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 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?*
Acronyms

HAD: High Aswan Dam
(existing downstream dam in Egypt)

GERD: Grand Ethiopian Renaissance Dam
(planned upstream dam in Ethiopia)
Satellite-Based Blueprint


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)** = \( \frac{\text{Water Consumption}}{\text{Water Supply}} \)

- 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

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**Diagram Description**

- **Water Consumption (SEBAL Approach)**
  - Monthly ET<sub>c</sub> (km<sup>3</sup>)
- **Water Supply (Satellite-Based Framework)**
  - Monthly HAD Release (km<sup>3</sup>)
- **WaSSI**
  - Monthly WaSSI

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**Notes**

- Municipalities: 11%
- Industrial: 13%
- Irrigation: 80%

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HAD Level during GERD Filling Scenarios

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

> 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

![Graph showing the trend of HAD Level during GERD Filling Scenarios. The graph plots the trend slope of HAD water level against the number of filling years (GERD). Different colors represent different WaSSI AG values: blue for Current WaSSI AG, magenta for WaSSI AG = 0.60, red for WaSSI AG = 0.70, and green for WaSSI AG = 0.80. The graph shows the trend slopes for these values over the years from 2 to 12.]
HAD Recovery during GERD Operation

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

Recovery: How long will it take for HAD to recover its normal operation level?
# Assessment of GERD/HAD

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

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

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