From Ethiopian Falls

Nile River

To Egyptian Pyramids

A Blueprint for Adapting High Aswan Dam Operation to Challenges of Filling and Operation of the Grand Ethiopian Renaissance Dam

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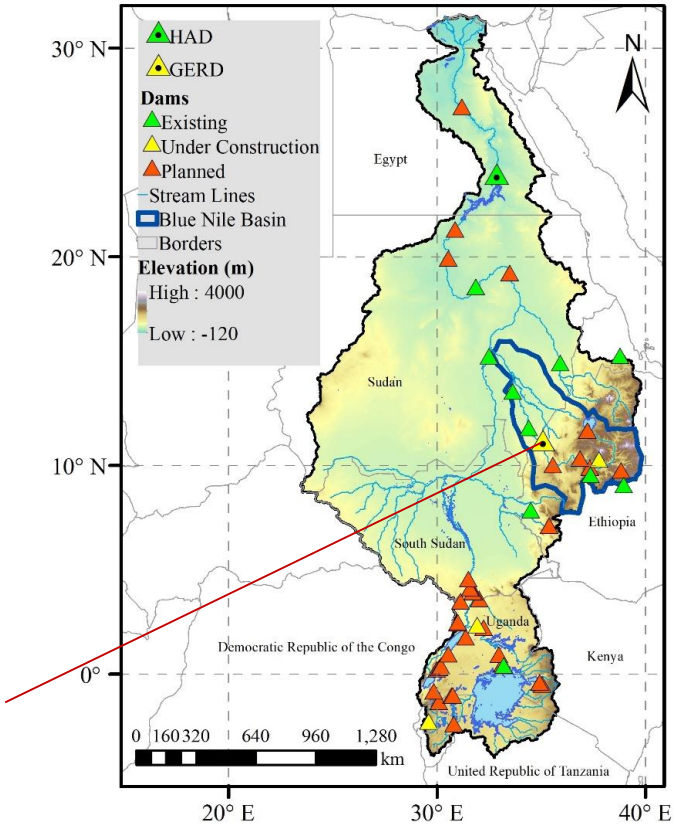
Nile River Basin (NRB)

- Transboundary river
- Population growth
- Increasing food/energy demand
- Climate variability
- Planned dams

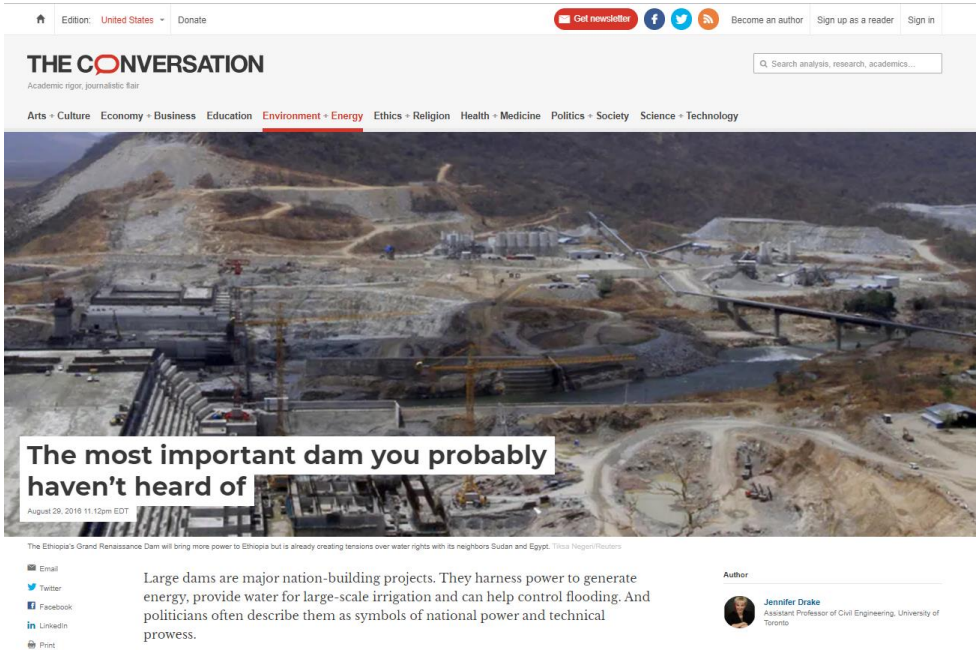
Dams in NRB

- 11 existing dams
- 35 planned hydropower dams
- 4 dams under construction



GRanD Database (Lehner et al., 2011) and Zarfl et al. (2015)

Grand Ethiopian Renaissance Dam (GERD)

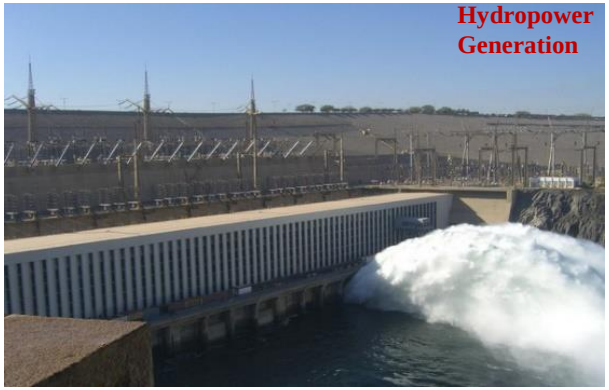


- **currently under construction in Ethiopia**
- **controlling the Blue Nile (Political Tensions)**
- **the largest hydropower dam in Africa**
- **74 km3 of reservoir storage**

6 times Grand Coulee dam in Washington~ 12 km3

Overarching Goal

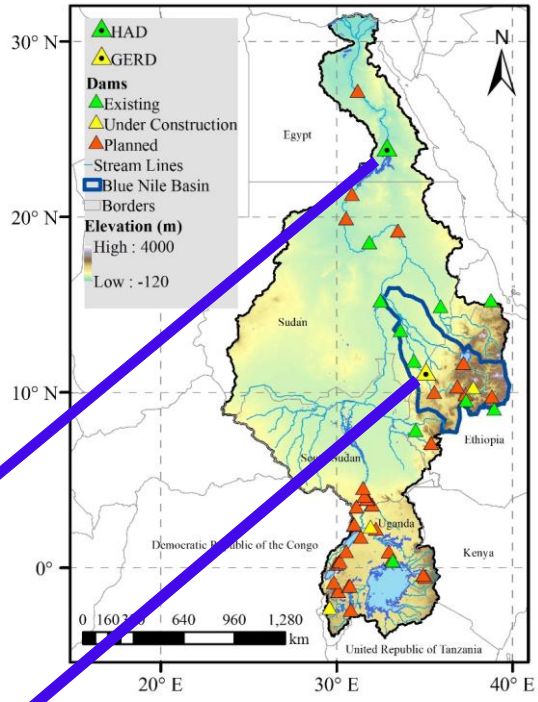
The overarching goal is to **derive adaptive reservoir operating policy** under the combined impacts from climate variability, planned transboundary dams and population pressures.



Research Question ***How can existing reservoirs adapt their operation to intrinsic and extrinsic transboundary challenges?***

Wikipedia Ranking of Reservoirs by Volume

Rank	Name of dam	Reservoir	River	Country	Year	Nominal volume km³
1	Kariba Dam	Lake Kariba	Zambezi River	Zambia and Zimbabwe	1959	180.6
2	Bratsk Dam	Bratsk Reservoir	Angara River	Russia	1964	169
3	Akosombo Dam	Lake Volta	Volta River	Ghana	1965	150
4	Daniel-Johnson Dam	Manicouagan Reservoir	Manicouagan River	Canada	1968	141.851
5	Guri Dam	Lake Guri	Caroní River	Venezuela	1986	135
6	Aswan High Dam	Lake Nasser	Nile River	Egypt	1971	132
7	Grand Ethiopian Renaissance Dam		Blue Nile River	Ethiopia	under construction	79
8	W. A. C. Bennett Dam	Williston Lake	Peace River	Canada	1967	74.3
9	Krasnoyarsk Dam	Krasnoyarsk Reservoir (ru)	Yenisei River	Russia	1967	73.3
10	Zeya Hydroelectric Station (ru)	Zeya Reservoir	Zeya River	Russia	1978	68.4



Acronyms

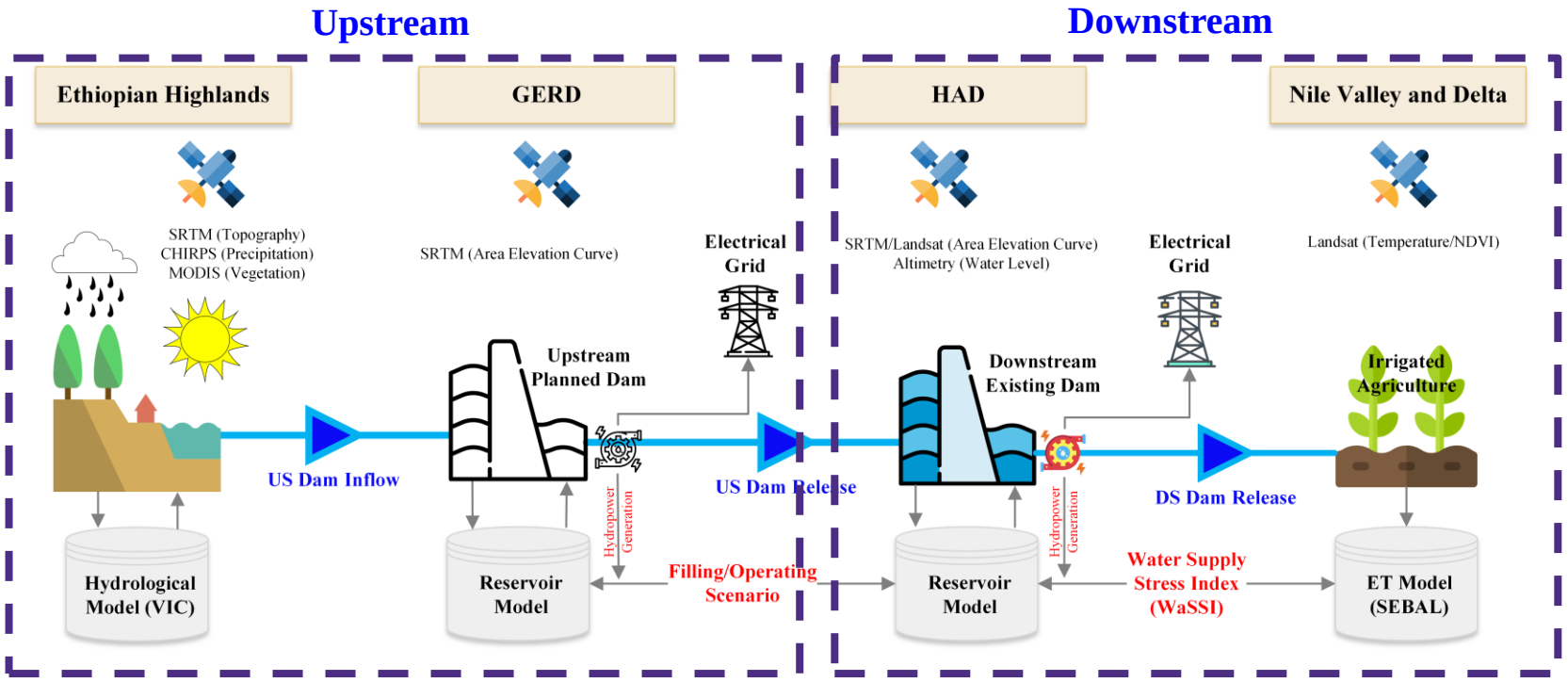
HAD: High Aswan Dam

(existing downstream dam in Egypt)

GERD: Grand Ethiopian Renaissance Dam

(planned upstream dam in Ethiopia)

Satellite-Based Blueprint



* *Eldardiry, H., & Hossain, F. (2019). Understanding Reservoir Operating Rules in the Transboundary Nile River Basin Using Macroscale Hydrologic Modeling with Satellite Measurements. Journal of Hydrometeorology, 20(11), 2253-2269.*

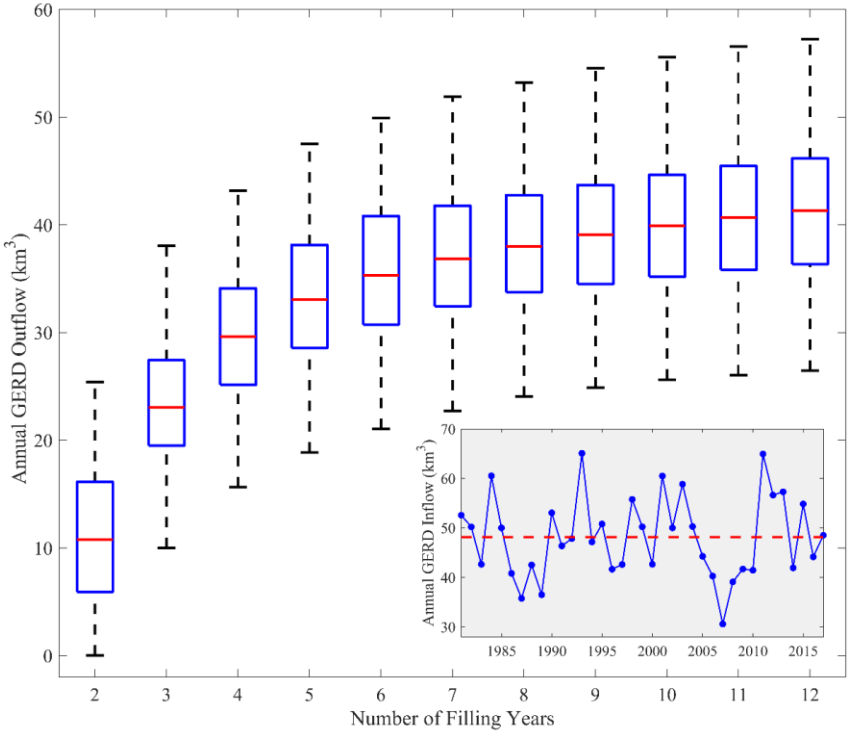
* *Eldardiry, H., and Hossain, F. (In revision). A Blueprint for Adapting High Aswan Dam Operation in Egypt to Challenges of Filling and Operation of the Grand Ethiopian Renaissance Dam, Journal of Hydrology.*

GERD Filling Scenarios

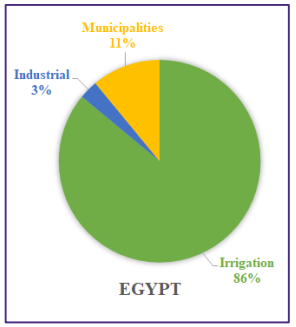
- Filling scenarios of GERD (from 2- to 12-years)
- Using the historical inflow (1981-2017) simulated by the VIC model.
- Less impacts downstream for filling scenarios of greater than 7 years.

Median Flow=47.5 km^3/year

Reservoir Storage=74 km^3

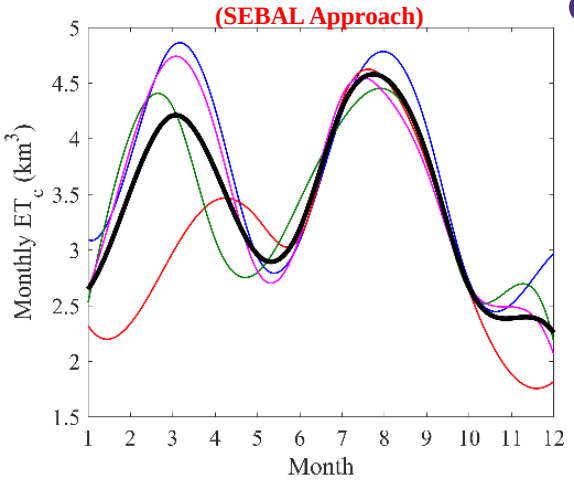


HAD Adaptation

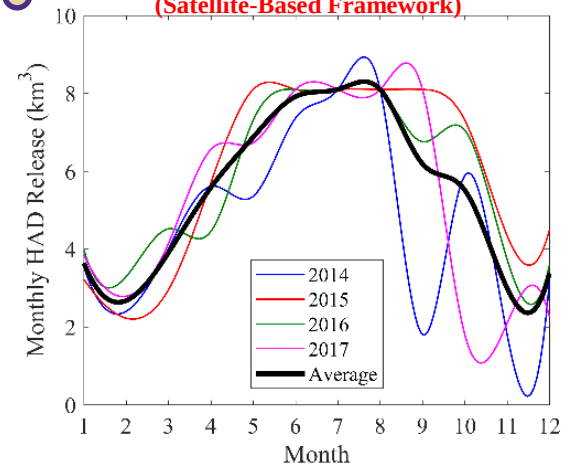


Water Supply Stress Index (WaSSI) $= \dfrac{\text{Water Consumption}}{\text{Water Supply}}$

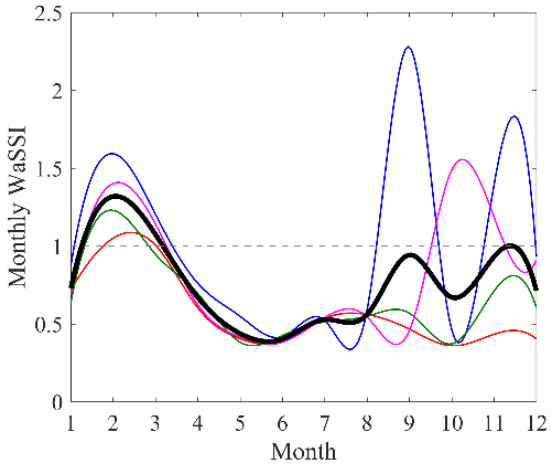
Water Consumption
(SEBAL Approach)



Water Supply
(Satellite-Based Framework)



WaSSI



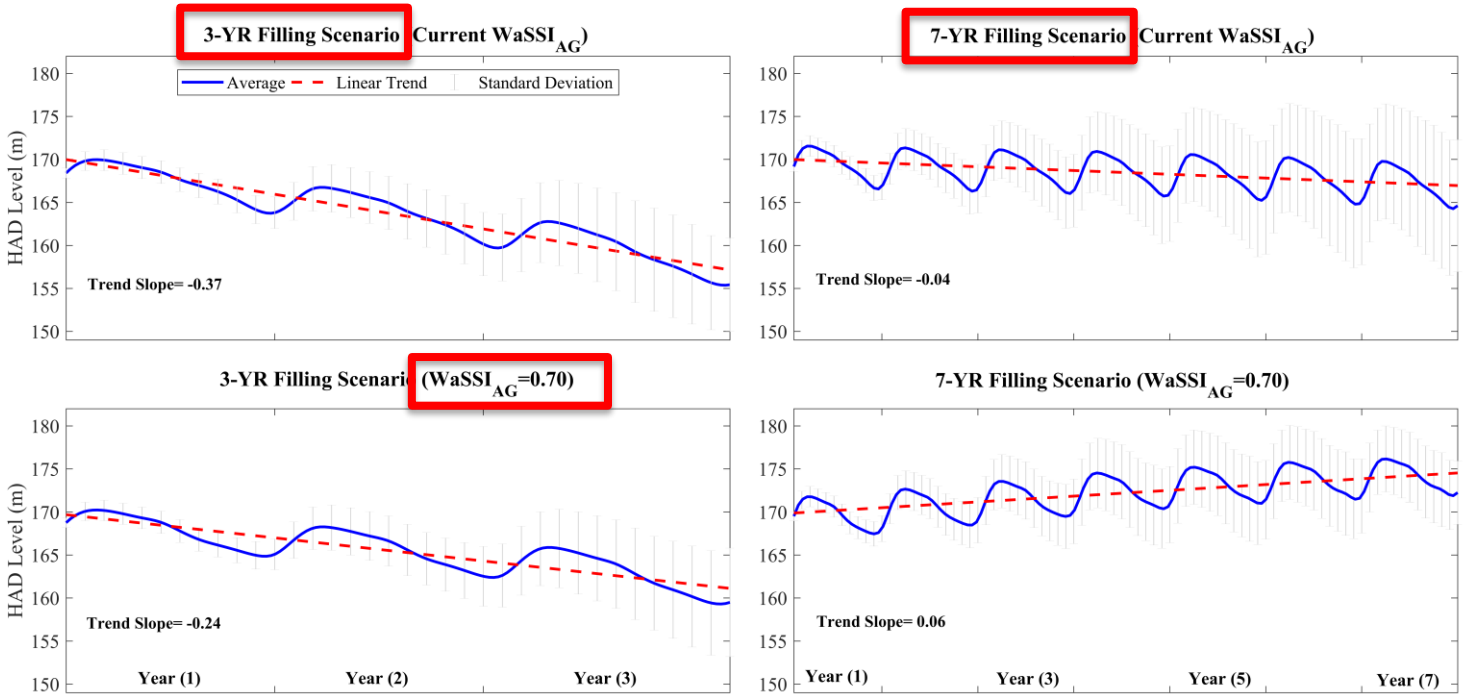
- Lower stress levels are noticed in the summer months (opportunities to adapt)
- Insufficient supply of HAD releases is encountered by relying on rainfall or groundwater

HAD Level during GERD Filling Scenarios

Testing different filling scenarios (Upstream conditions)
Testing different stress scenarios (Downstream Conditions)

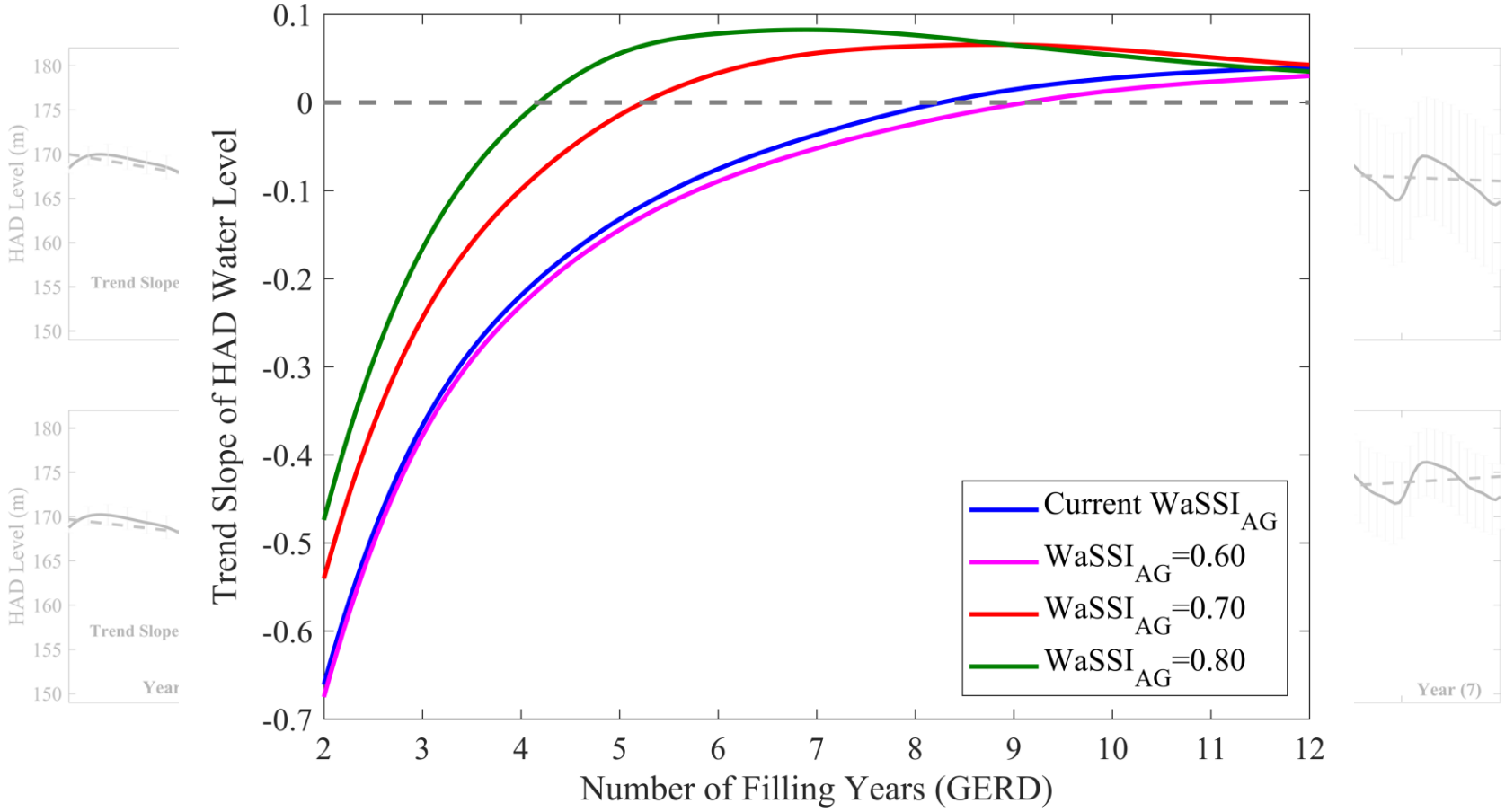
FSL=182 m AMSL

MOL=147 m AMSL



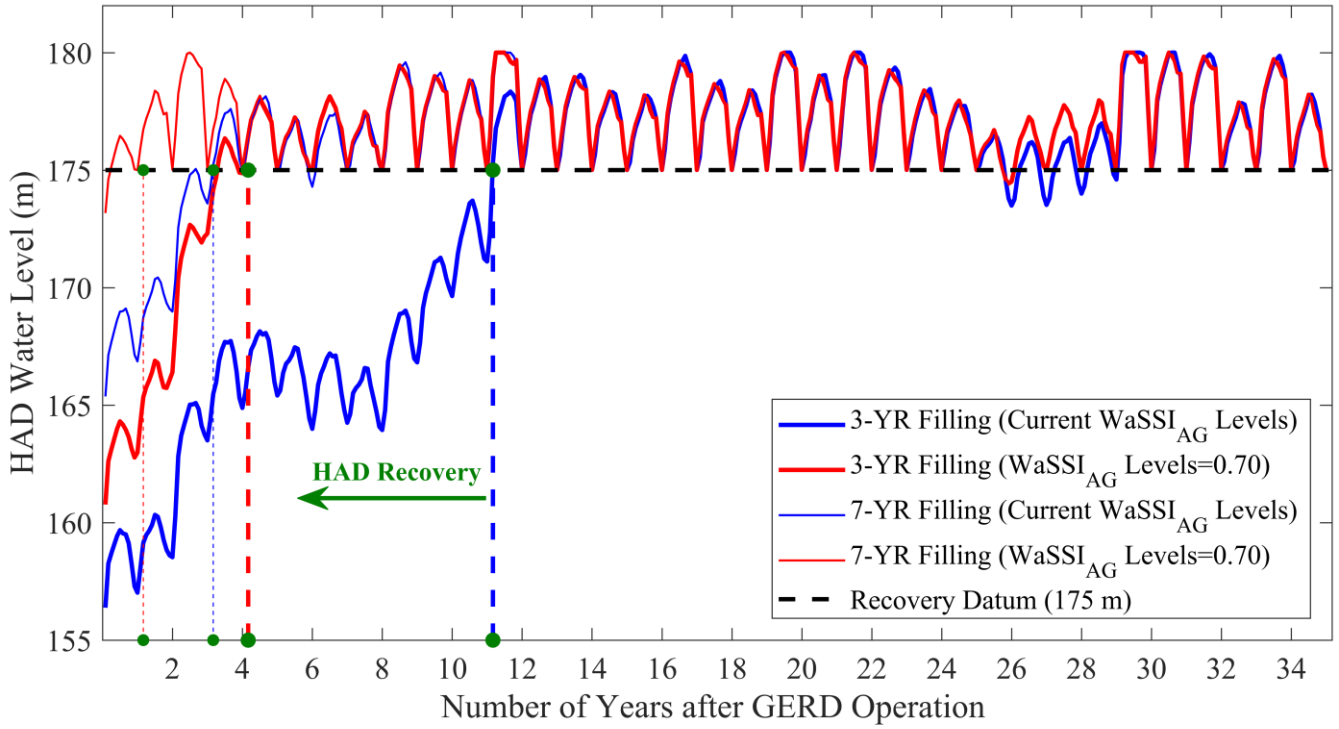
- A significant drop in the HAD level when assuming a 3-year filling scenario.
- A flatter pattern is noticed for 7-year filling scenario with negligible trends.

HAD Level during GERD Filling Scenarios



HAD Recovery during GERD Operation

Recovery: How long it will take for HAD to recover its normal operation level?



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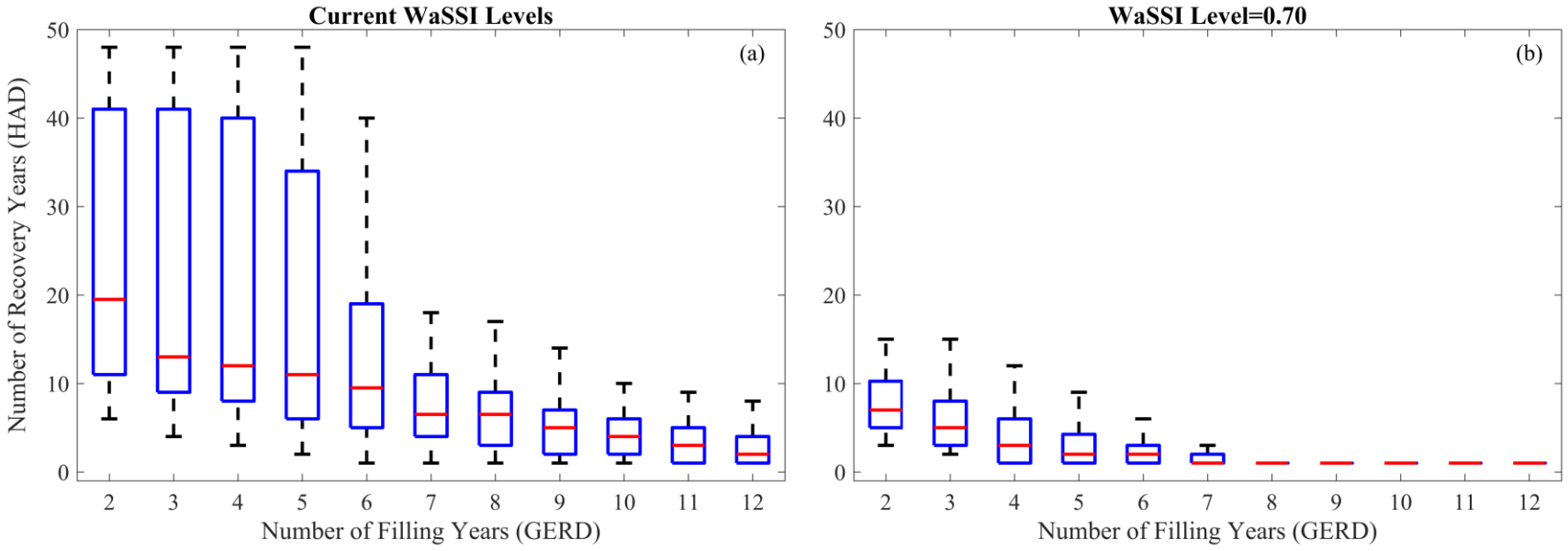


Assessment of GERD/HAD

Location	Factor	Scenario
Upstream Planned Dam (GERD)	**GERD Inflow**	**Dry vs Normal vs Wet**
	GERD Storage Capacity	74 vs 80
	GERD FSL	640 vs 650
	GERD Filling	**3 vs 7 Years**
	GERD Starting Filling Month	January vs August
	GERD HP Demand	Uniform vs Varying (Demand Curve)
	GERD HP Load Factor	LF=0.3 vs 0.4 vs 0.5
	GERD Starting Operation Climate	Dry vs Normal vs Wet
	GERD Filling Strategy	Summer vs Yearly vs Agreed Outflow
Downstream Existing Dam (HAD)	Sudan Share	0.75 vs 0.70 vs 0.60
	White Nile inflow	Low vs Average vs High
	HAD Starting Level	Low vs Average vs High
	HAD HP	By-product vs Optimization
	HAD HP Load Factor	CF=0.3 vs 0.45 vs 0.6
	HAD HP Demand	Uniform vs Varying (Demand Curve)
	HAD DS WaSSI	**Status Quo WaSSI vs Predefined WaSSI**

Key Findings and Future Pathways

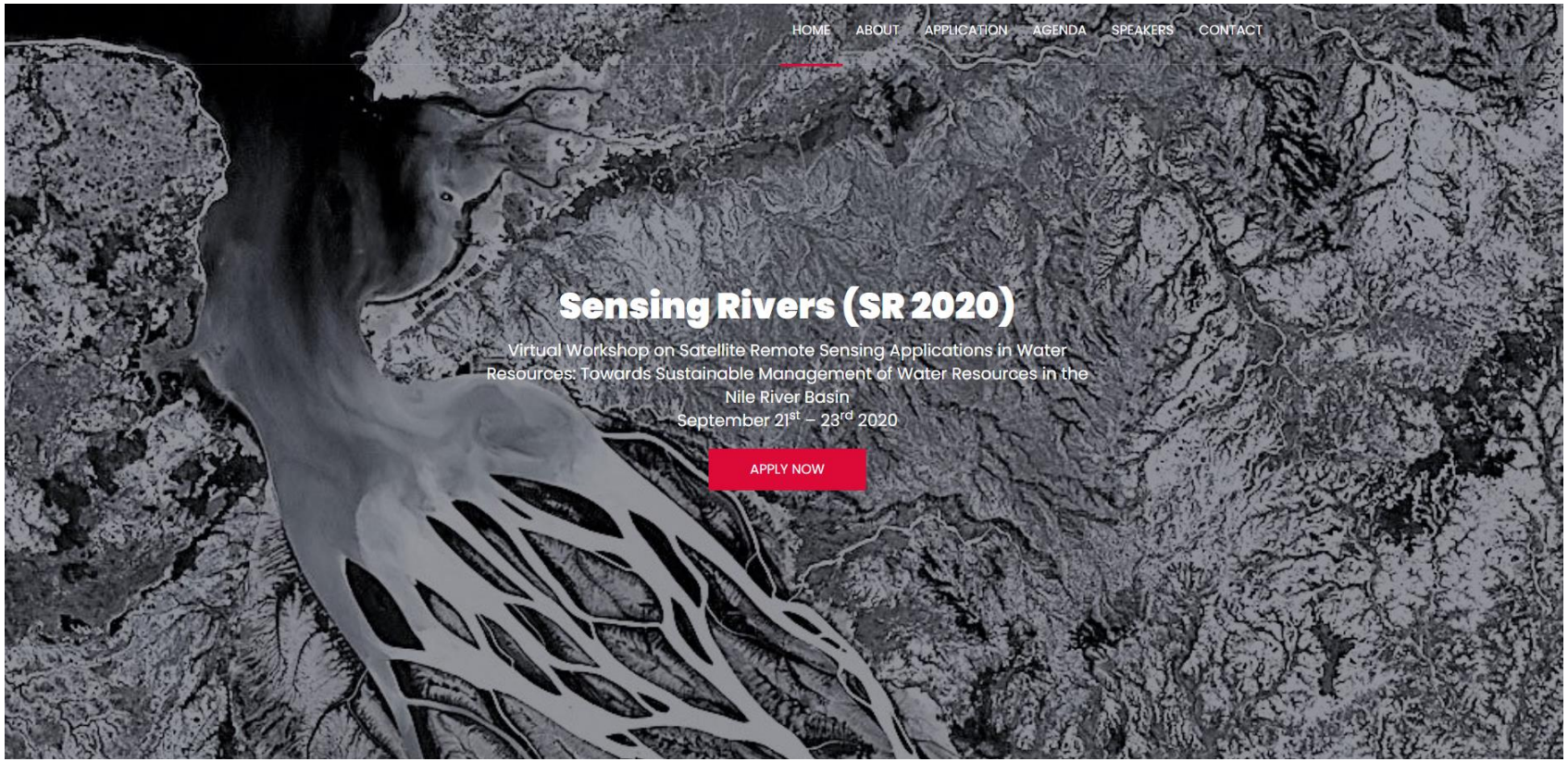
- Filling scenario (> 7-year) has less impacts on HAD operation.
- HAD can adapt to GERD filling in summer months.
- Forecast-based Adaptive Reservoir Operation (FARO).
- Foster negotiations to agree upon a long-term framework that explicitly accounts for the impacts of transboundary projects.

The leaders of Egypt, Ethiopia and Sudan all gathered in Khartoum to sign the agreement of principles in 2015 (Source: BBC).


Thank You!
“Egypt is the Gift of the Nile”
Greek Historian Herodotus (440 BC)
Sunset on the Nile
Aswan, Egypt (August 2007)

If interested

3-day workshop on using satellite remote sensing in the Nile River Basin



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