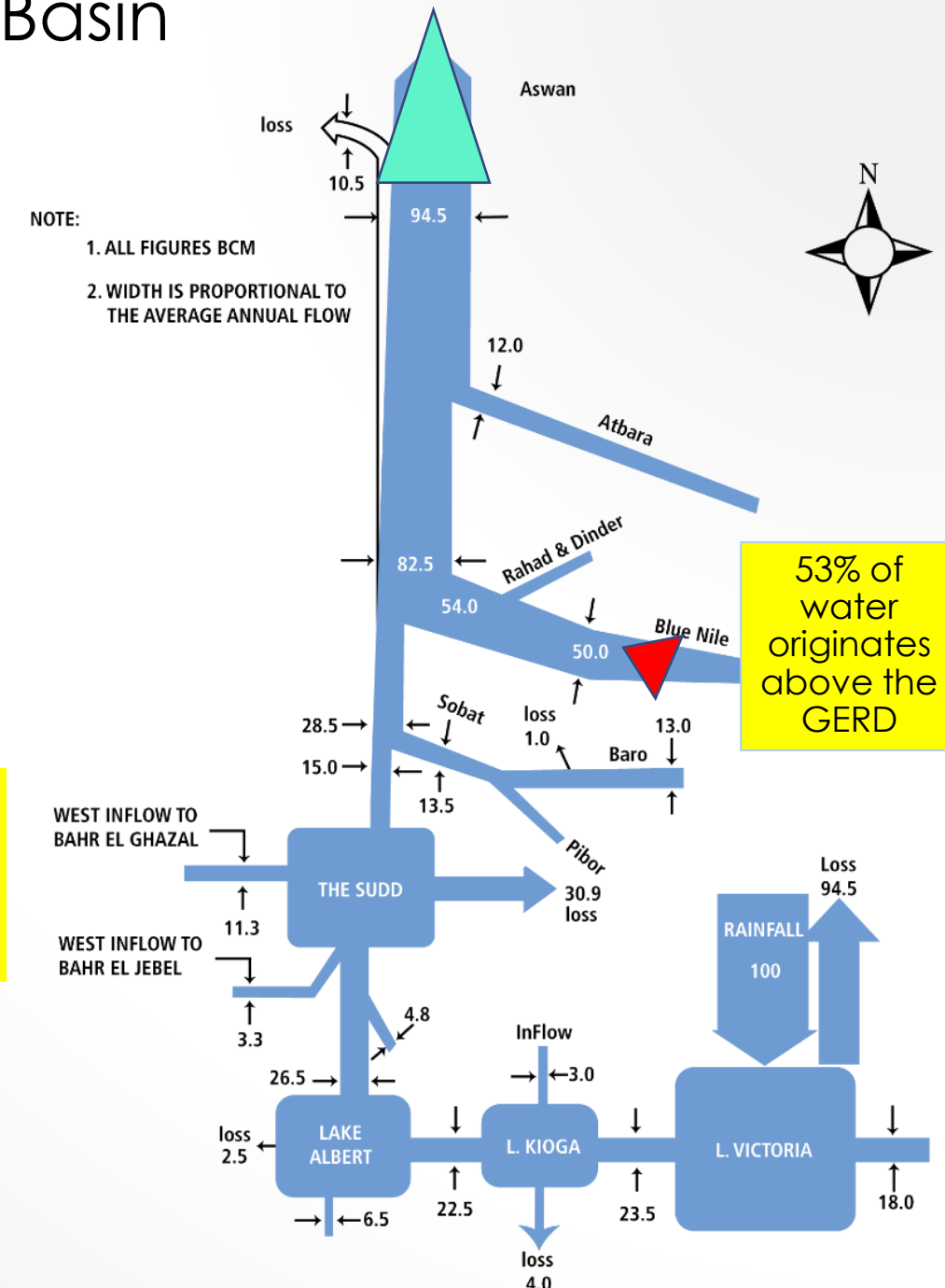


Blue Nile

Lake Tana

Grand Ethiopian Renaissance Dam (GERD)

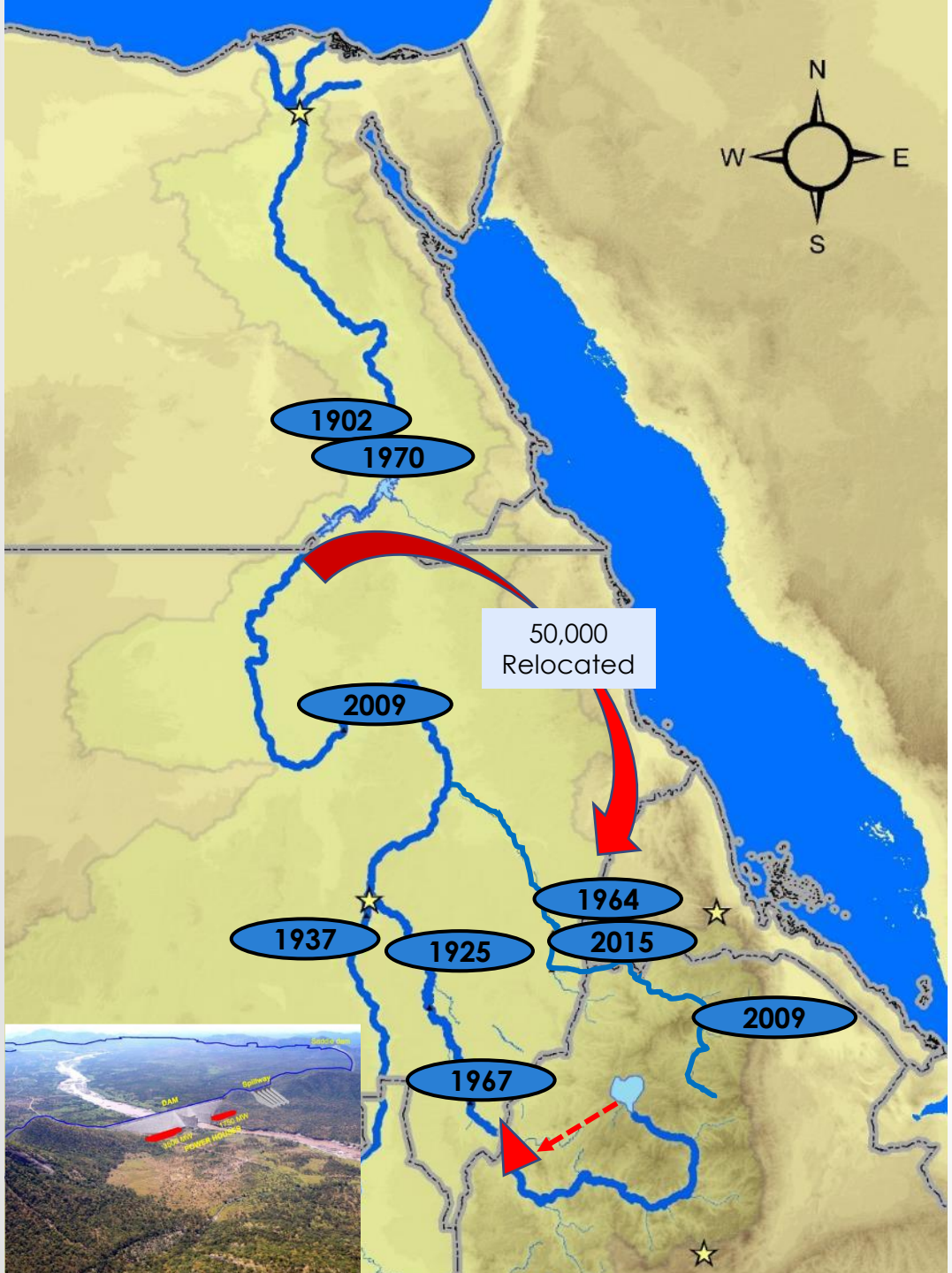
Sudd Wetland



Colonial Independence

1959 Agreement between the Republic of the Sudan and the United Arab Republic [Egypt] for the full utilization of the Nile waters

- 55.5 Billion Cubic Meters to Egypt
- 18.5 Billion Cubic Meters to Sudan



Modern Historical Development

Egypt

- Aswan Dam (1902)
- High Aswan Dam (1960-70)

Sudan

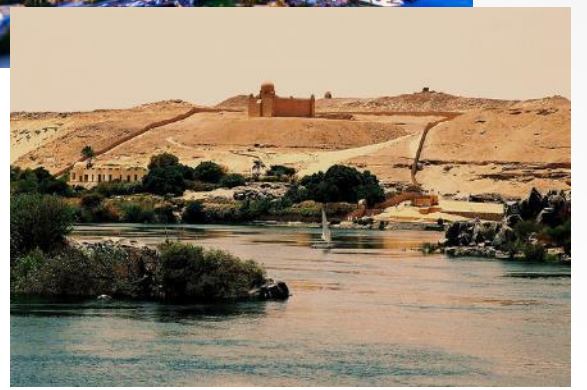
- Sennar Dam (1925)
- Jebel Aulia Dam (1937)
- Khashm El Girba (1964)
- Rosaries Dam (1967)
- Merowe Dam (2009)
- Upper Atbara/Setit (2015)

Ethiopia

- Tekeze Dam (2009)
- Tana Beles HP (2009)
- GERD

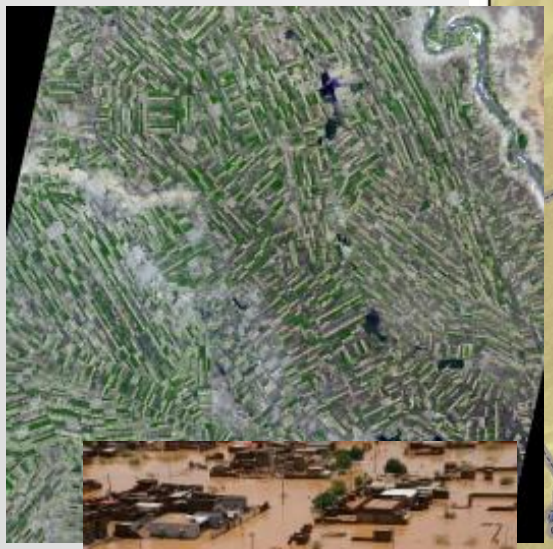
Egypt

"Skyline Cairo ." (CC BY 2.0) by MNmagic



"Egypte - Assouan : mausolée de l'Aga Kh" (CC BY 2.0) by LaurPhil

Sudan

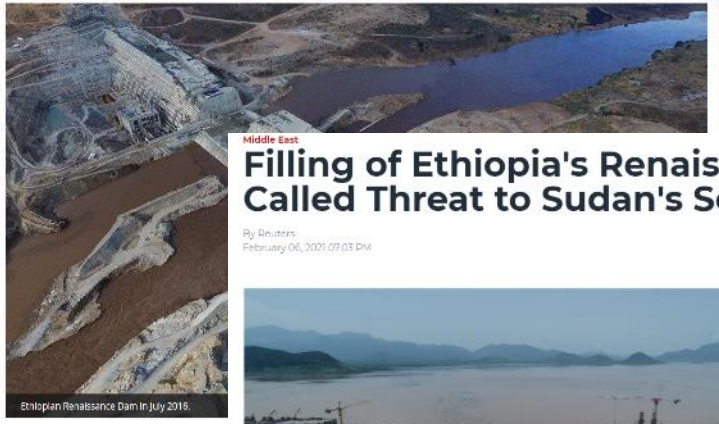


Ethiopia

"Women carry water back to their homes in" (CC BY-NC-ND 2.0) by UNICEF Ethiopia

Ethiopian dam will have a devastating effect on Egypt, warns water expert

November 12, 2016 at 10:03 am | Published in: Africa, Egypt, Ethiopia, News



TRENDING THIS WEEK

01 News Iraq army crushes child under a tank amidst war...

02 News Sisi wants apology from Saudi monarch before

Middle East

Filling of Ethiopia's Renaissance Dam in July Called Threat to Sudan's Security

By Reuters

February 06, 2021 07:03 PM

FILE - This handout picture taken on July 20, 2020, and released by Adwa Pictures on July 22, 2020, shows an aerial view of the Grand Ethiopian Renaissance Dam on the Blue Nile River in Guba, northwest Ethiopia

SPECIAL PROJECT

Egypt softe

CAIRO — The Egyptian g
isputa with Ethiopia con
xperts have espoused a
dvancement of mutual in
ew political and technical
e previous round of nego

SUMMARY

Egypt hopes US' Biden engages in Ethiopia dam crisis

January 15, 2021 at 5:56 pm | Published in: Africa, Asia & Americas, Egypt, Ethiopia, News, Sudan, US

TRENDING THIS WEEK

01 News Sudan army clashes with Ethiopia forces, regains control of...

02 News Reports: Israel discussing possible attack on Iran

03 Article Bin Salman's plan backfires as trolls turn Khashoggi documentary...

04 News Egypt journalist repeatedly sexually assaulted in prison

05 News British academics reject UK government's 'working definition of antisemitism'

LATEST NEWS

February 8, 2021 Egypt, Jordan, Iraq hold talks in Cairo

NEWS

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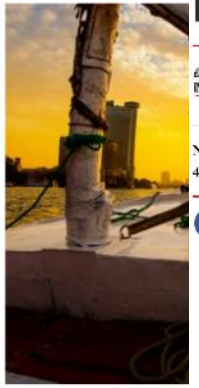
The 'wate
River Nile d

24 February 2018



EGYPT

Arab Leagu
Ethiopia's N

Egypt Independent

November 27, 2017
4:33 pm

Water flows through Ethiopia's Grand Renaissance Dam as it undergoes construction work on the river Nile in Guba Woreda, Benishangul Gumuz Region, Ethiopia September 26, 2019. (Reuters)

MORE COVERAGE

Distress over the access to water for millions of people living along the Nile prompted the Arab League on

Advertisement

A new dam on the Nile could trigger a war over water unless Ethiopia can agree a deal with Egypt and Sudan, writes the BBC's Africa Correspondent Alastair Leithead.

oversy on huge Ethiopian dam deepens after futile meeting

Egypt is now raising concerns about its share of the Nile River water after the fruitless meeting

By **cce news** · November 13, 2017

1778 5

Ethiopia upsets neighbors with dam plan

STORY HIGHLIGHTS

- Ethiopia is building the largest hydro-electric dam in Africa
- The country says the Grand Renaissance Dam project could transform its economy
- But neighboring Egypt and Sudan fearful that their water supply is under threat
- Ethiopia says it will use

(CNN) -- The waters of the Blue Nile have for millennia flowed down from the Ethiopian highlands enriching the countries on its banks.

The rocks that make up its riverbed have been eroded by Ethiopia's past and now that the construction of Africa's largest hydro-electric dam has begun, these same rocks are helping to build the country's future.

The Grand Renaissance Dam project was announced last year by the Ethiopian government, in a unilateral move that is not sitting

Part of complete coverage on Marketplace Africa

Giant robot cops tackle city traffic

May 28, 2014 – Updated 1816 GMT (0216 HKT)

Kinshasa, the sprawling capital of the Democratic Republic of Congo, has installed two talking robots to help regulate the city's hectic traffic.

No cash, no cards - just a smartphone

February 20, 2014 – Updated 1121 GMT (1921 HKT)

A South African app allows buyers to pay for goods using their phone, without having to worry about carrying cash or credit cards.

Zambia's answer to the iPad

February 19, 2014 – Updated 1633 GMT (0033 HKT)

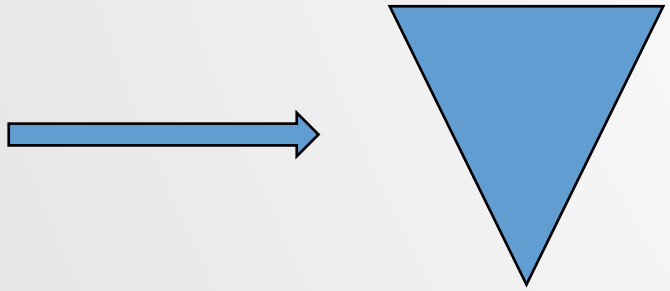
A Zambian computer tablet – known as the ZEduPad – is trying to open up the country's information highway.

5 African wines making a splash

January 9, 2014 – Updated 1057 GMT (1857 HKT)

South Africa may be the dominant force in Africa's wine economy, but other countries are making inroads in the

RATIO OF ACTIVE STORAGE: AVERAGE ANNUAL FLOW



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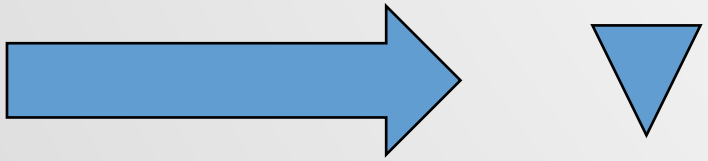

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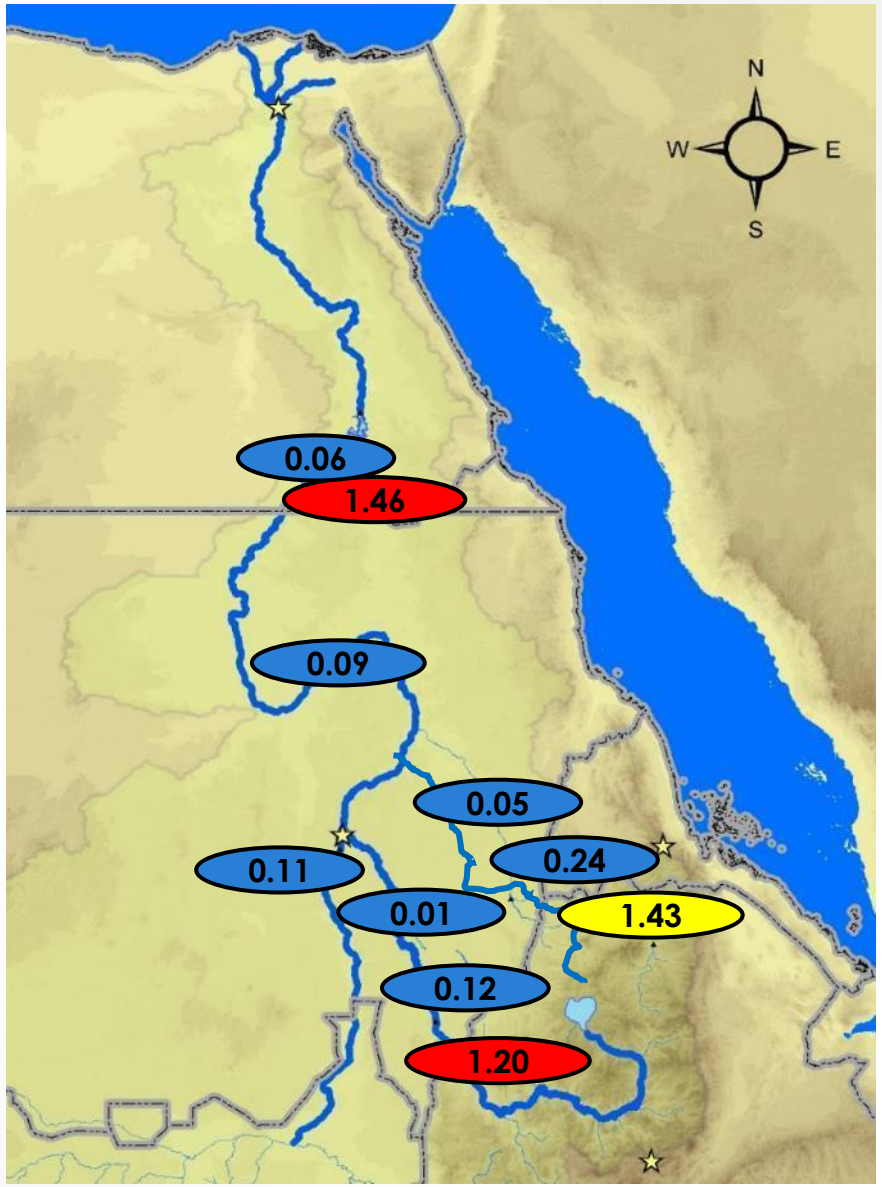
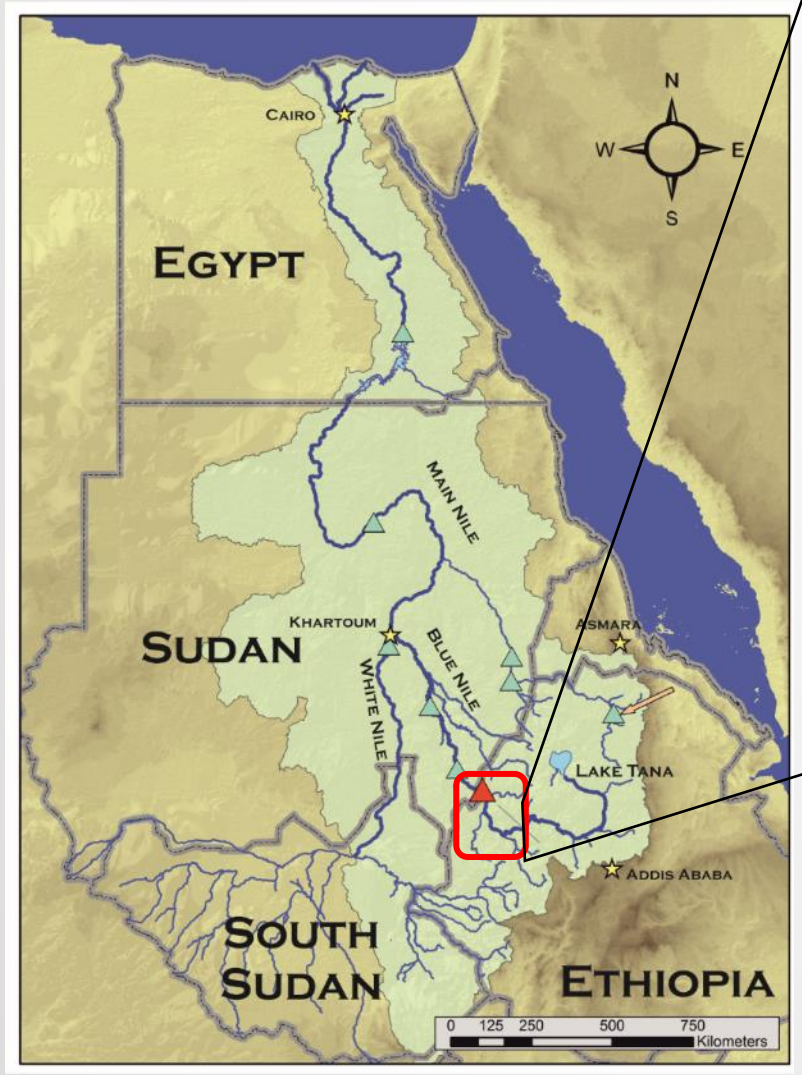
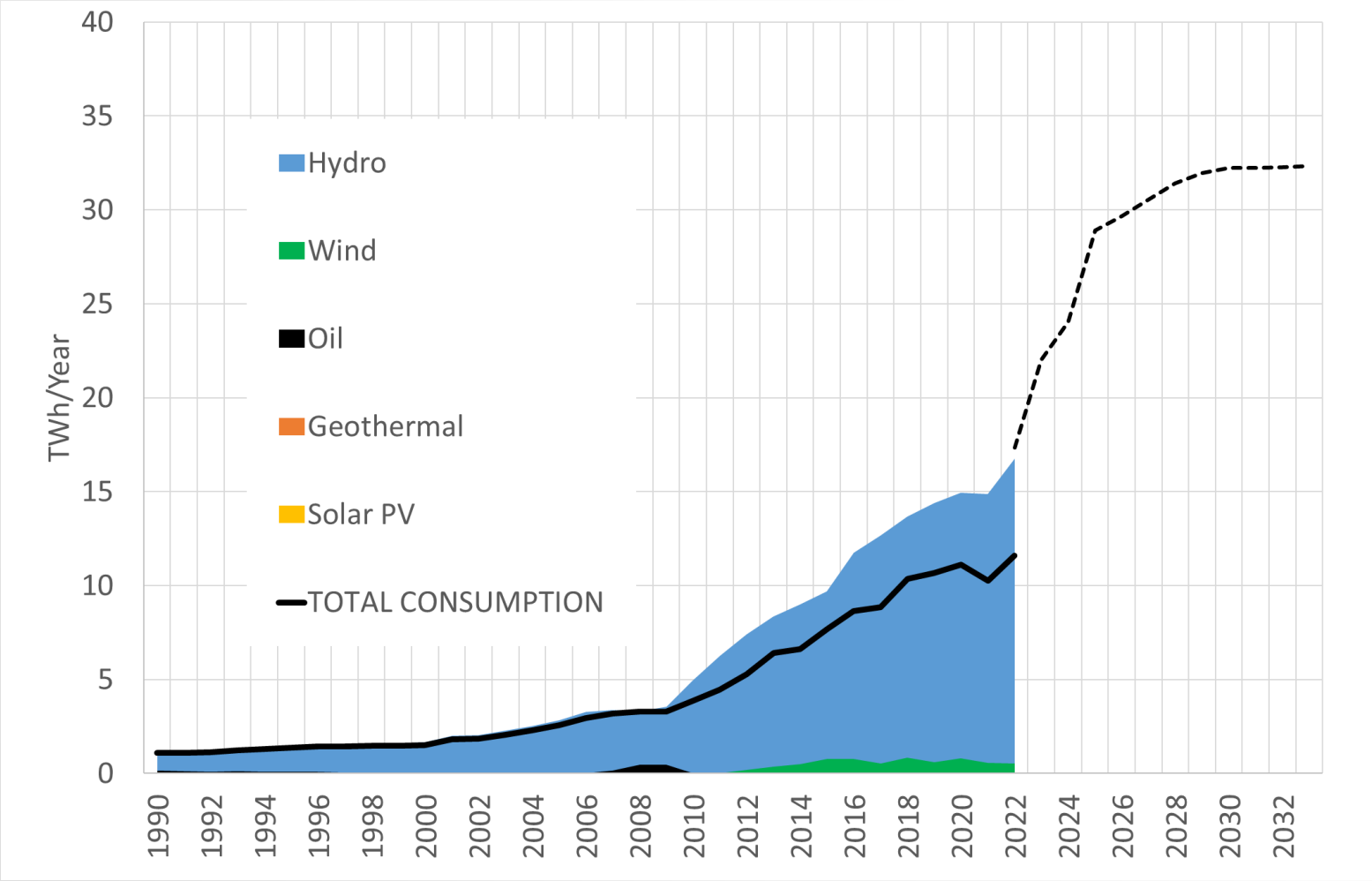


GERD LOCATION



Average Annual Inflow = 48 bcm (39 maf)
Total Storage = 74 bcm (60 maf)
Active Storage = 59 bcm (48 maf)
Active Storage/Average Annual Inflow = 1.2

GERD IMPACT ON ETHIOPIAN ENERGY PRODUCTION

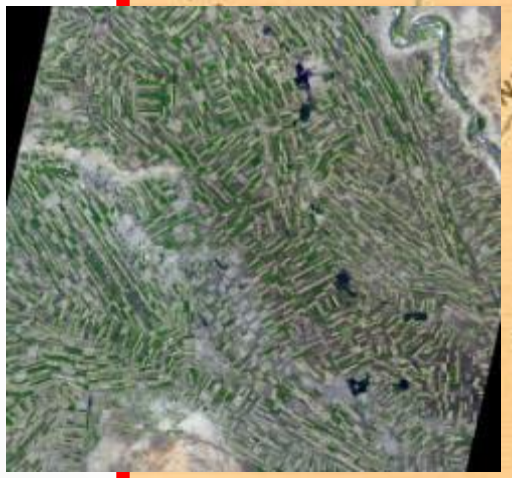


GERD

- ~15 TWh/year energy
- 5150 MW power generation capacity

POTENTIAL EFFECTS OF THE GERD TO SUDAN

- Potential Benefits
  + Increased Irrigation Potential
  + Improved Flood Risk Management
  + Decreased Sediment
  + Improved Hydropower Generation (Uplift)



POTENTIAL EFFECTS OF THE GERD TO SUDAN

- Potential Benefits
  - + Increased Irrigation Potential
  - + Improved Flood Risk Management
  - + Decreased Sediment
  - + Improved Hydropower Generation (Uplift)

- Potential Risks
  - – Uncoordinated releases = more flooding!
  - – Loss of Flood Agriculture
  - – Unknown Alteration of Ecosystems
  - – Loss of Nutrient Transport

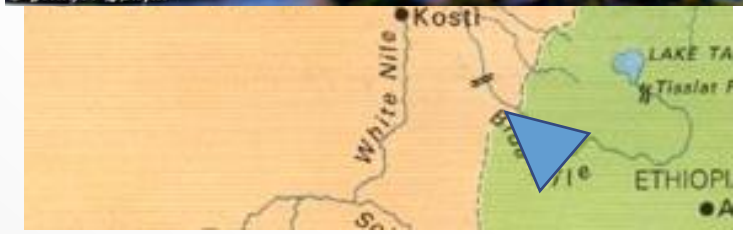
Fasseh Shams/IWMI

AP Photo/Mosa'ab Elshamy

POTENTIAL EFFECTS OF THE GERD TO EGYPT

- Potential Benefits
  - + Increased Upstream Storage
    - > Increased Water Security
  - + Decreased Sediment
- Potential Risks
  - – Decreased Control of Flows
    - >Decreased Water Security
  - – Decreased Hydropower Generation

Dam Operations becomes the Negotiation Space



"Skyline Cairo ." (CC BY 2.0) by MNmagic

KEY NEGOTIATION POSITIONS

ETHIOPIA 

- The GERD is a non-consumptive use of water
- Ethiopia has the right to build infrastructure and use water
- Operations should be solely based on Ethiopian objectives

EGYPT 

- The GERD poses an existential risk to Egypt
- All water is currently being consumed by Egypt and Sudan
- The GERD should be used to support Egypt during a drought

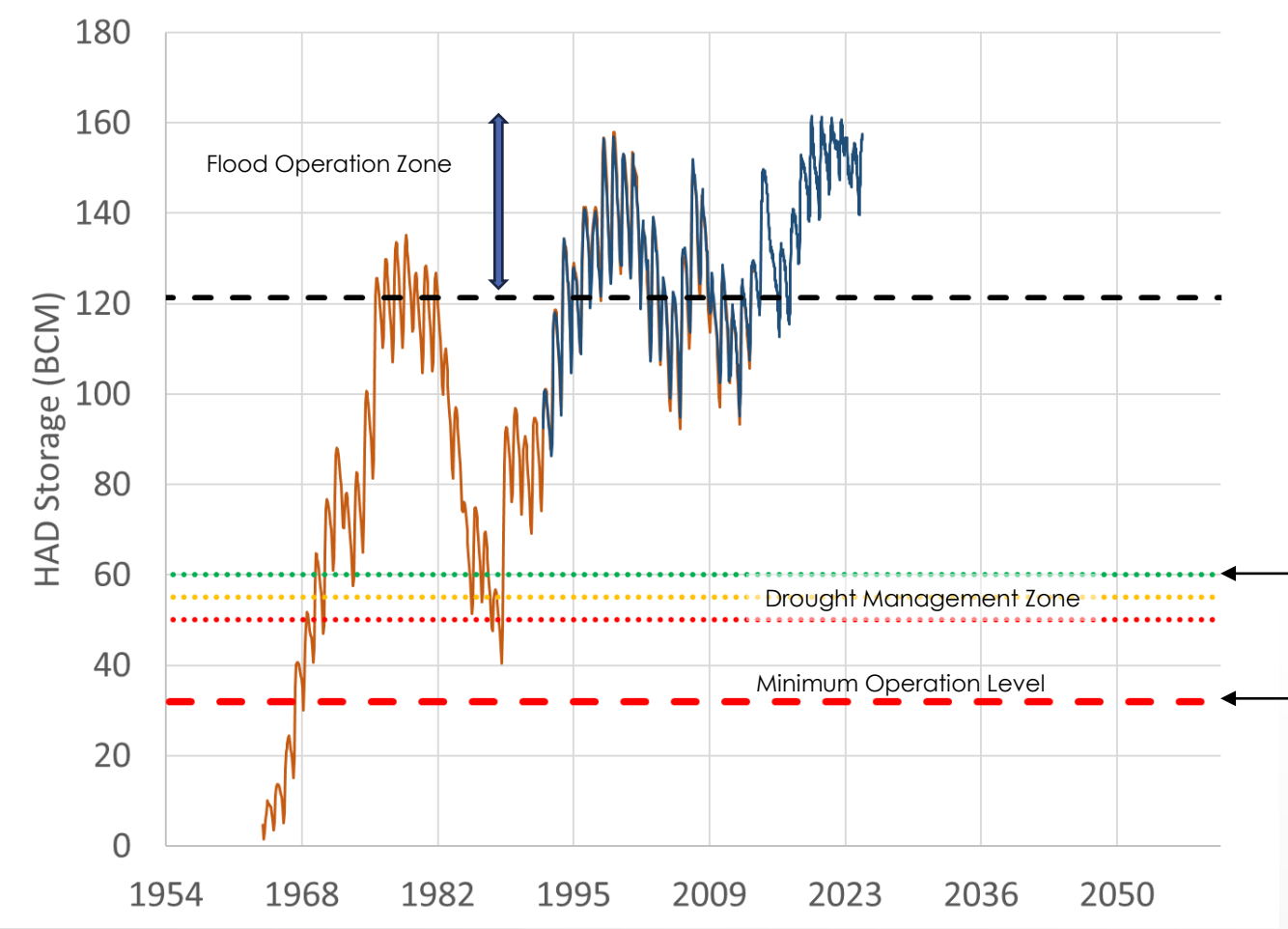
STATUS OF THE GERD

- GERD filling is now complete
- GERD filling did not cause appreciable harm to Egypt because …
  - high annual flows during the filling period
  - prudent planning efforts by the Egyptian government

Today both the High Aswan Dam (HAD) Reservoir and the GERD Reservoir are ‘full’

→ “New Normal”

STORAGE OF THE HIGH ASWAN DAM



Policy Shortages to Egypt Begin

Hydrologic Shortages to Egypt

QUESTION: TO WHAT EXTENT COULD ETHIOPIA USE THE GERD TO INFLICT HARM ON EGYPT?

- Imagine [hypothetically] that Ethiopia wanted to inflict harm on Egypt
- NOT saying that Ethiopia actually wants to inflict harm

EXAMINE 3 APPROACHES THAT ETHIOPIA COULD ADOPT TO OPERATE THE GERD

1. 'Self-Interest' → operates GERD to maximize hydropower production without regard for the consequences for the downstream riparians.

2. 'Compromise' → operates GERD to balance Ethiopia's interests with those of downstream riparian countries → assist downstream riparians during extreme multi-year droughts by making supplemental water releases

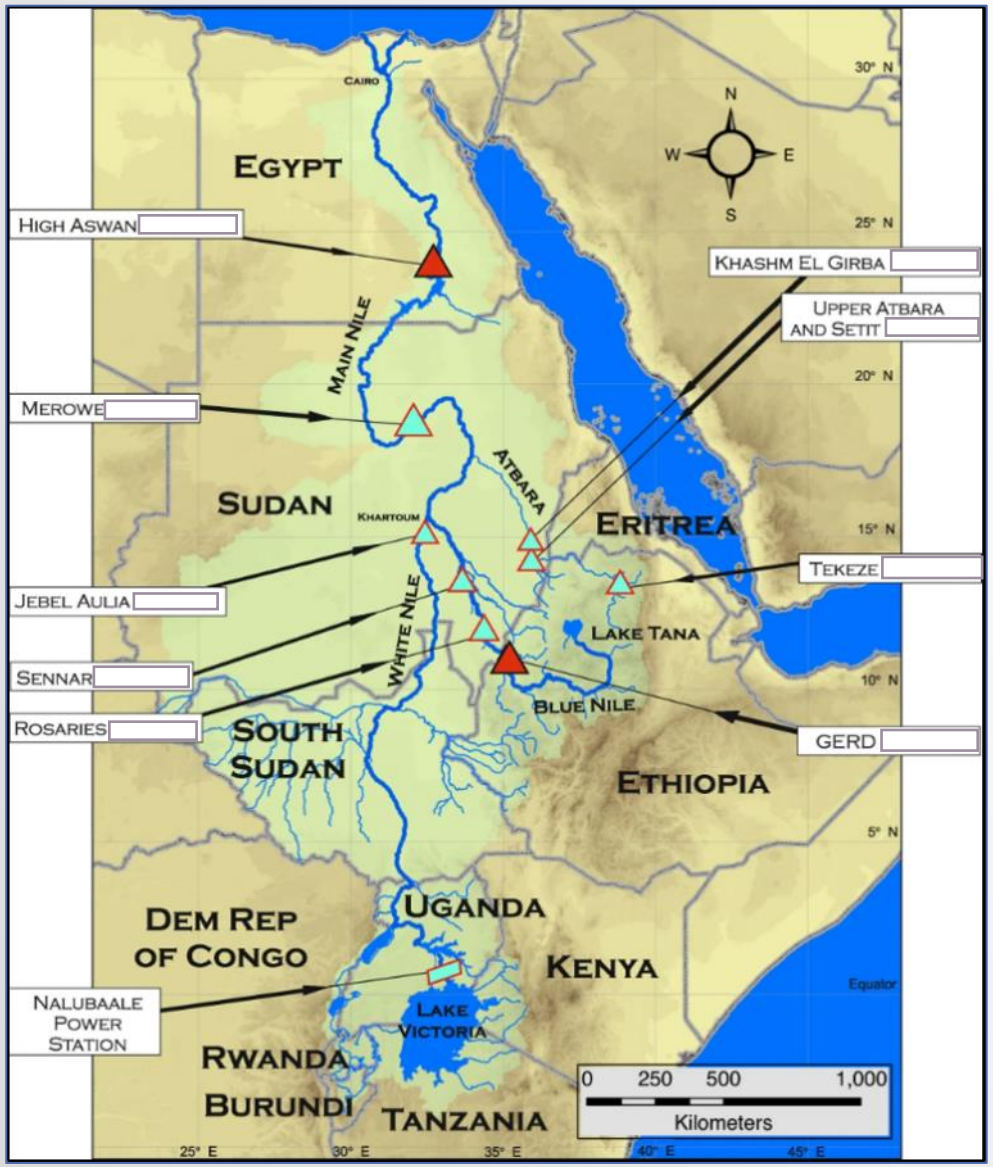
3. 'Adversarial' → operates the GERD to intentionally inflict harm on Egypt

COLLABORATIVE MODEL BUILDING

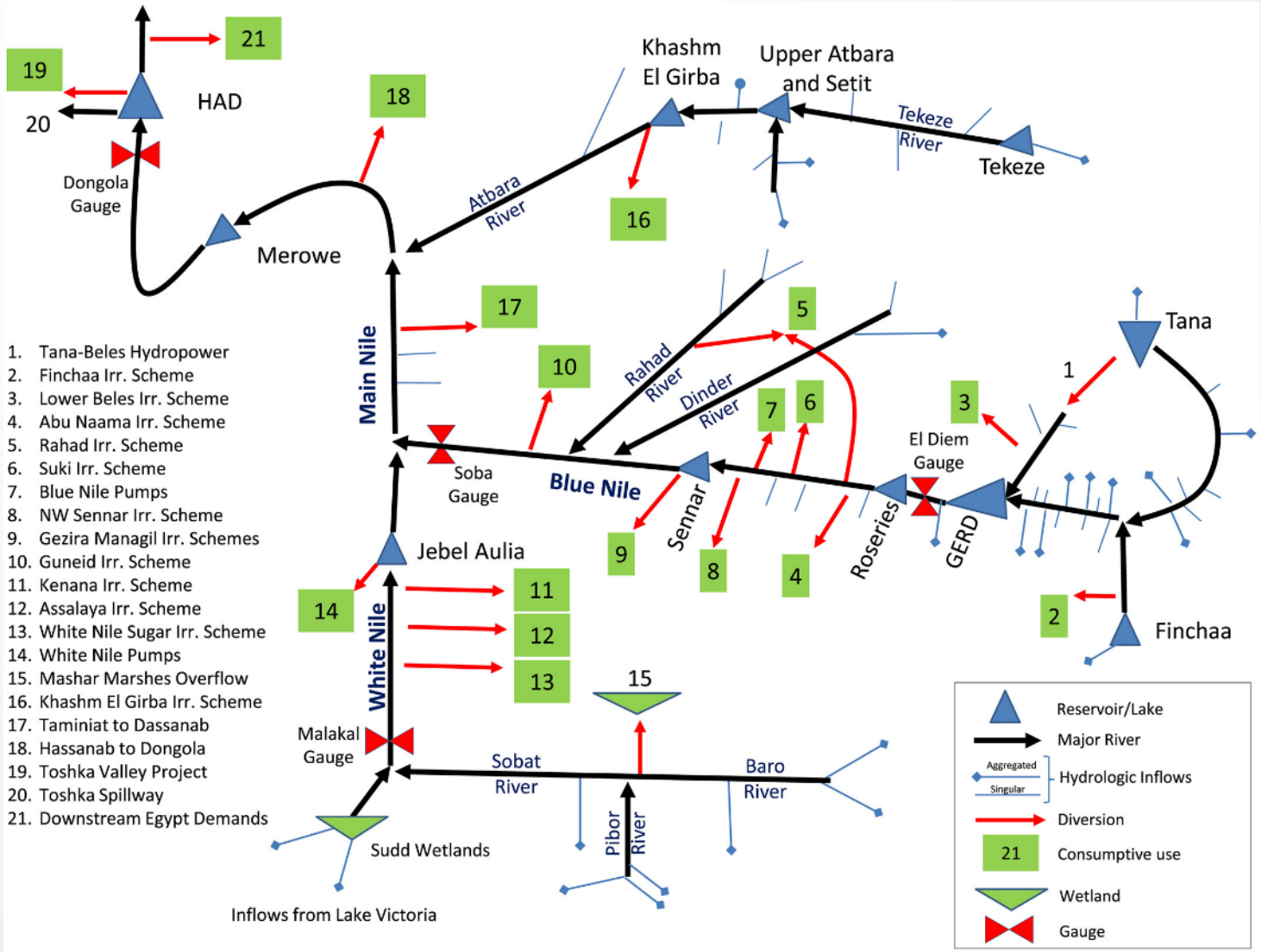
4 Countries + ~ 30 Visits + 7 in-person training sessions + online training + extensive stakeholder participation + data collection + field visits

- ✓ Academics
- ✓ Water ministry engineers
- ✓ Dam operators
- ✓ NGOs
- ✓ Basin organizations
- ✓ Consultants

EASTERN NILE RIVERWARE MODEL SCHEMATIC



Map of the Nile Basin with existing infrastructure, from Wheeler at al. (2020).

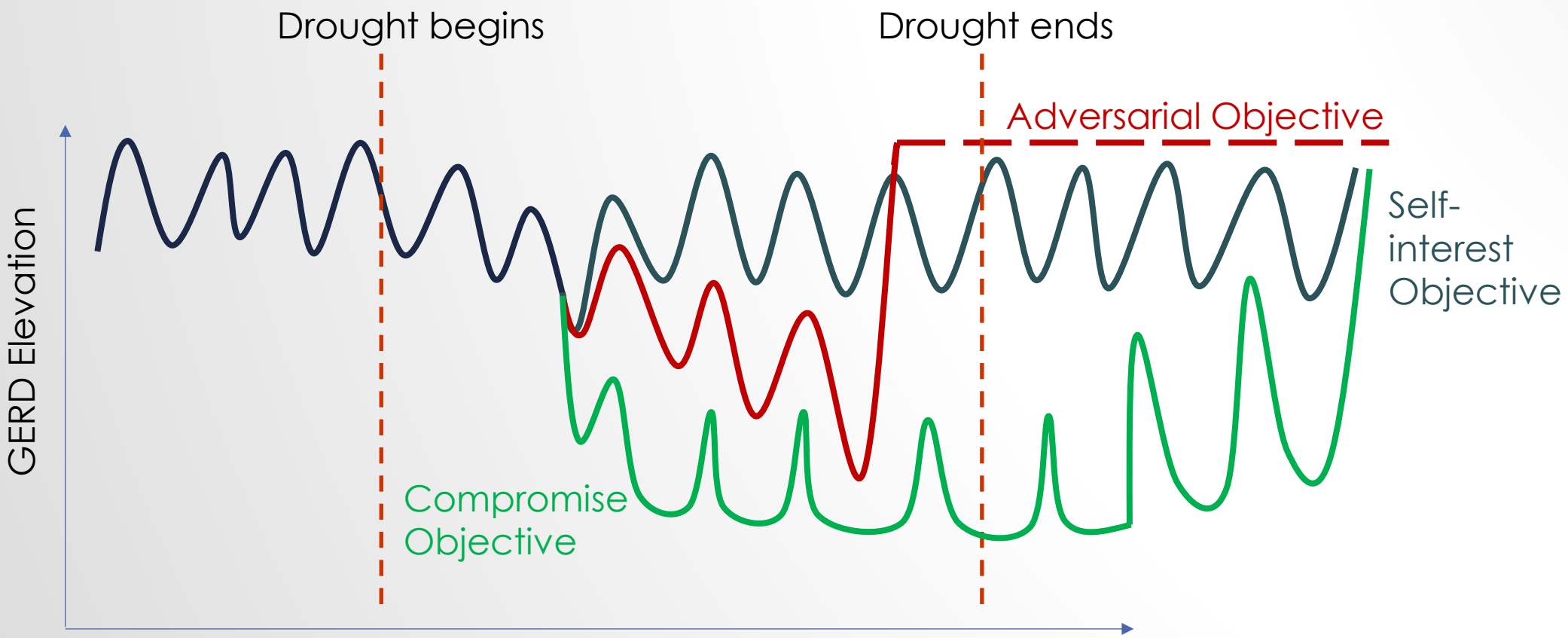


Schematic of the Eastern Nile RiverWare Model, from Wheeler at al. (2018).

FOUR SCENARIOS

- **No GERD** – Counterfactual baseline used to measure changes due to three possible GERD operating policies
- **Self-Interest Objective –** Ethiopia operates the GERD to generate 1600 MW during above average hydrological conditions, but reduces power generation during below average hydrological conditions
- **Compromise Objective -** Ethiopia generates 1600 MW whenever possible but agrees to make supplemental downstream releases under multi-year drought conditions; Drought recovery assures the GERD and HAD refill concurrently.
- **Adversarial Objective –** Ethiopia operates the GERD to generate 1600 MW, but abruptly fills the GERD when the HAD falls below 70 bcm

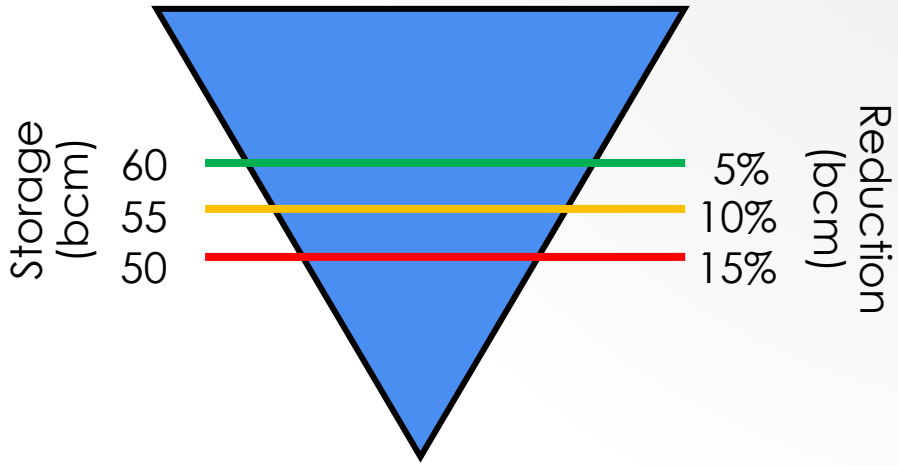
CONCEPTUAL SCENARIOS – GERD ELEVATION



HYDROLOGY ANALYSIS

- Historical drought condition (1980's drought)
- 100 traces using a stochastic streamflow generator - Simulated annealing
  - Wheeler, K. G., et al. (2025). "Multisite Nonparametric Stochastic Streamflow Generation for the Eastern Nile Basin." Journal of Hydrologic Engineering 30(1): 04024056.

ASSUMPTIONS



1. Water withdrawals

   - Sudan → 16.7 bcm/year

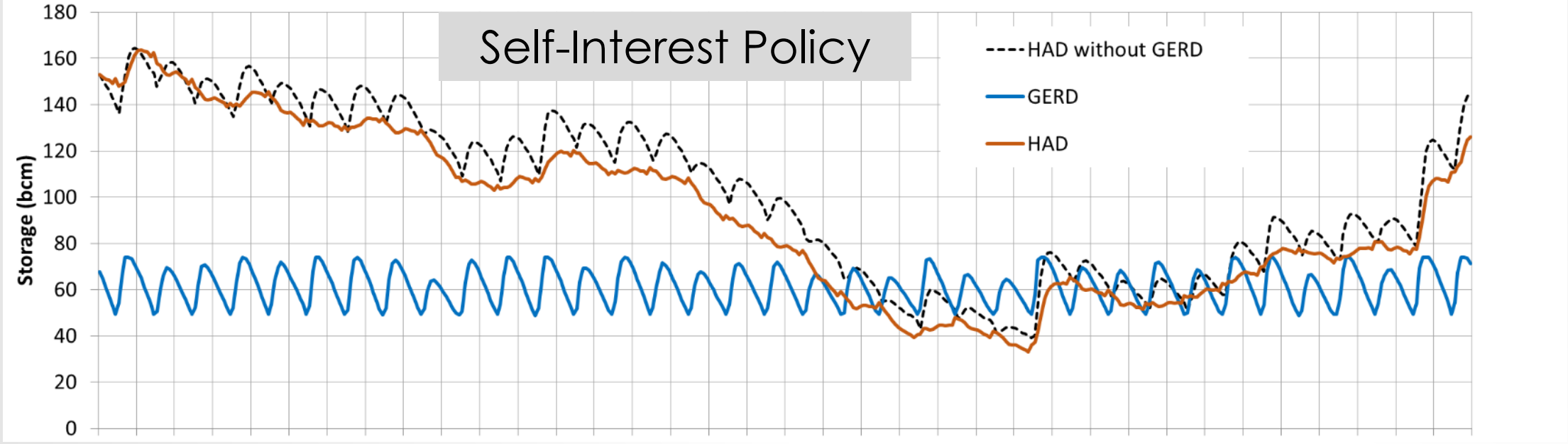
   - Ethiopia → 0.45 bcm/year

   - Egypt attempts to release 55.5 bcm/year

2. Egypt's current drought management plan in effect → HAD reduces outflows by 5, 10, and 15% as storage falls below 60, 55, and 50 bcm, respectively.

RESULTS

1. System performance during a historical drought event
2. Effects on annual hydropower generation from the GERD
3. Risk of water shortages in Egypt


Self-Interest Policy
HAD without GERD
GERD
HAD
Storage (bcm)
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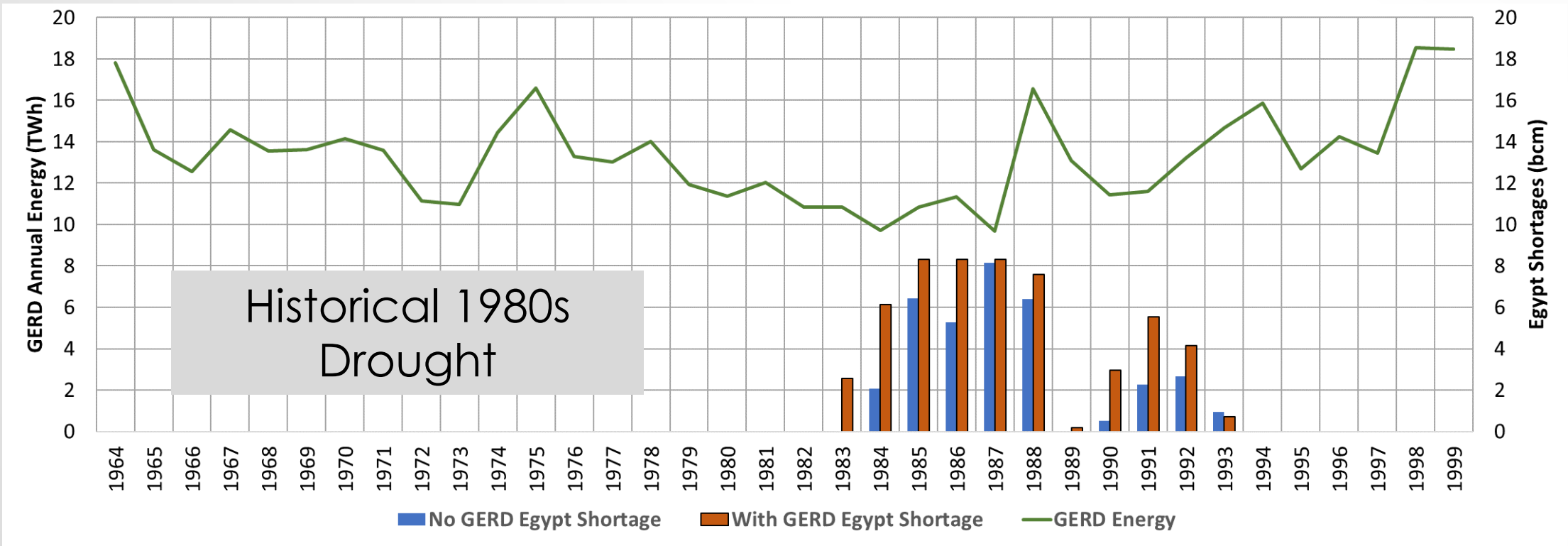
Historical 1980s Drought
GERD Annual Energy (TWh)
Egypt Shortages (bcm)
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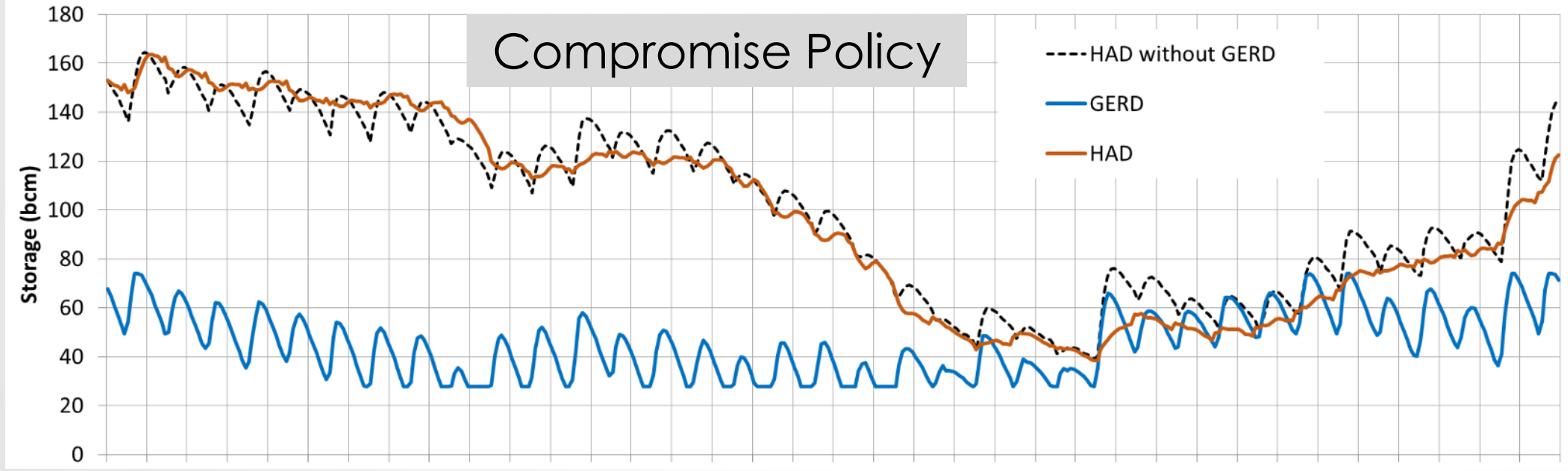
No GERD Egypt Shortage
With GERD Egypt Shortage
GERD Energy


Compromise Policy
HAD without GERD
GERD
HAD
Storage (bcm)
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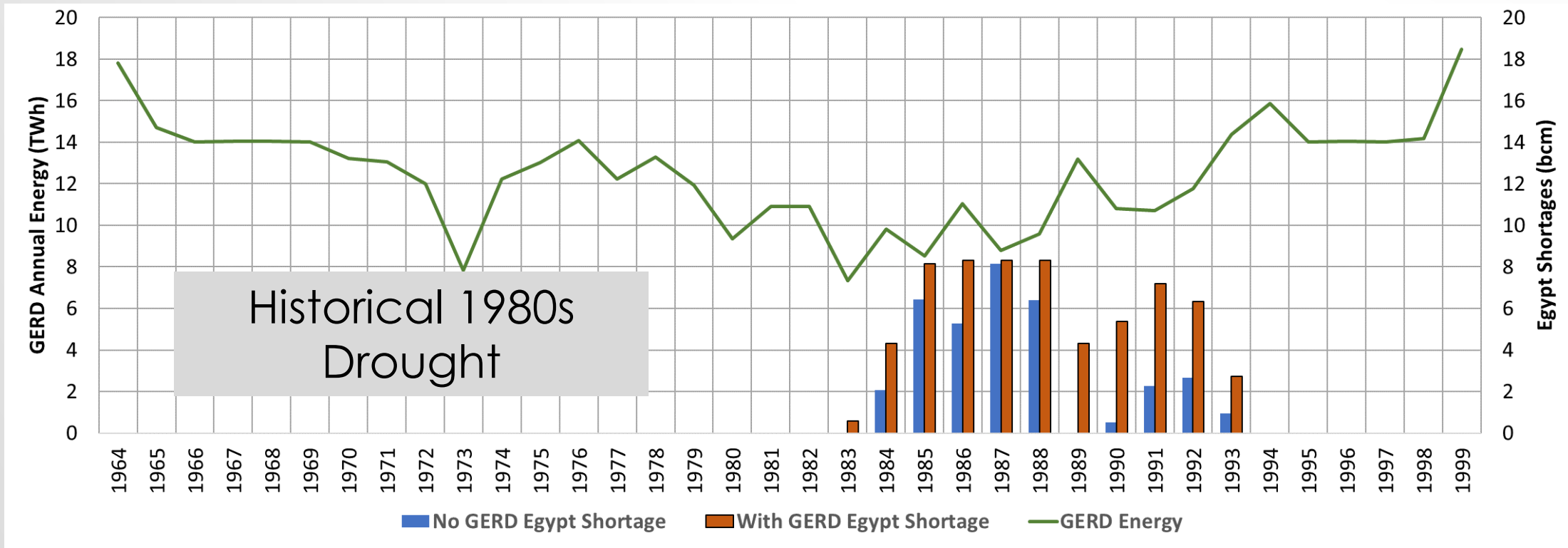
Historical 1980s Drought
GERD Annual Energy (TWh)
Egypt Shortages (bcm)
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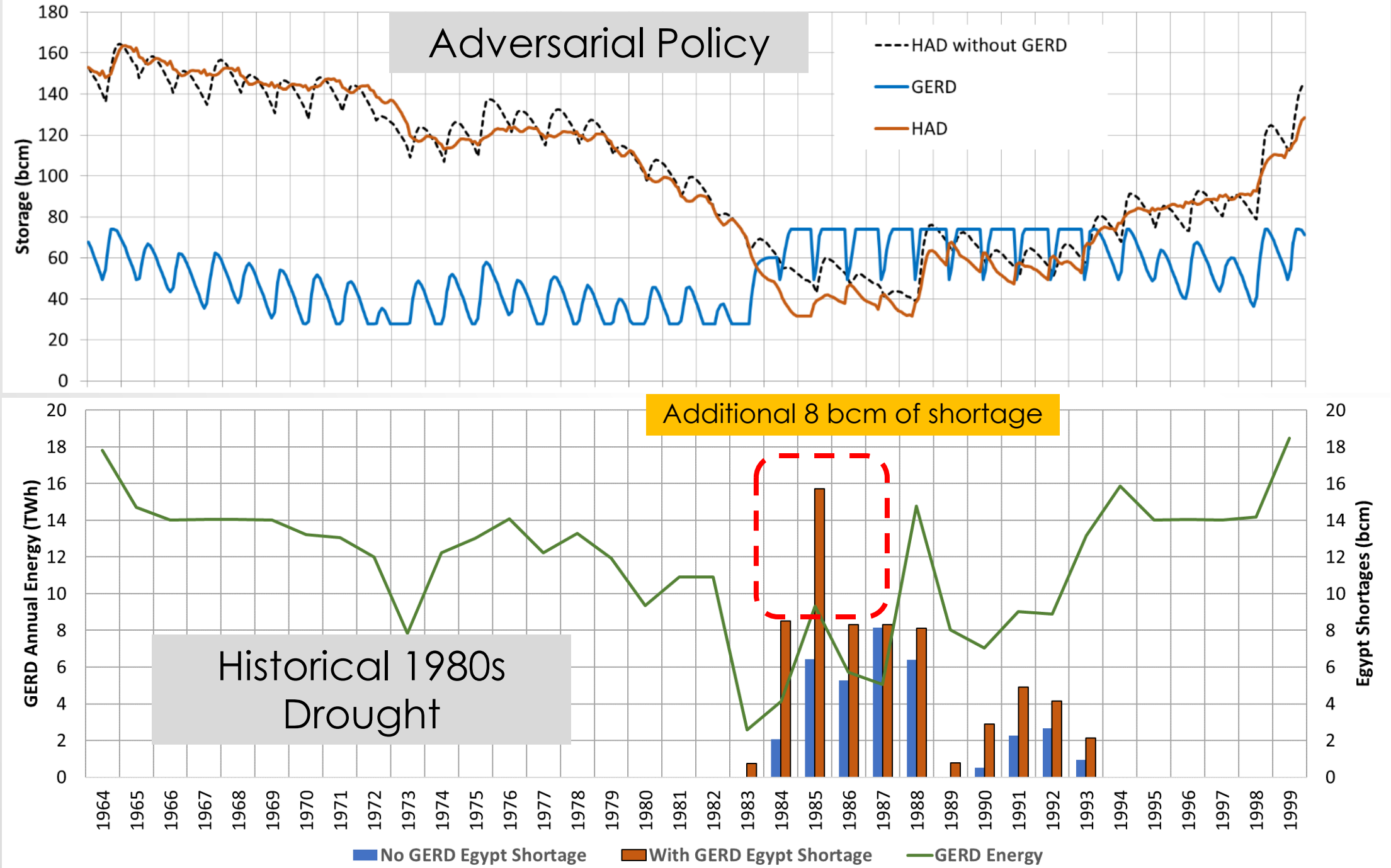
No GERD Egypt Shortage
With GERD Egypt Shortage
GERD Energy


Adversarial Policy
HAD without GERD
GERD
HAD
Storage (bcm)
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Additional 8 bcm of shortage
Historical 1980s Drought
GERD Annual Energy (TWh)
Egypt Shortages (bcm)
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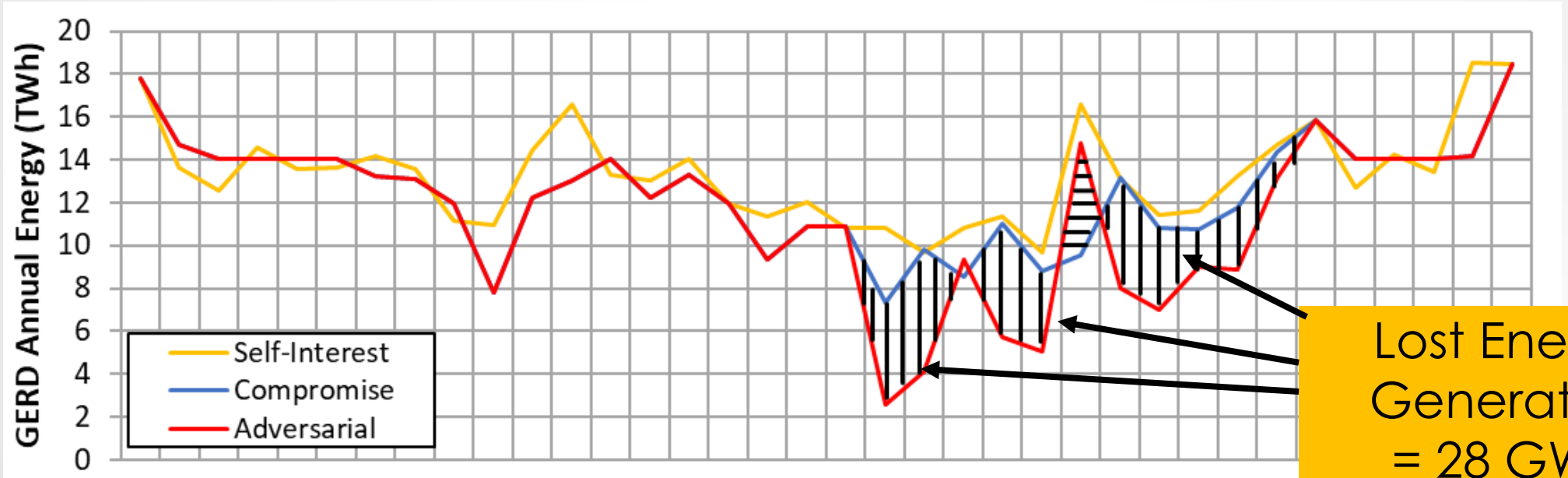
No GERD Egypt Shortage
With GERD Egypt Shortage
GERD Energy

HISTORICAL DROUGHT ANALYSIS

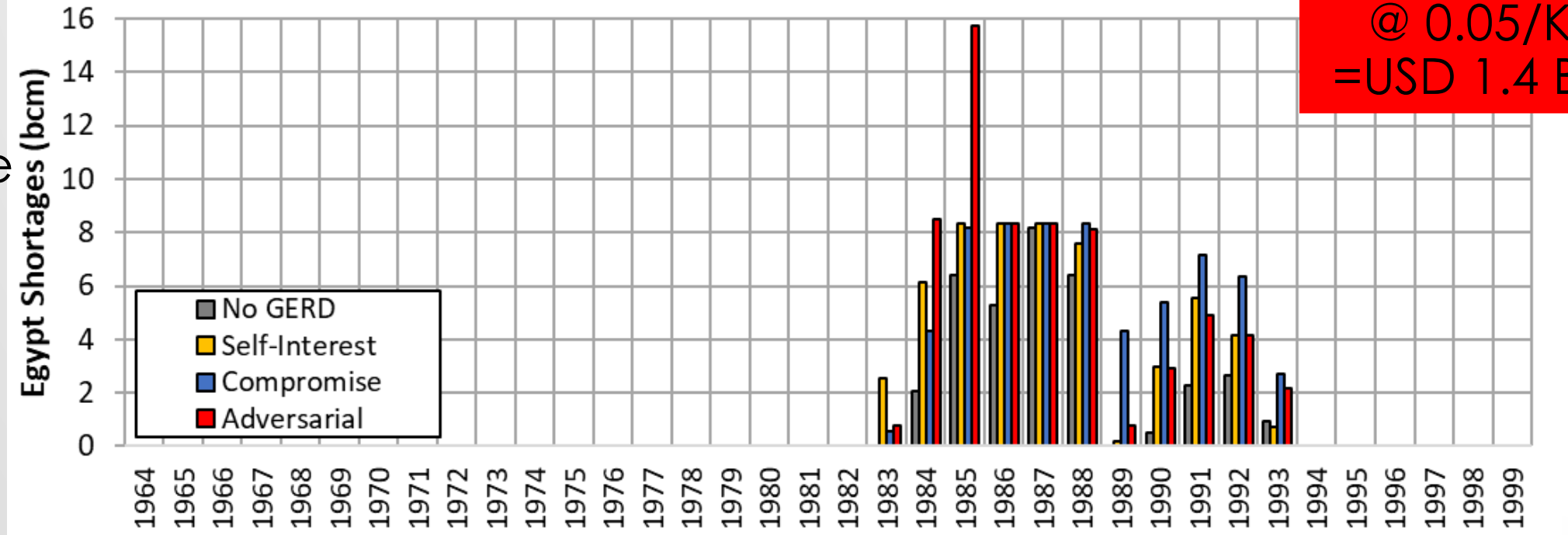
GERD Annual Energy



Lost Energy Generation = 28 GWh

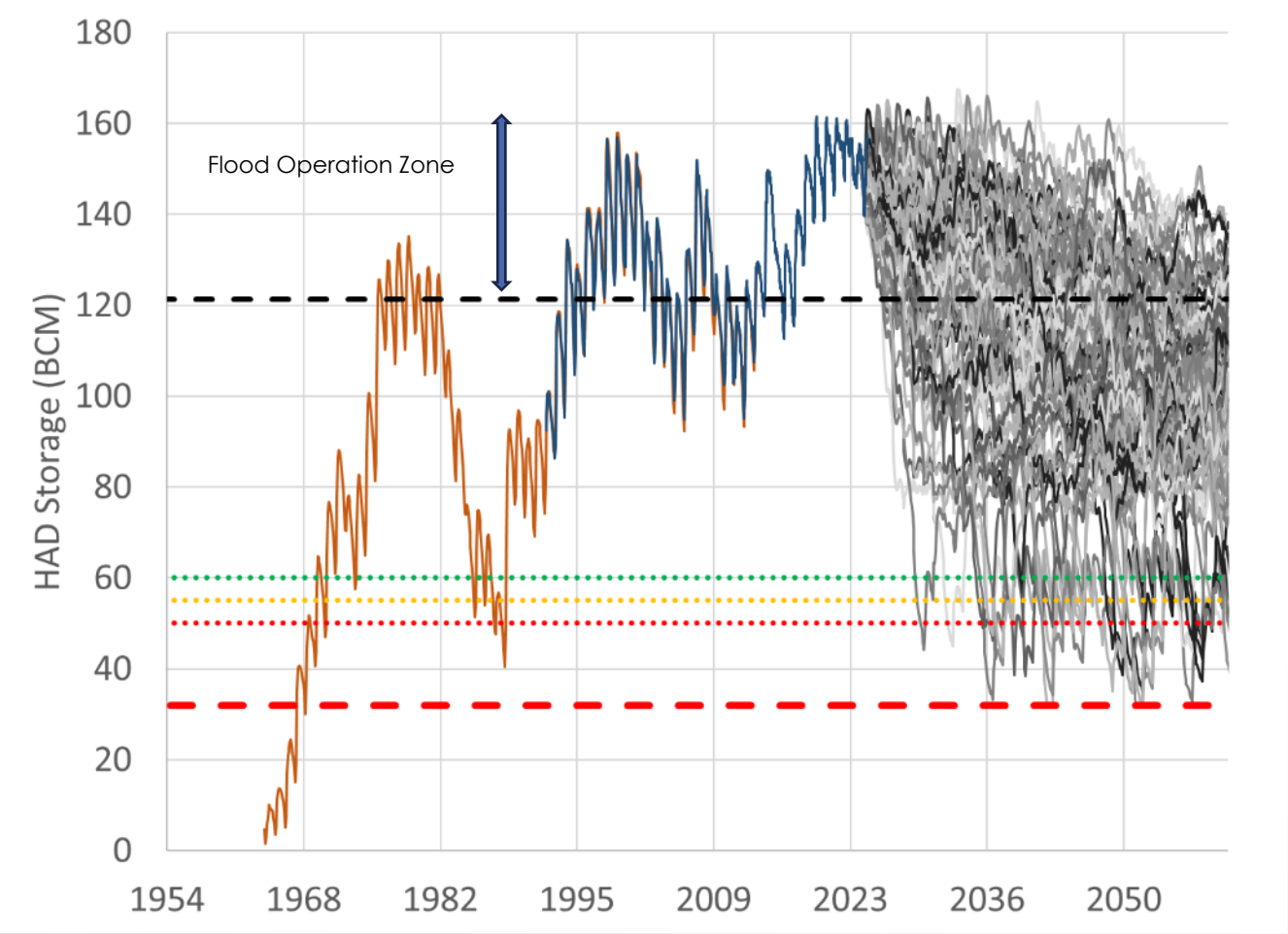
@ 0.05/KWh =USD 1.4 Billion

Egypt Annual Shortage

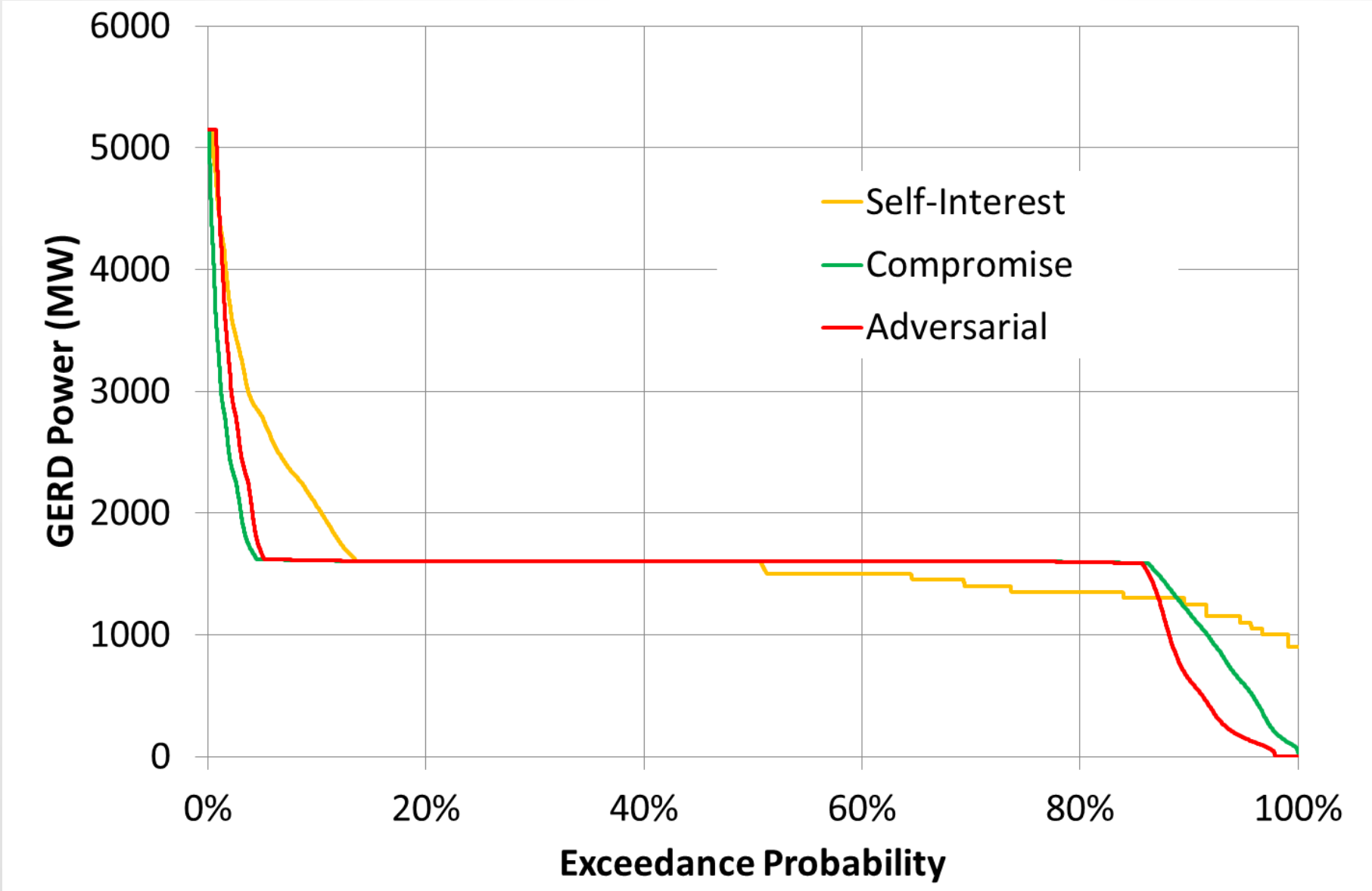


WHAT ARE THE PROBABILISTIC IMPACTS?

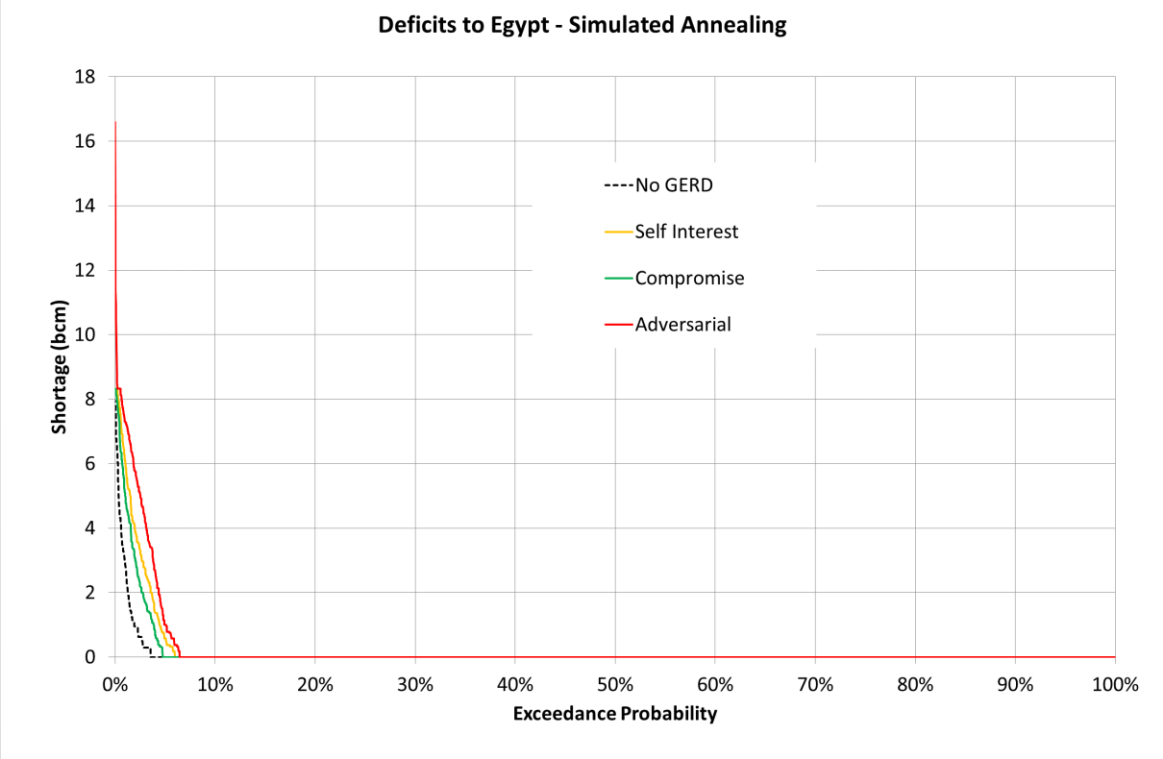
High Aswan Dam Storage

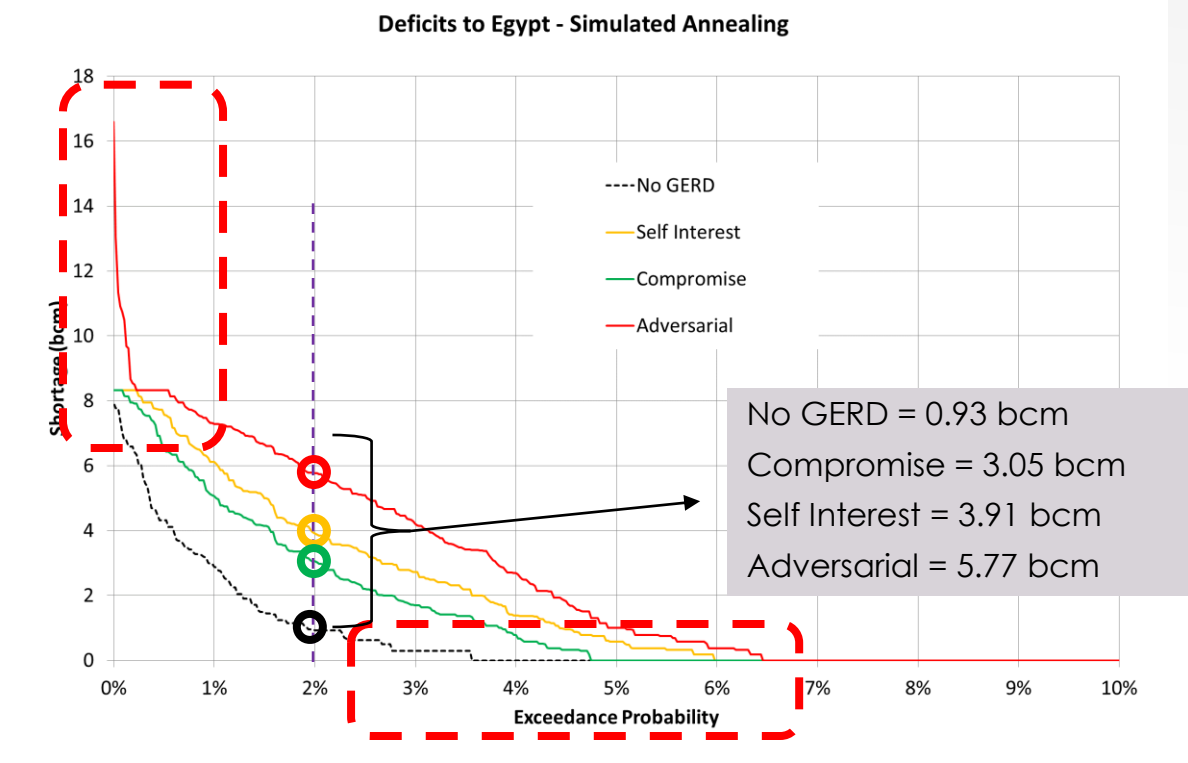


GERD POWER GENERATION – EXCEEDANCE PROBABILITY



SHORTAGES TO EGYPT – EXCEEDANCE PROBABILITY





- Less than 7% probability of occurrence of any shortage
- Less that 0.3% probability of extreme additional impacts

CONCLUSIONS

- Conditions would be rare when both reservoirs are in a low situation
- Less than 7% probability that Egypt would need to be shorted, even under adversarial conditions
- On low-probability occasions (0.2 annual exceedance probability), adversarial operation of the GERD could increase shortages by Egypt 2.72 bcm/year relative to a compromise scenario
- Under extremely rare cases, adversarial operation of the GERD could reduce releases from the HAD by 8 bcm, but only briefly and at a significant cost to Ethiopia

CONCLUSIONS

- Ethiopia would have very little financial justification to inflict harm on Egypt
- Paradox – Only by Ethiopia lowering the elevation of the GERD to help Egypt could they significantly inflict significant harm on Egypt

Nile Publications

Kevin Wheeler
Kevin.wheeler@ouce.ox.ac.uk

Should Egypt be afraid of the Grand Ethiopian Renaissance Dam? The consequences of adversarial water policy on the Blue Nile. *Whittington, D., Hall, J.. Murgatroyd, A., Wheeler, K. (2025). Water Policy 27(1): 104-117.*

The implications of further reservoir development on the Blue Nile in Ethiopia: trade-offs between hydropower, irrigation and transboundary water security. *Murgatroyd, A., Wheeler, K., Hall, J., Whittington, D., (2024). Environmental Research Letters 19: 094055.*

Understanding and managing new risks on the Nile with the Grand Ethiopian Renaissance Dam.
Wheeler, K. G., Jeuland, M., Hall, J. W., Zagona, E., & Whittington, D. (2020). Nature Communications, 11(1), 5222.

Exploring Cooperative Transboundary River Management Strategies for the Eastern Nile Basin
Wheeler, K., Hall, J. W., Abdo, G. M., Dadson, S. J., Kasprzyk, J. R., Smith, R., & Zagona, E. A. (2018). Water Resources Research, 54(11), 9224-9254.

Cooperative filling approaches for the Grand Ethiopian Renaissance Dam
Wheeler, K., Basheer, M., Mekonnen, Z. T., Eltoum, S. O., Mersha, A., Abdo, G. M., Zagona, E. A., Hall, J. W., & Dadson, S. J. (2016). Water International, 41(4), 611-634.