Future DAMS
Design and Assessment of water-energy-food-environment Mega-Systems

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Multiple constraints and objectives should inform the negotiated filling of the Grand Ethiopian Renaissance Dam

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Presentation outline

- **Item 1** Introduction
- **Item 2** GERD engineering
- **Item 3** Methodology
- **Item 4** Results
- **Item 5** Implications for the initial filling

1- Introduction

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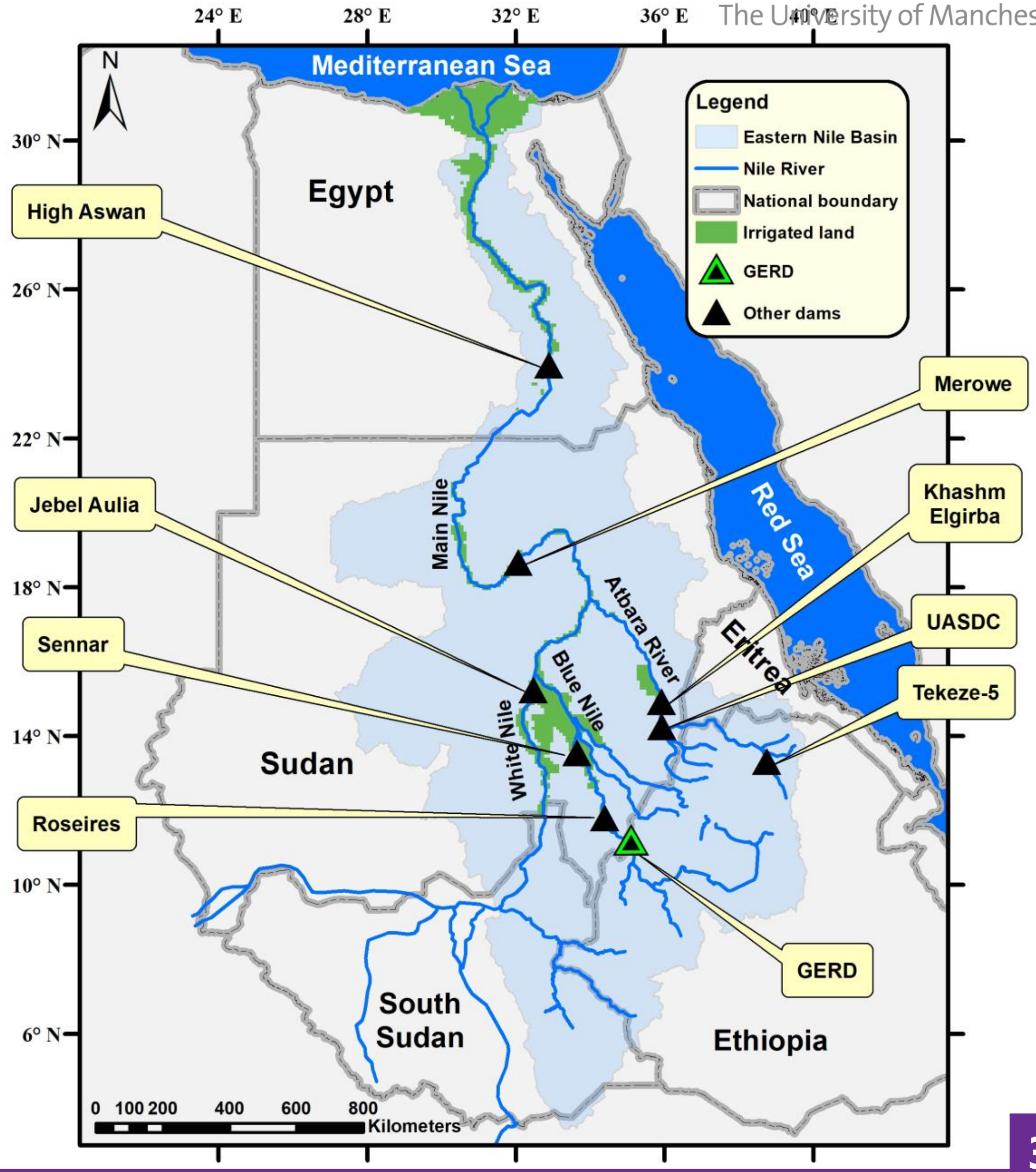
- The Eastern Nile Basin is located in East Africa.
- Covers around 6% of the African continent.
- Geographically shared between four countries: Ethiopia, Sudan, Egypt, and South Sudan
- The total population of the Eastern Nile Basin countries is around 260 million.
- The Grand Ethiopian Renaissance Dam (GERD) is currently under construction on the Blue Nile in Ethiopia.
- Much discussion and negotiations are ongoing since 2011 when the construction started.



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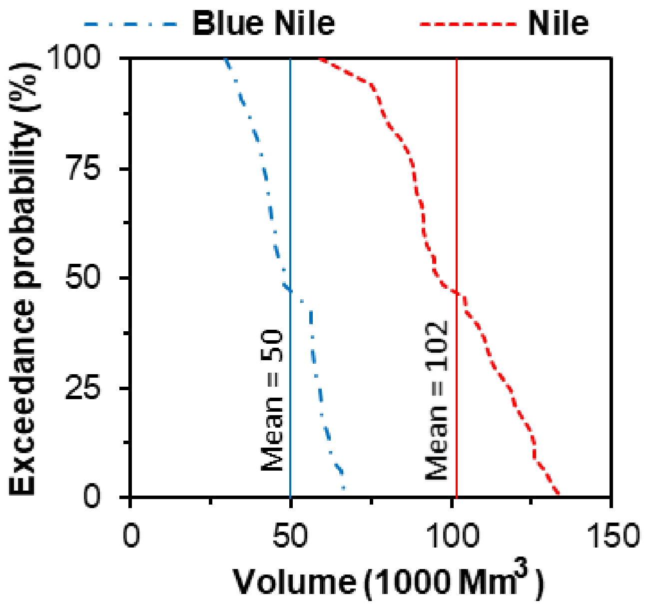
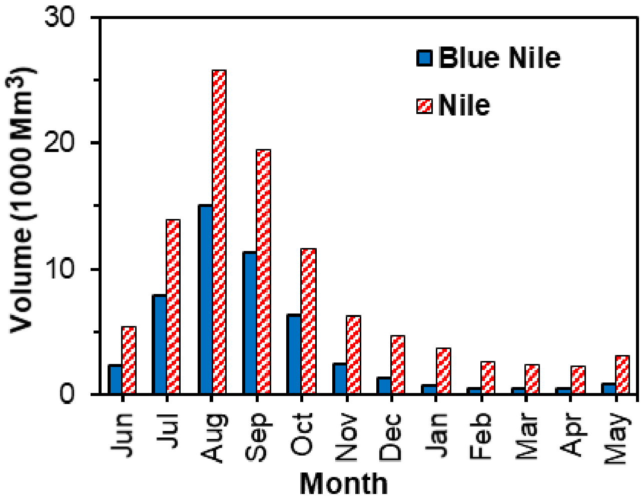
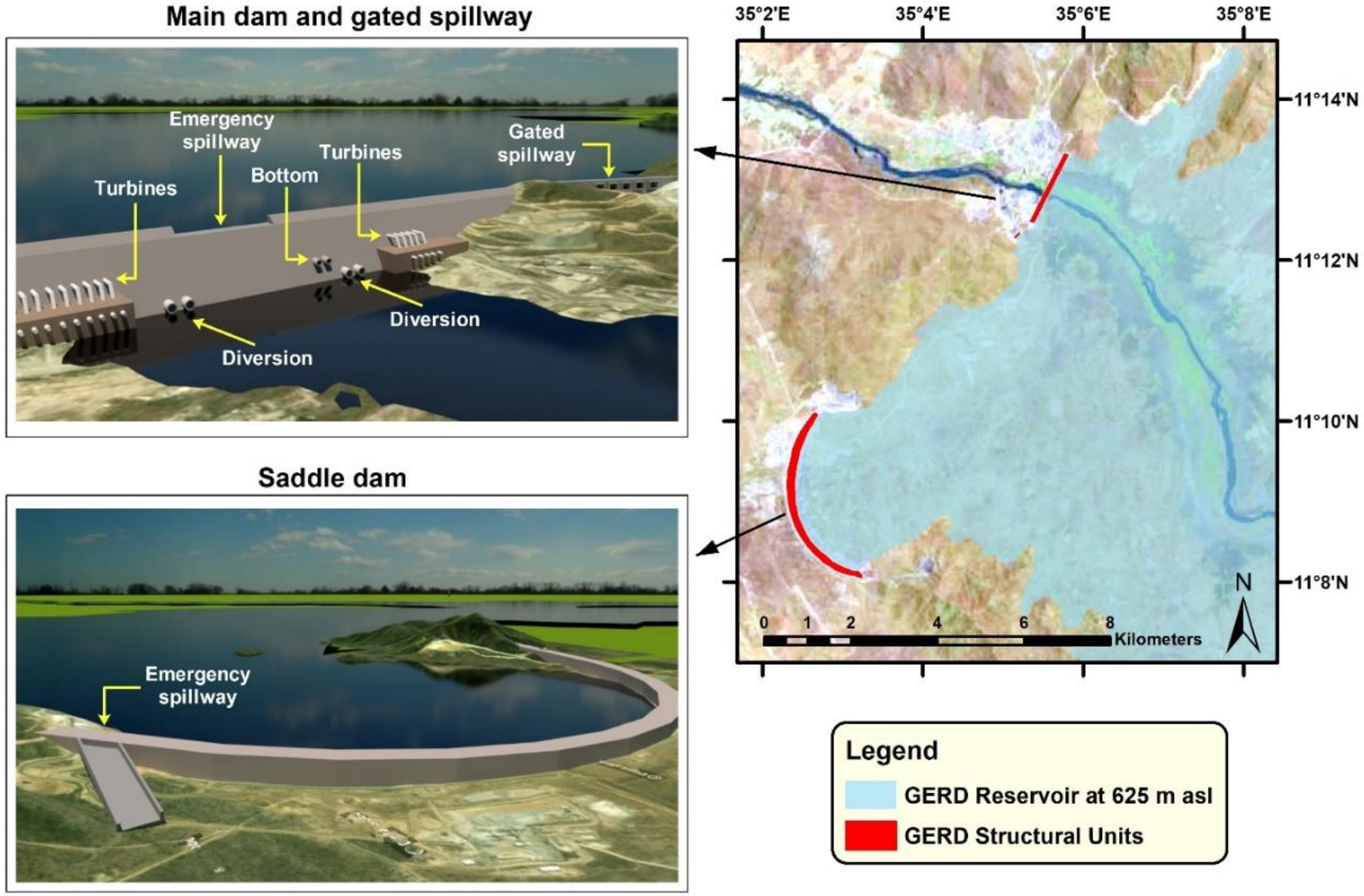
- ❑ The annual flow of the Nile is highly variable.
- ❑ This inter-annual variability concerns Egypt.
- ❑ The high seasonality of the Blue Nile flow is key to Sudan's irrigation.
- ❑ The GERD has a storage capacity of 74,000 Mm3, equivalent to 1.5 the annual flow of the Blue Nile.
- ❑ The negotiations focused on the impacts of the initial filling and long-term operation of the GERD on water availability and hydropower generation in Sudan and Egypt.
- ❑ **It is normally assumed that the capacity of the GERD outlets is sufficient to enable any possible reservoir filling agreement**





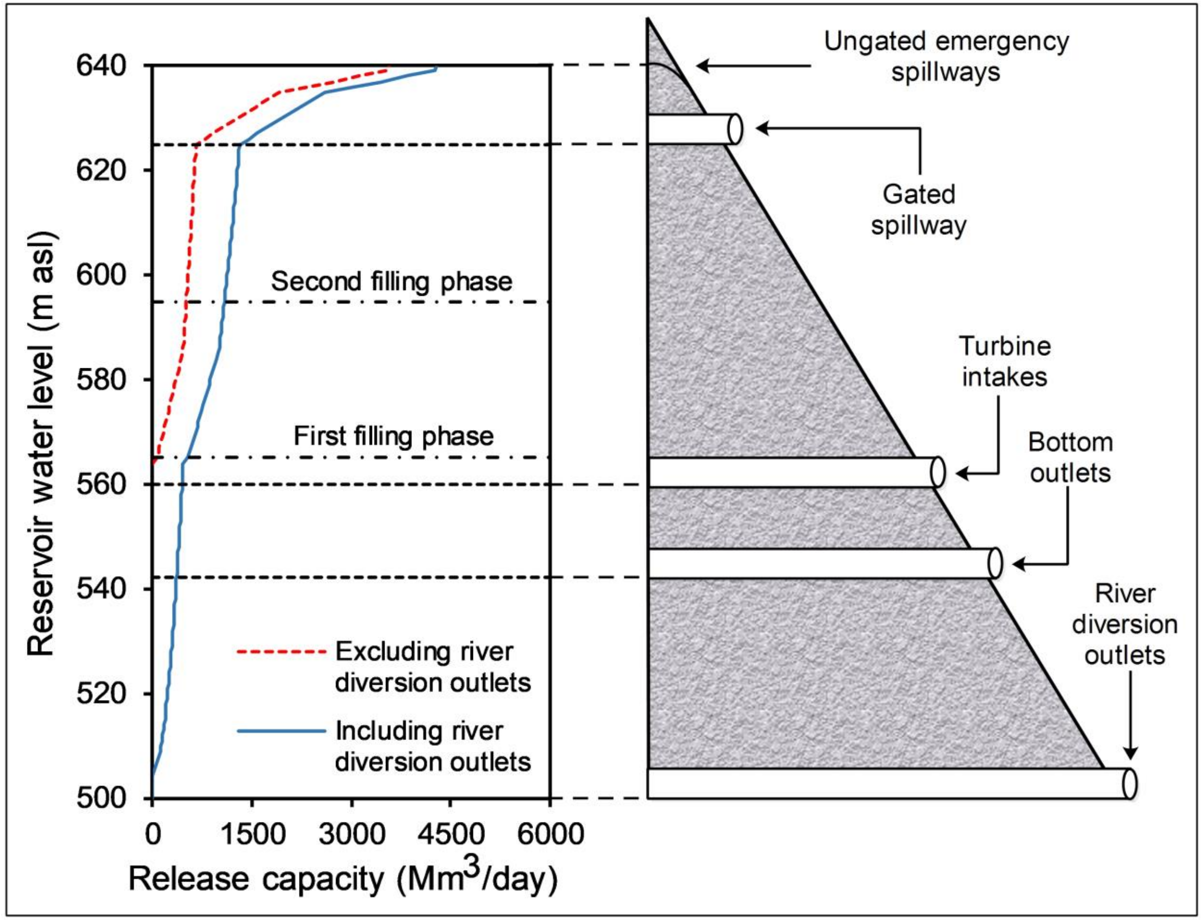
2- GERD engineering

- The GERD consist of three structural units:
  - Main dam
  - Spillway
  - Saddle dam
- The GERD has five types of outlets:
  - River diversion outlets
  - Bottom outlets
  - Turbine intakes
  - Gated spillway
  - Emergency spillway



2- GERD engineering

- The release capacity of the dam outlets increases with the water level.
- Only the river diversion outlets are available for use with a reservoir level of below 560 m asl



3- Methodology

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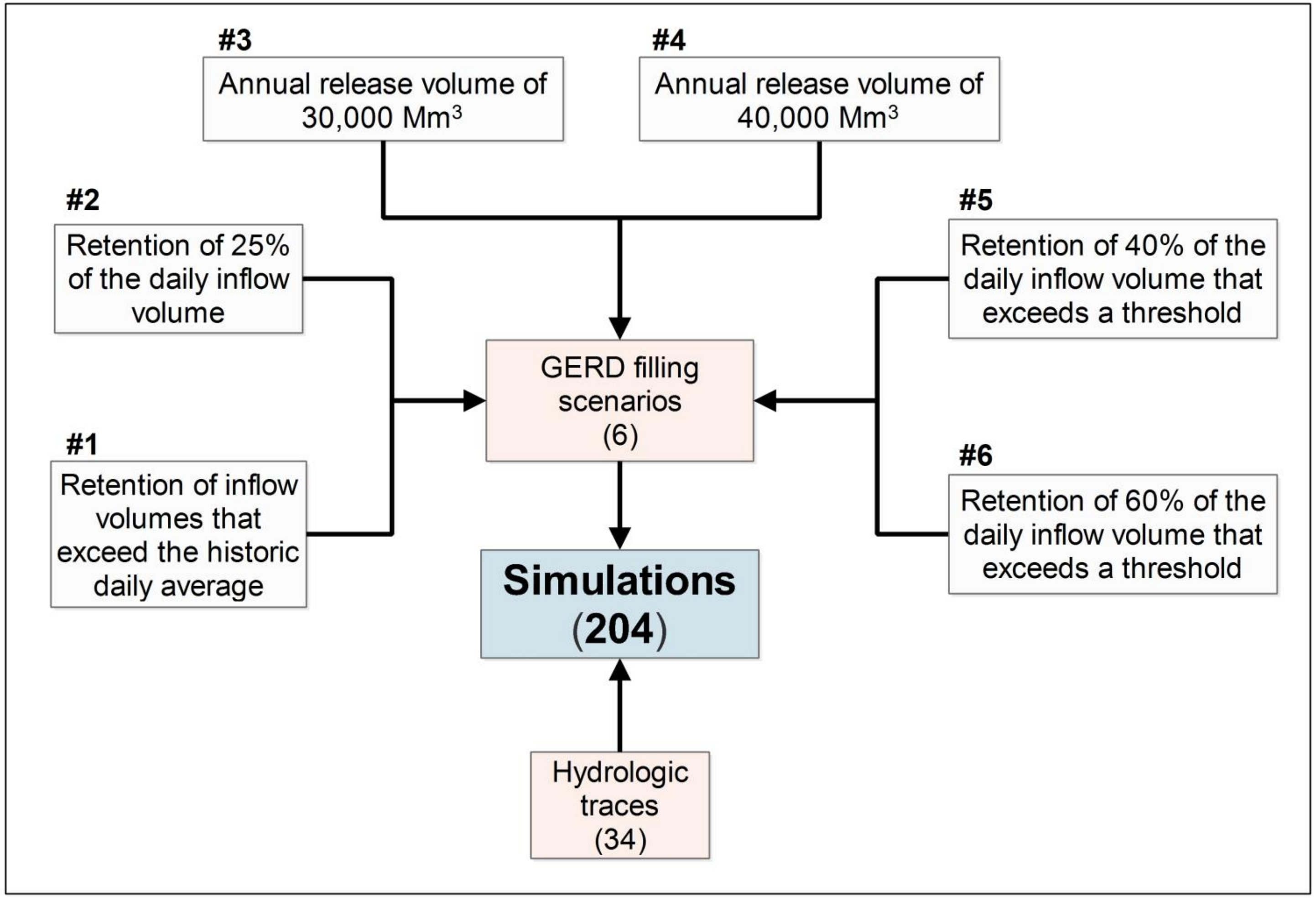
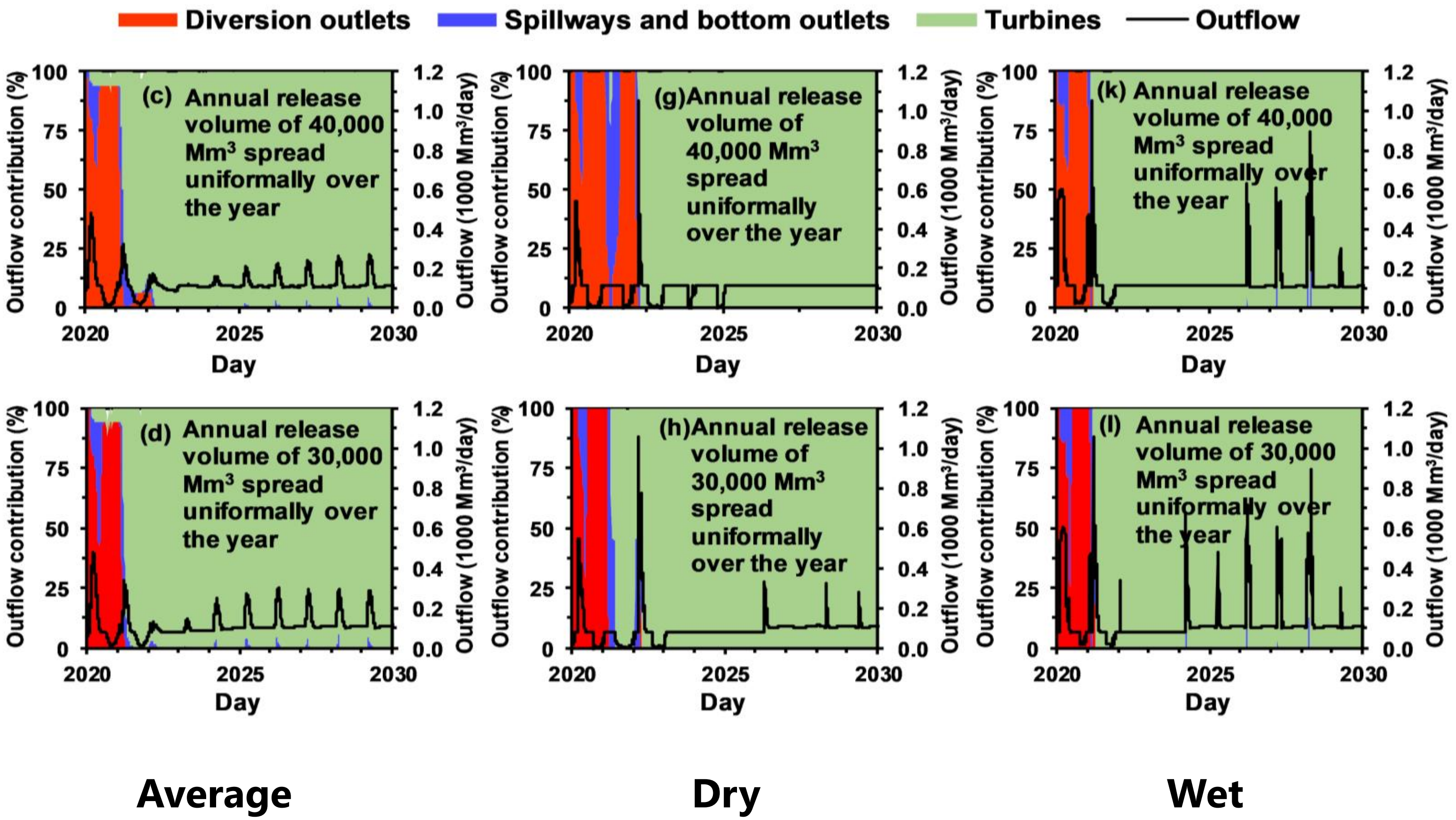
- We developed a daily water balance model for the GERD.
- Downstream releases from the GERD are constrained by outlet capacities.
- 34 hydrological sequences were generated based on the 1984-2017 flow record using the index-sequential method.
- Six initial filling scenarios are examined.
- It is assumed that the GERD would target 1400 MW after the filling is completed.



4- Results

- The turbine outlets have enough capacity to provide downstream releases in the long-term.
- The river diversion outlets are essential during the early filling stages.
- The river diversion outlets are key to turbine phasing-in.
- **Caution: low-level outlets have hydraulic constraints**



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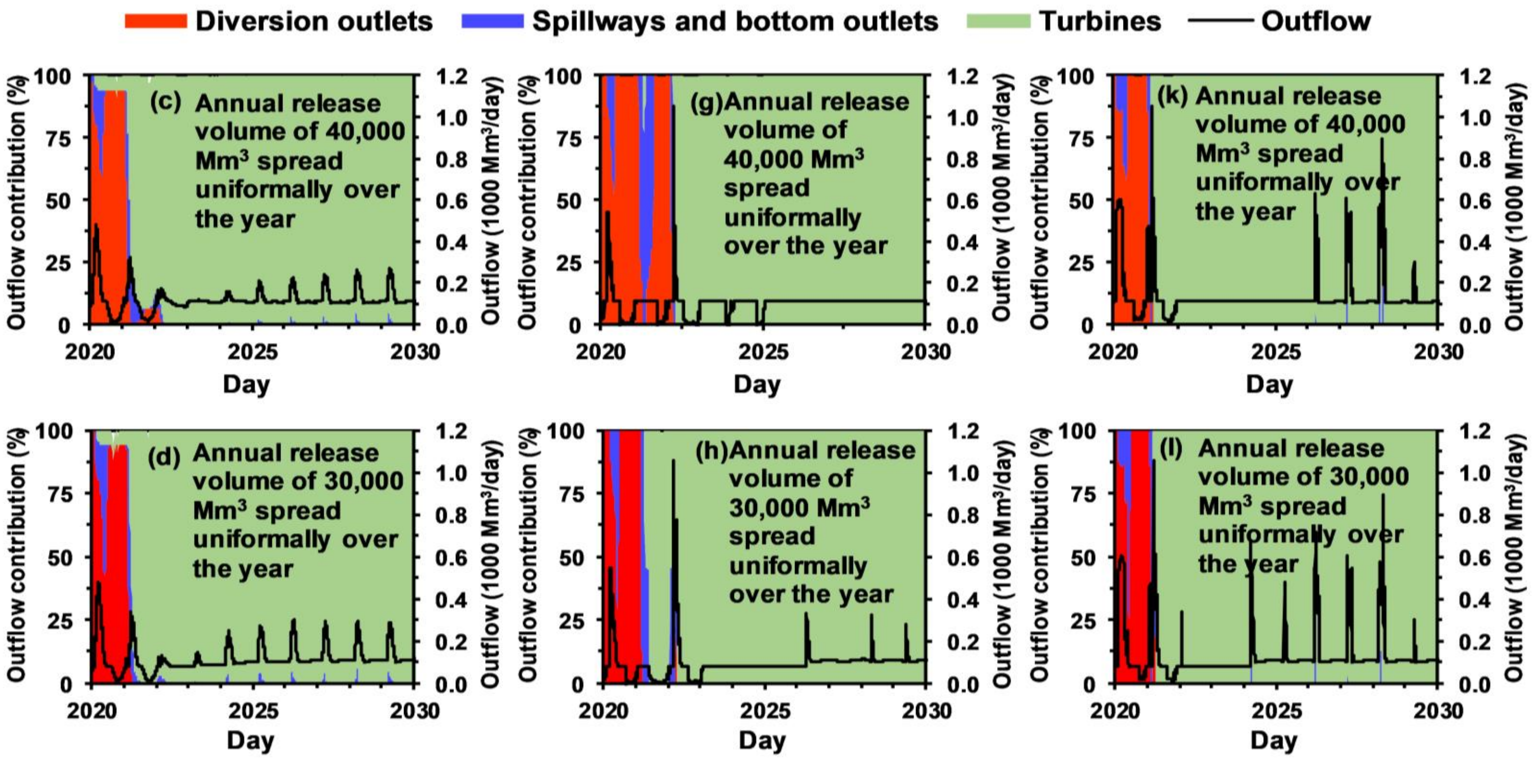
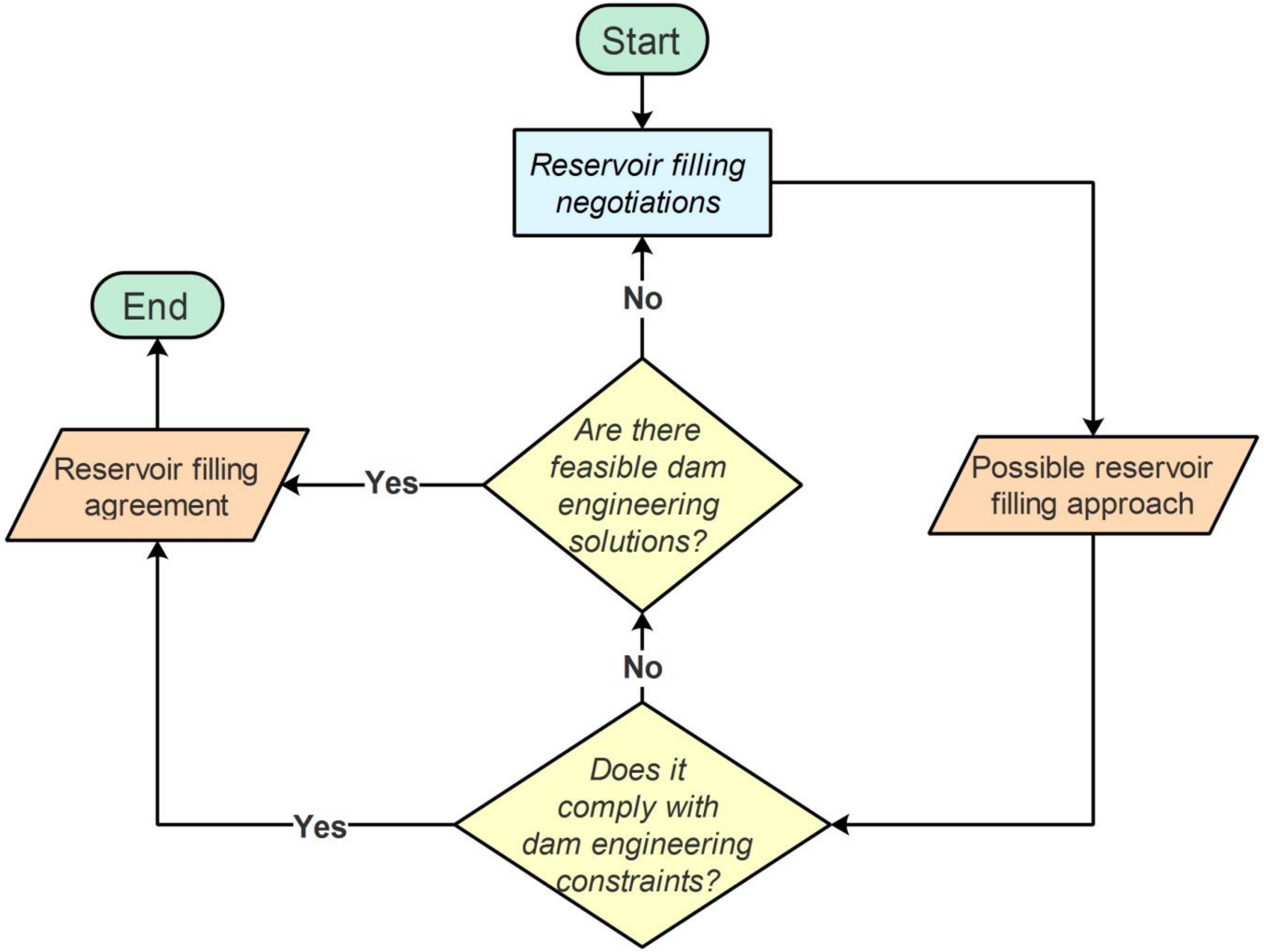
- ❑ Low-level outlets cannot make releases with high heads and flow speeds.
- ❑ This is to avoid excessive vibration and structural damage.



Average Dry Wet

5- Implications for the initial filling

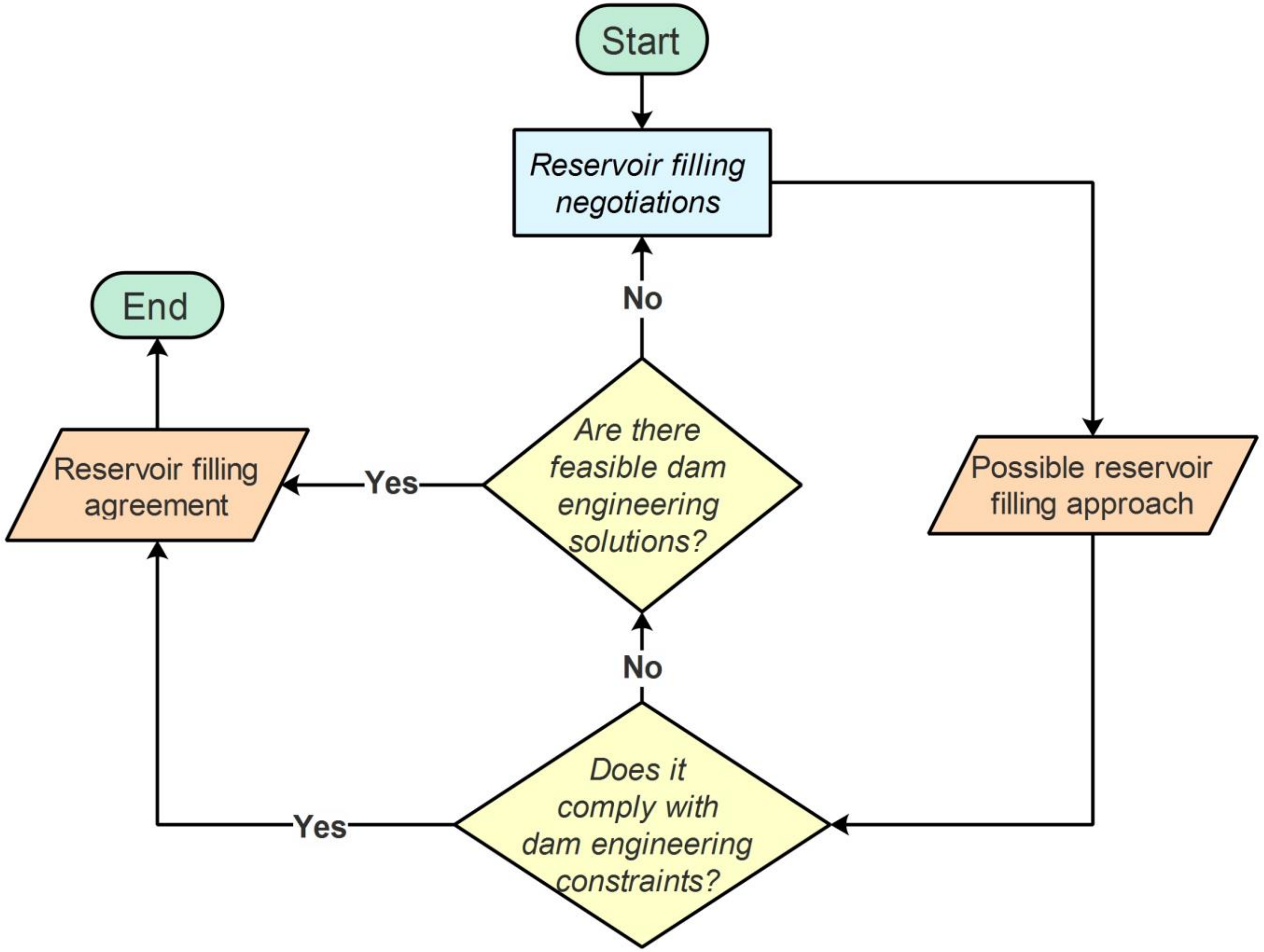
- The process of negotiation on reservoir filling should consider the dam engineering constraints.
- The process starts with negotiating a possible filling approach that maximizes the benefits and minimizes the costs to the relevant stakeholders.
- The resulting filling approach should be tested against dam engineering constraints.
- Compliance with dam engineering constraints results in a filling agreement



5- Implications for the initial filling

- In case the negotiated approach violates dam engineering constraints, engineering solutions could be explored for feasibility.

- This process would help avoiding last-minute changes to any possible agreement.



5- Implications for the initial filling

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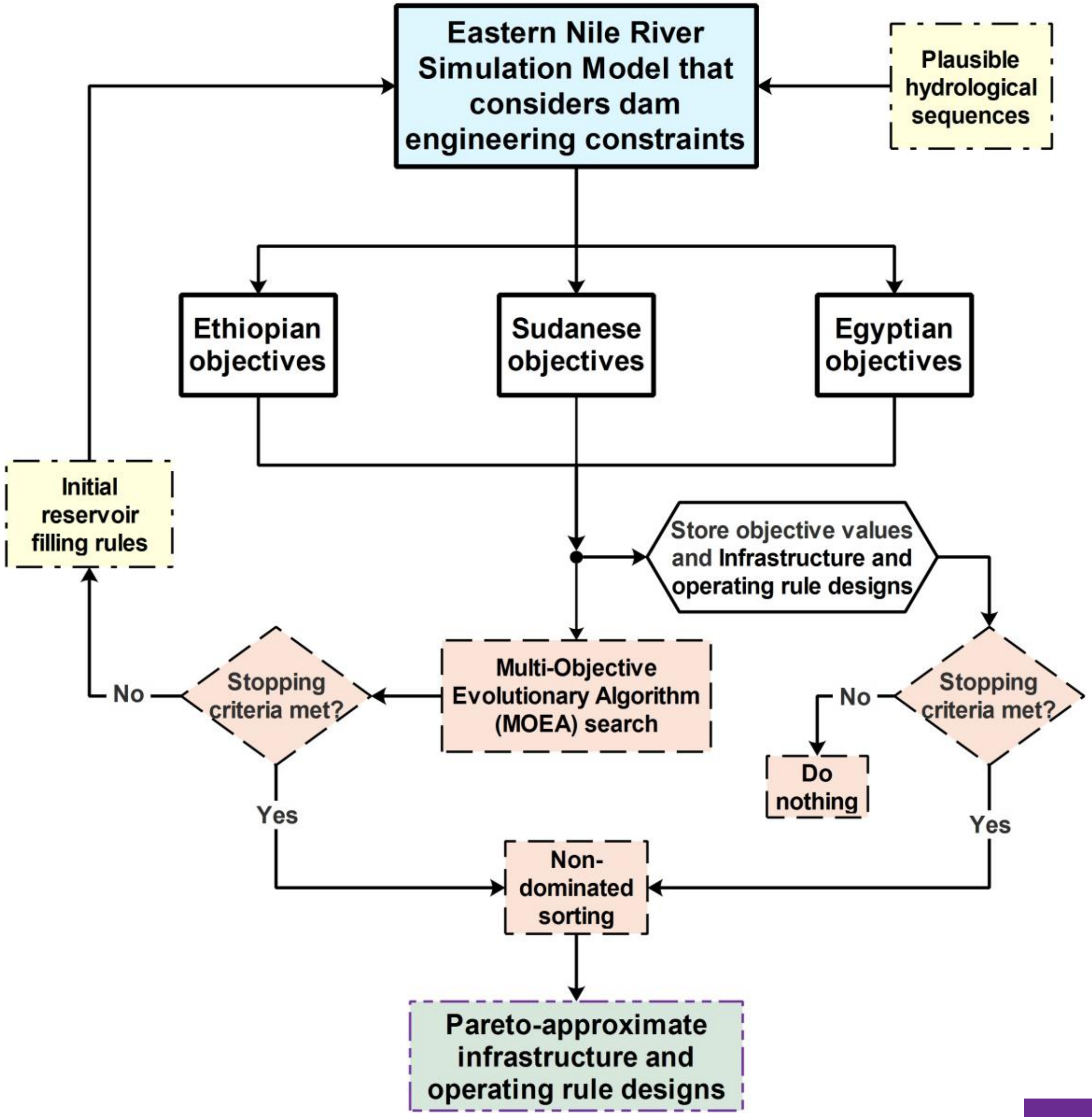
- Optimizing the initial filling and long-term operation should consider engineering constraints.

- A well designed simulation model could be coupled with a multi-objective search algorithm to optimization filling and long-term operation.



Thanks!