Nile Basin Initiative

Eastern Nile Technical Regional Office

Reservoir Filling Options Assessment For GERD

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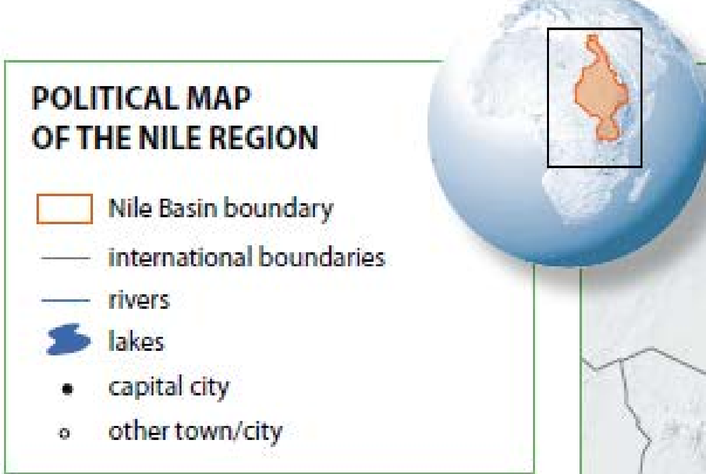
THE NILE



The Nile Basin

- Africa's largest river basin by area
- Area: 3.25 Million Km2 (10% Africa)
- Length: 6,695 Km (The longest in the world)
- Main Tributaries: **White Nile & Blue Nile**
- Population: 232 Million (with in NB)
- Mean annual discharge 84 BCM
- Huge Water Loss in the System
- Shared by 11 riparian countries

By way of comparison

Colorado River Basin	Nile River Basin
40 Million People	238 Million
7 States + 2 Countries	11 Countries
18.5 BCM/year	82.5 BCM/year
462 m^3/person	347 m^3/person
#1 Use = Agriculture	#1 Use = Agriculture

Trans-boundary Management Agreements	
1922 - Colorado Compact	No Basin-wide Agreement
1944 – USA/Mexico Treaty	
1948 - Upper Basin Compact	

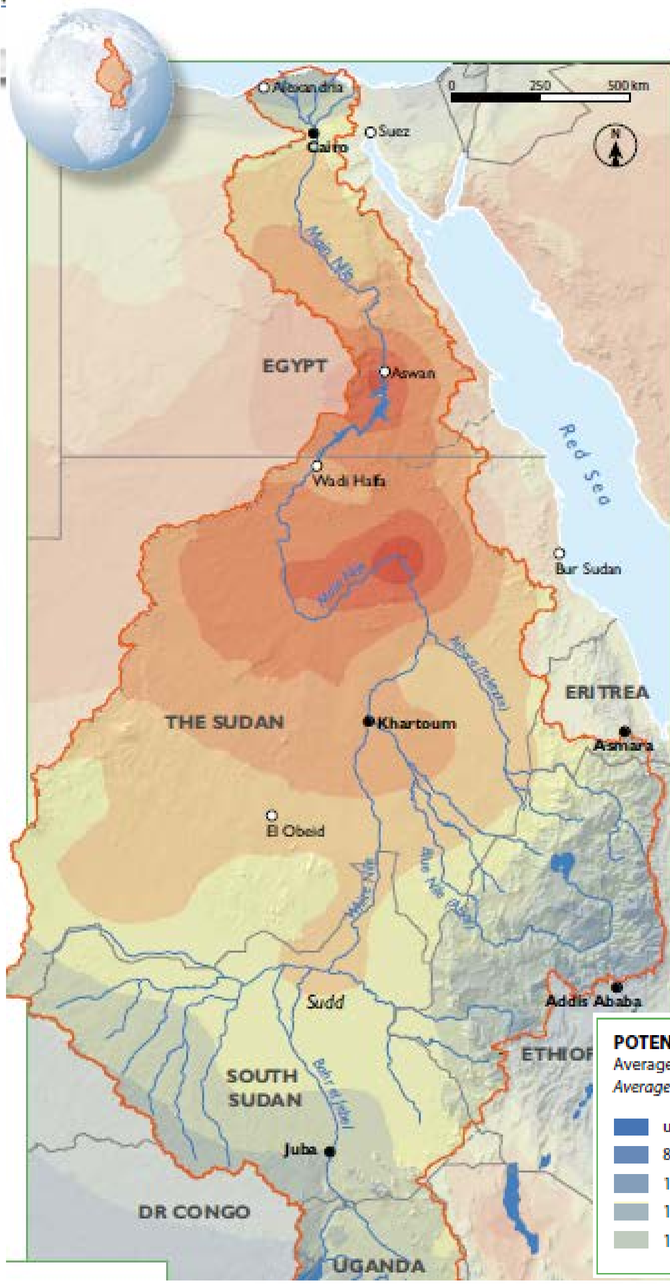
Ref: Kevin Wheeler Riverware users group presentation 2013

Key Challenges in the Nile Basin

- Extreme Poverty
- Complex hydrology: High Seasonal and Inter-annual flow variability.
- Week Resilience to Climate Shocks and extreme events.
- Rapid Population Growth
- Environmental degradation
- Low land Productivity
- Lack of Management

Opportunities in the Nile Basin

- Untapped hydropower potential
- Potential for Power trade
- Potential for water saving and reducing system losses
- Potential for agricultural expansion(horizontal and vertical)
- Improved water availability with better management of the existing uses.

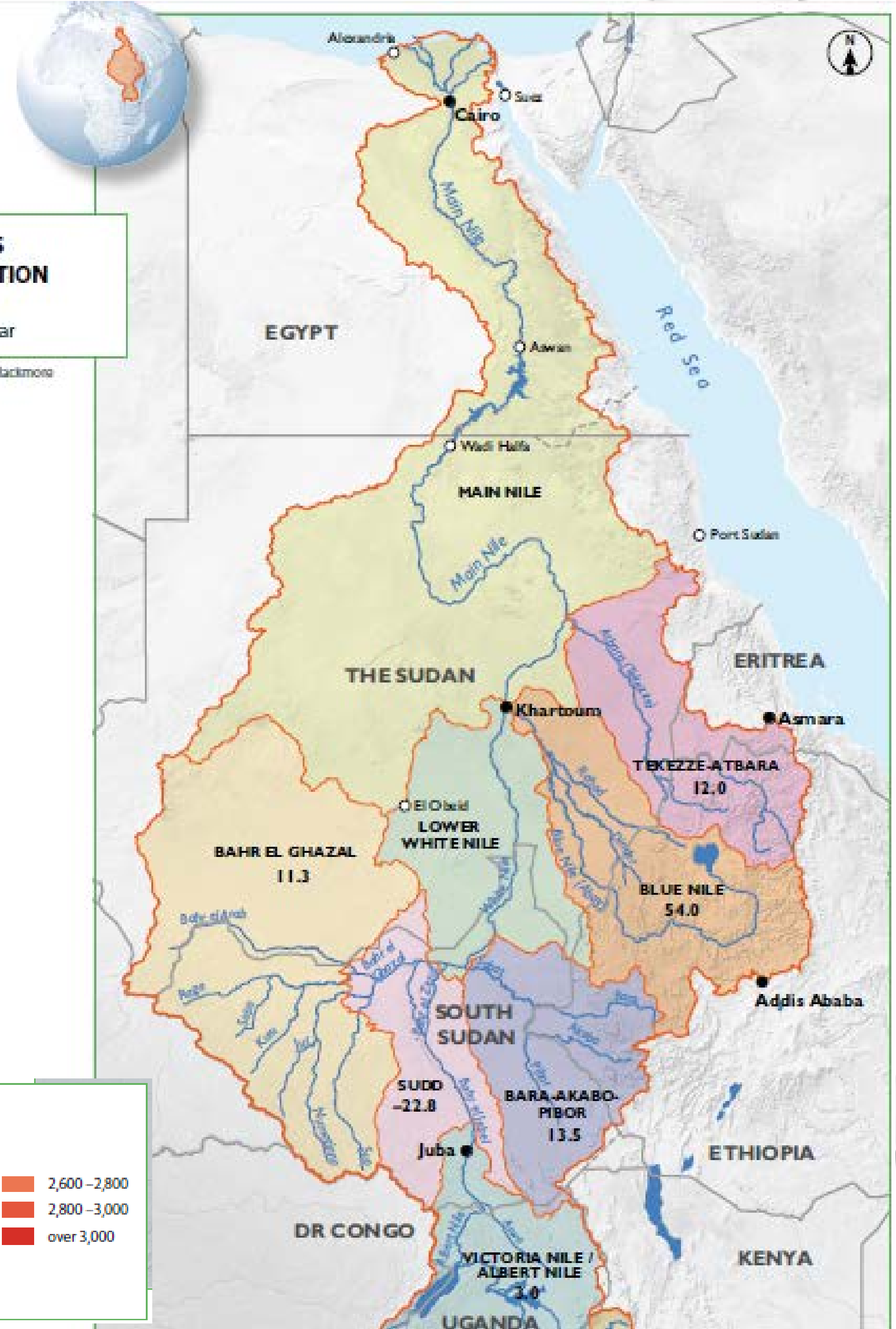


POTENTIAL EVAPOTRANSPIRATION
Average annual millimetres per year
Average values for 1960–90

under 800	1,600 – 1,800	2,600 – 2,800
800 – 1,000	1,800 – 2,000	2,800 – 3,000
1,000 – 1,200	2,000 – 2,200	over 3,000
1,200 – 1,400	2,200 – 2,400	
1,400 – 1,600	2,400 – 2,600	

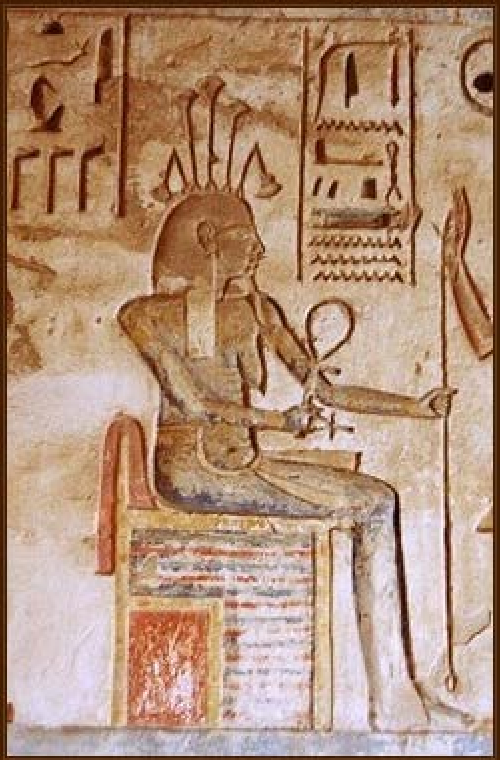
THE MAIN SUB-BASINS AND THEIR CONTRIBUTION TO THE NILE
billion cubic metres per year

lap prepared by the NBI; source of data: Blackmore
ld Whittington 2008)



The Story line

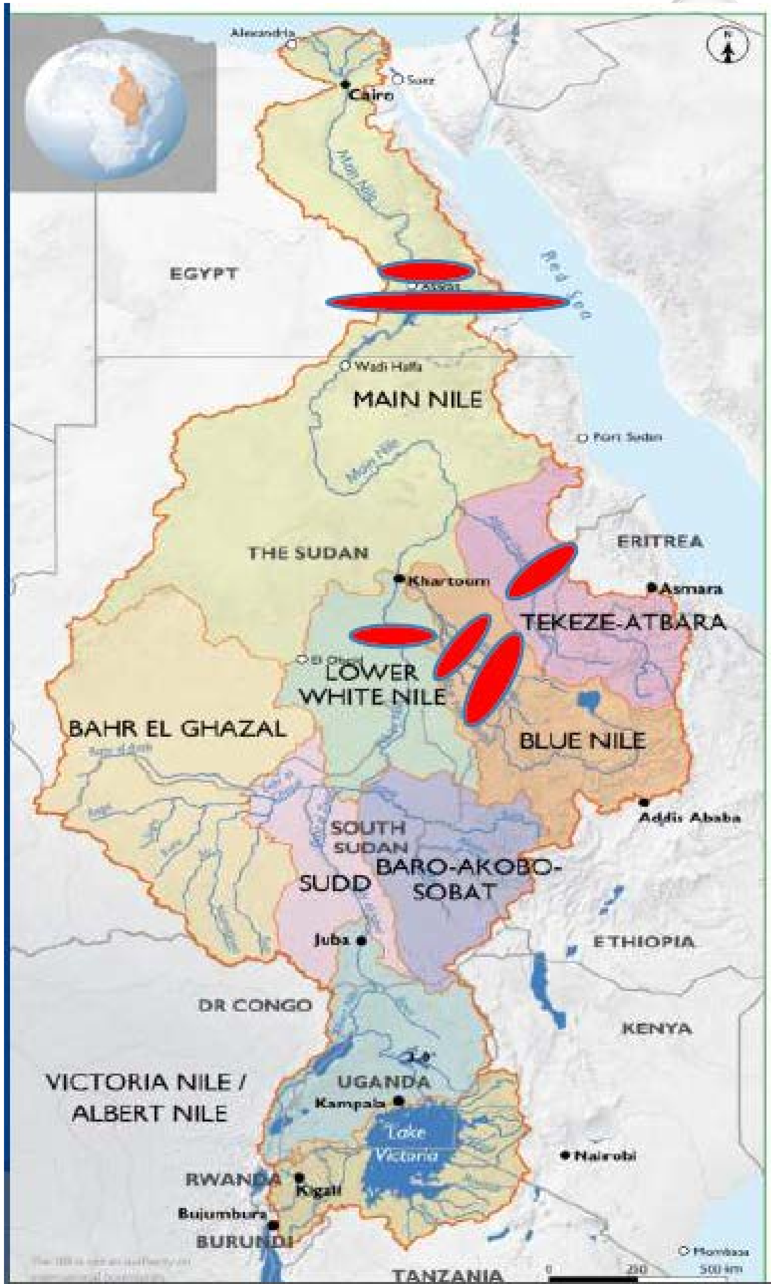
- The Nile River was supporting civilizations since ancient times.



Hapi - The Nile God

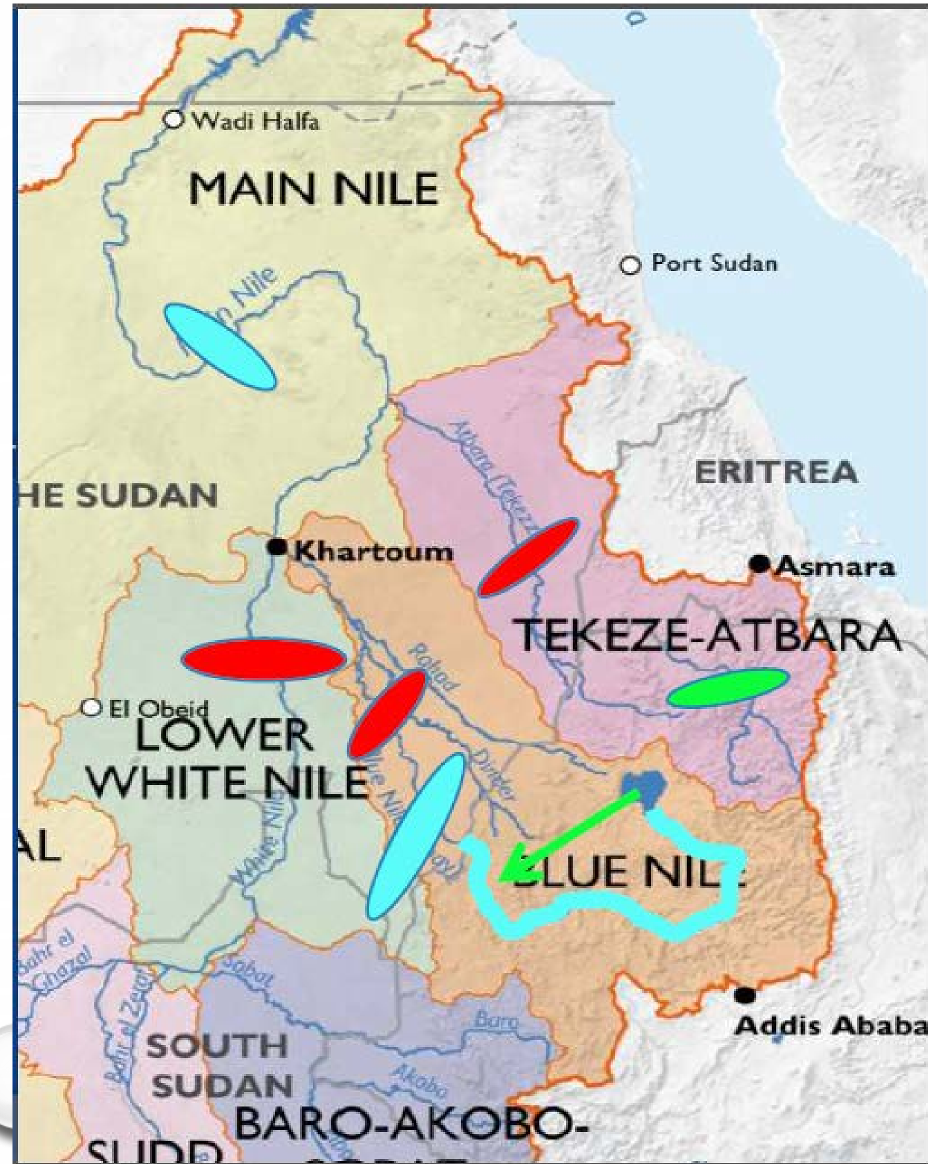
The Story line in the Easter Nile

- In 1902 the First Structure on the Nile the Low Aswan Dam was built in Egypt.
- 1925 - Sennar Dam (Sudan)
- 1929 - Egypt- Britain Treaty
- 1937 - Jebel Aulia Dam (Sudan)
- 1959 Egypt- Sudan Treaty
- 1964 - High Aswan Dam (Egypt)
- 1965 - Khashm El Girba (Sudan)
- 1967 - Rosaries Dam (Sudan)
- 1964 – USBR Study “Land And Water Resources Of The Blue Nile Basin”



The Story line in the Easter Nile

- 1999 – The Nile Basin Initiative
- 2009 - Tekeze Dam (Ethiopia)
- 2009 – Merowe Dam (Sudan)
- 2010 - Tana-Beles Hydropower Diversion (Ethiopia)
- 2012 –10 m Heightening of Rosaries Dam (Sudan)
- 2011- GERD (Under Construction)
- 2012 – Rumella Berdana (Sudan)



Some facts about Great Ethiopian Renaissance Dam (GERD)

Grand Ethiopian Renaissance Dam	
Country	Ethiopia
Location	Benishangul-Gumuz Region
Purpose	Power
Status	Under construction
Construction began	April 2011
Opening date	July 2017[1]
Construction cost	$4.8 billion USD
Owner(s)	Ethiopian Electric Power Corp
Dam and spillways	
Type of dam	Gravity, Roller-compacted concrete
Impounds	Blue Nile River
Height	170 m (558 ft)
Length	1,800 m (5,906 ft)
Reservoir	
Creates	Millennium Reservoir
Total capacity	73×10^9 m^3
Power station	
Commission date	2018 (planned)
Turbines	16 x 375 MW Francis turbines
Installed capacity	6,000 MW(max. planned)
Annual generation	15,692 GWh Est

Source : EEPCO

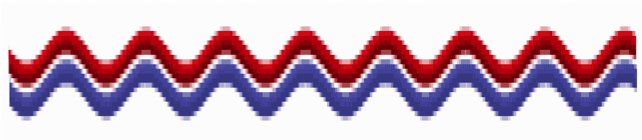
What are the major issues that needs to be considered ?

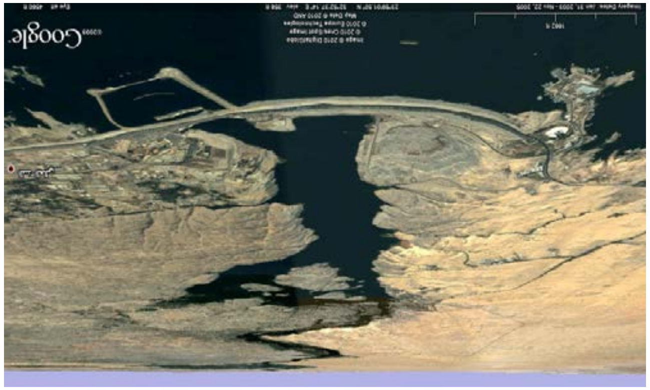
- How can we fill the reservoir in an optimal way while minimizing downstream impacts ?
- How can we operate the dam in the long run to minimize downstream impact but also generate optimal hydropower ?
- How can we optimize the benefit out of the Eastern Nile after the GERD is in place ?

What are the uncertainties involved ?

The Hydrology During the filling and the recovery period

Water Level of downstream Reservoirs at the start of the filling



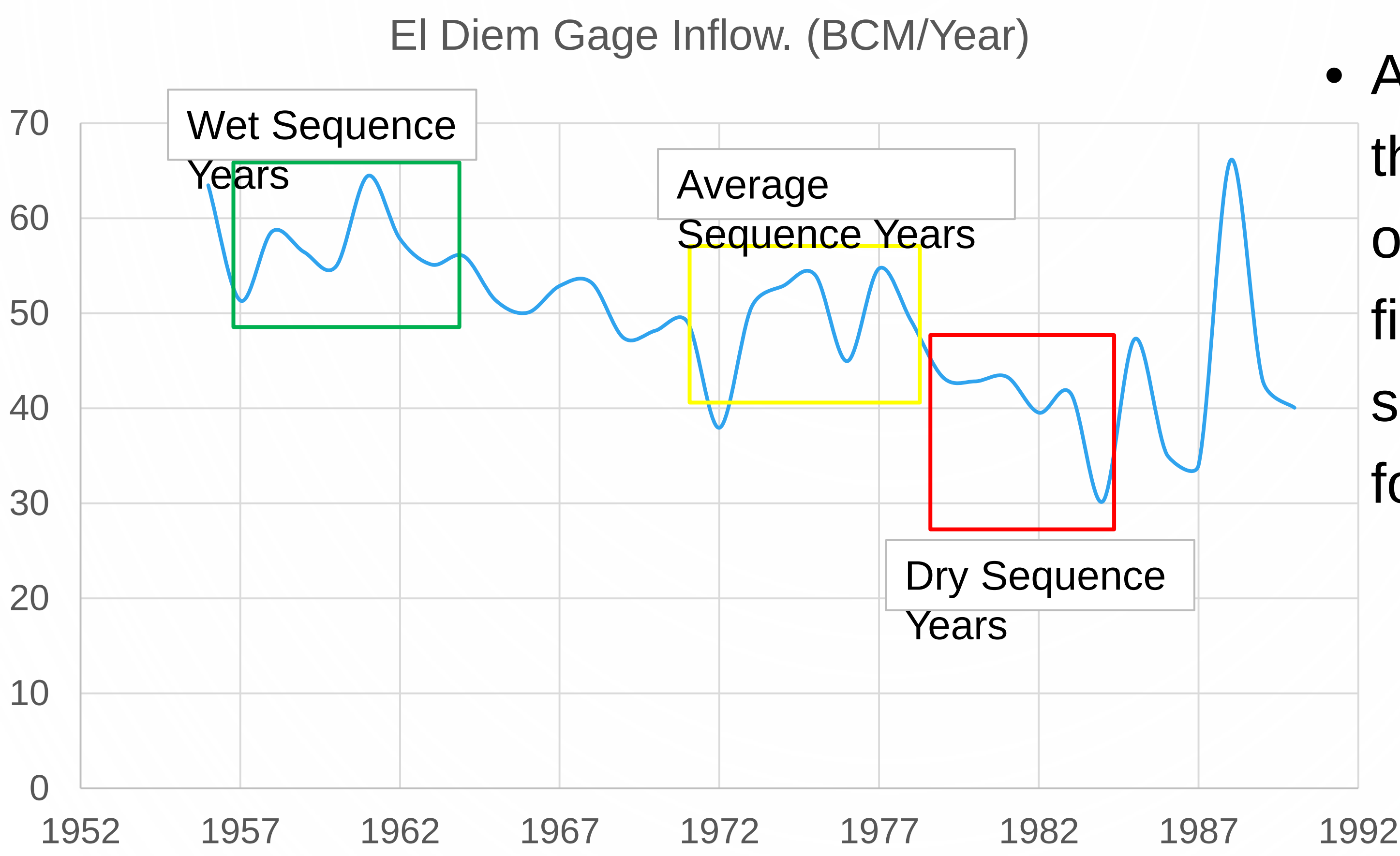


Filling Periods

Objective of this study

- To replace the classical method of evaluating the impact of filling under three hydrological conditions i.e. Wet , Dry and Normal or Average sequence of years.
- Provide the probability of
    - energy shortage, energy production,
    - water shortage, water saving,
    - water level drop in downstream reservoirs below a threshold value,
    - probability of meeting/not-meeting environmental flows, evaporation losses, etc. during the filling of the reservoir by running multiple traces of hydrology.

Classical Approach

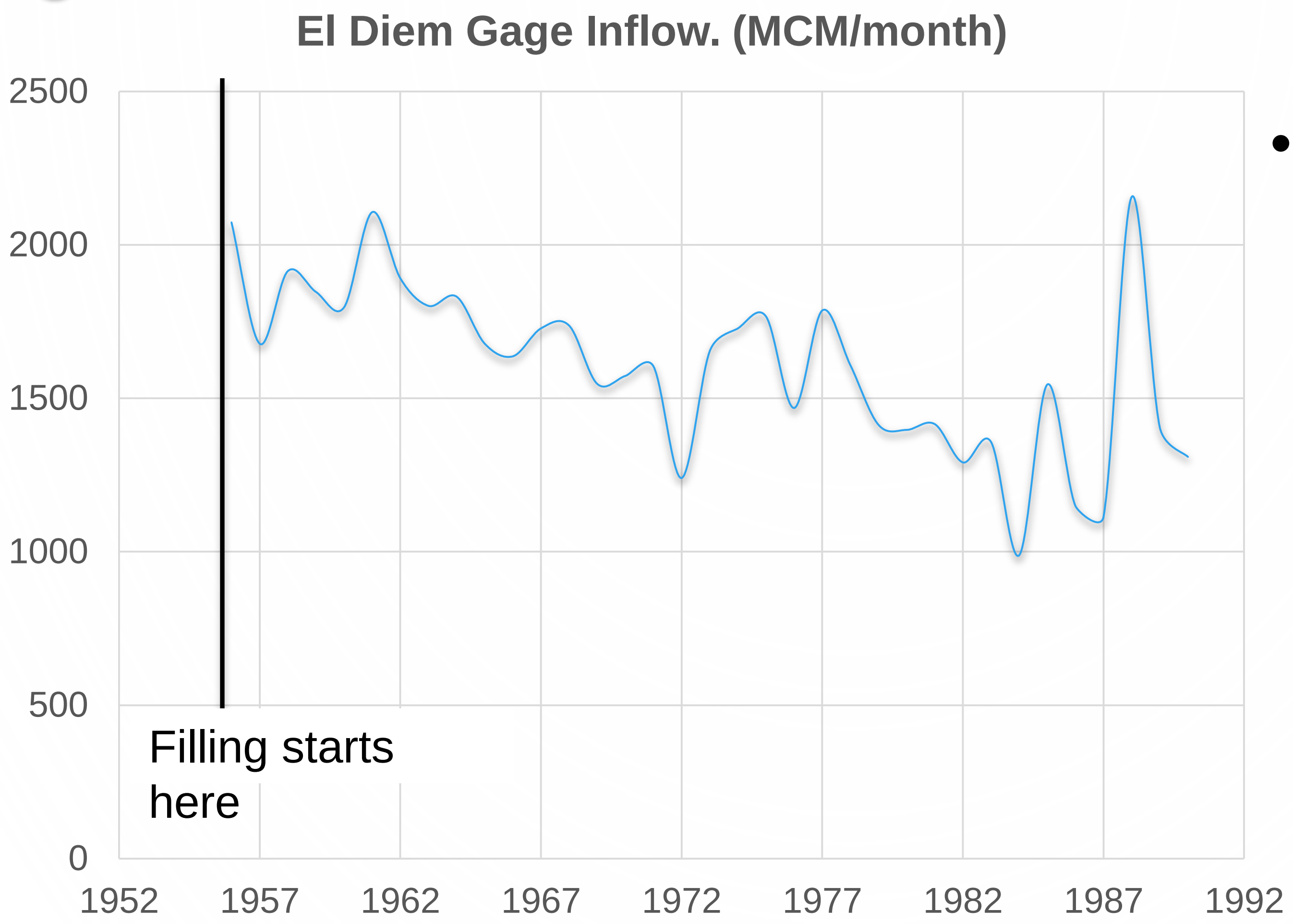


- Assumes this three conditions occur during the filling period for scenario formulation

What's the problem with this approach ?

- Decision makers are presented with extreme cases
- Can hinder the negotiation as each party is interested in one of the extreme cases.

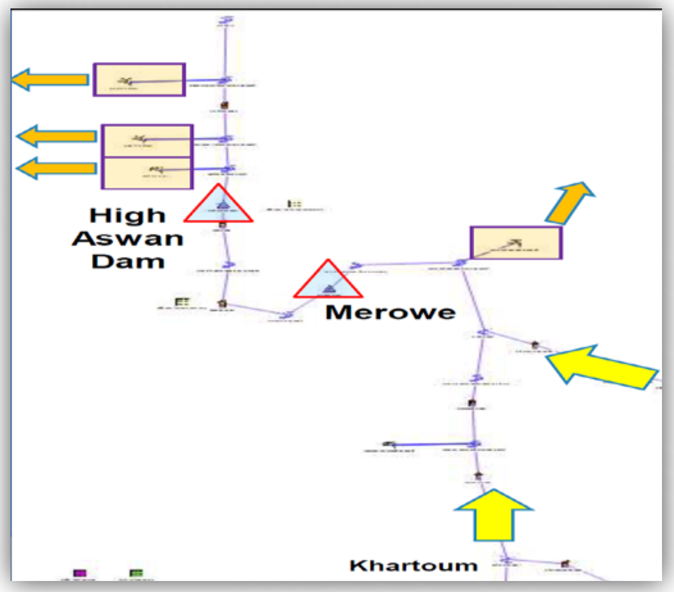
Approach followed by this study

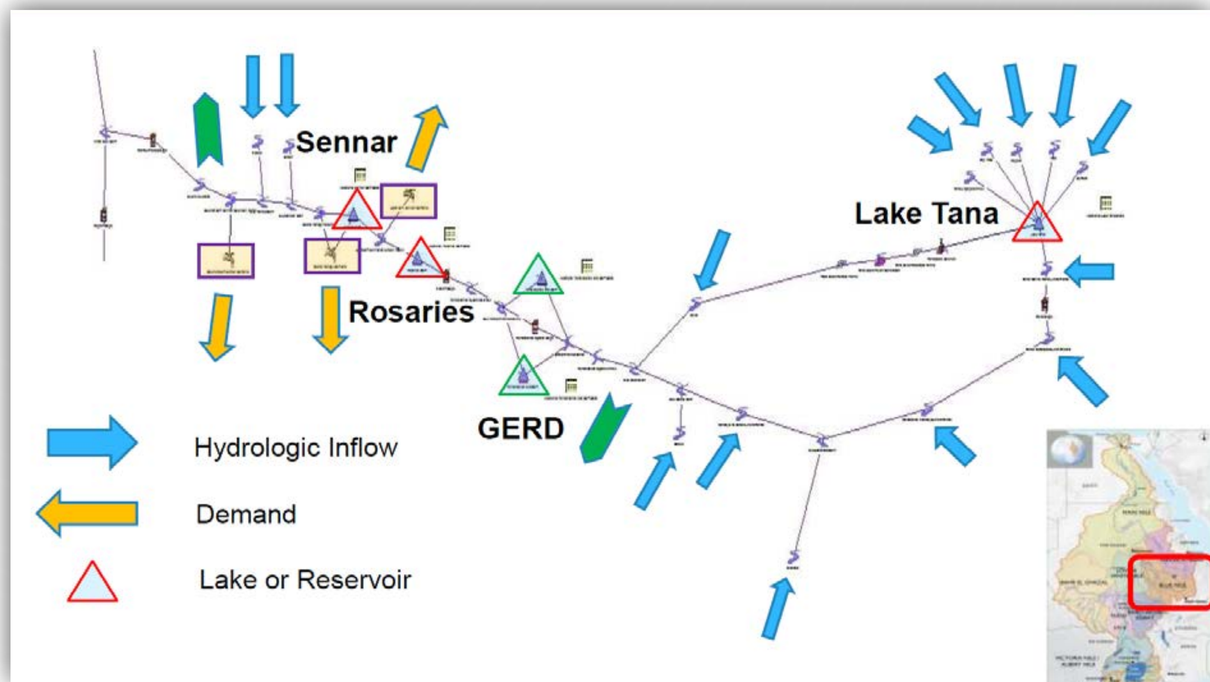


- Assumes the filling of the reservoir can occur at any point in time for the given time period.

Configuration of the model

- All the infrastructures and management rules has been incorporated in the model
- It covers the entire Eastern Nile Region
- Has been calibrated and used to study development scenarios by the Eastern Nile Technical Regional Office





Scenario development

- HAD WL 165
  - 5 years filling for GERD
  - 6 years filling for GERD
  - 7 years filling for GERD
  - → 35 Traces of Hydrological Scenario for Each Scenario
- HAD WL 170
  - 5 years filling for GERD
  - 6 years filling for GERD
  - 7 years filling for GERD
  - → 35 Traces of Hydrological Scenario for Each Scenario
- HAD WL 173
  - 5 years filling for GERD
  - 6 years filling for GERD
  - 7 years filling for GERD
  - → 35 Traces of Hydrological Scenario for Each Scenario
- HAD WL 178
  - 5 years filling for GERD
  - 6 years filling for GERD
  - 7 years filling for GERD
  - → 35 Traces of Hydrological Scenario for Each Scenario

A total of 525 Scenario runs have been carried out for this analysis.

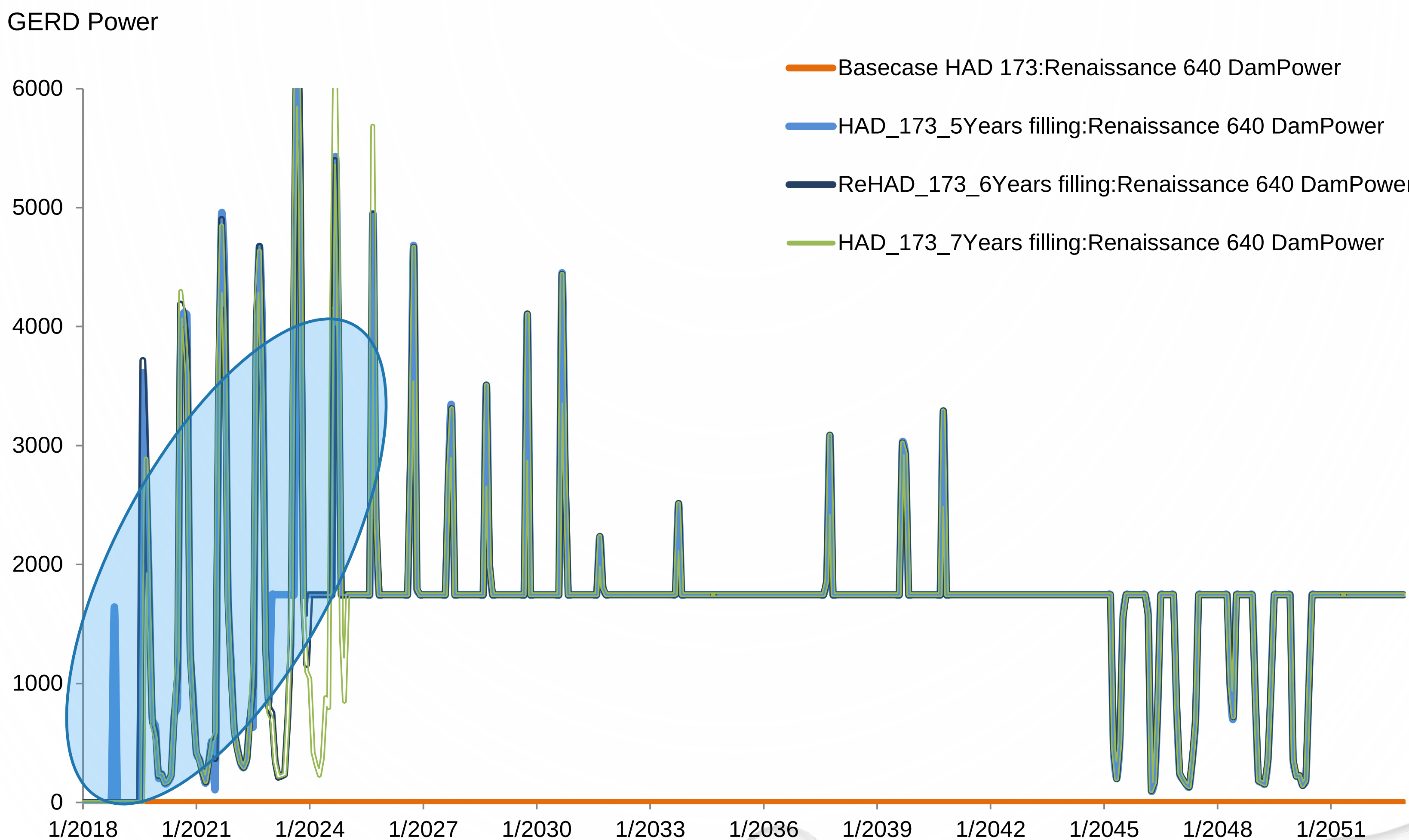
Looking at One Trace

Some of the analysis results are summarized and presented below.

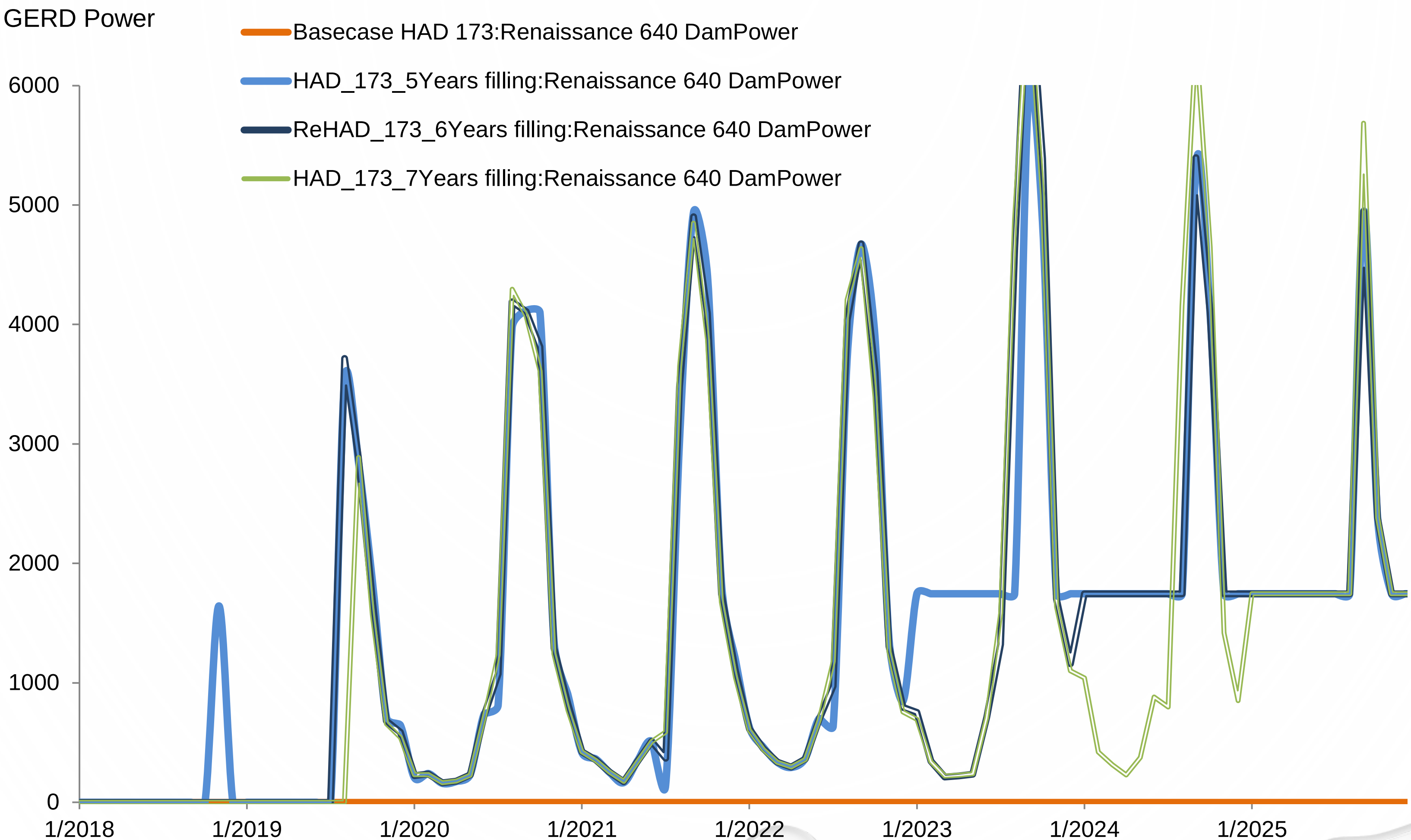
- Average annual percentage change of the three filling scenarios from baseline until the system fully recovered. (13 Years From the start of filling). 173 masl for initial water level of High Aswan Dam.

Parameter	Change from the current situation during the first 13 years from the start of impoundment.
Egypt hydropower production	8.34 % (Decrease)
Ethiopia hydropower production	400 % (Increase)
Sudan Hydropower production	14.47% (Increase)
Ethio-Sudan border (El-diem station) stream flow.	3.33 % (Decrease)
Nile at Aswan station stream flow	8.02% (Decrease)
Water released from High Aswan Dam	3.01 % (Decrease) * Assuming the operation of the Dam stays the same

GERD Power Generation Under the Different Filling



GERD Power Generation Under the Different Filling



Simplified economic analysis of the different Scenarios

from energy perspective only (Accumulated Seven years for one trace)

- The electricity selling price in the three countries are
  - **Egypt**: 0.0303 USD/KWh,
  - **Ethiopia** 0.0261 USD/KWh and
  - **Sudan** 0.03103 USD/KWh.
- Cost of shifting from 5 years filling plan to a 7 years filling plan from electricity point of view is 14,347.25 GWh multiplied by basin average cost i.e 0.02941 USD/KWh. Which is around **418 Million USD.**

Note: This analysis didn't assume any appreciation or depreciation in either the currency or the selling rates. And the selling price is much lower than economic value of electricity and this paper used selling price as a conservative approach

Energy in GWh	Basecase	5Years filling	6 Years filling	7 Years filling
Sudan Total Energy	61966.51	65840.37	63567.38	60833.74
Deviance From Base Case	0	3873.86	1600.87	-1132.77
Deviance From 5 Years filling			-2272.99	-5006.63
Deviance From 6 Years filling				-2733.64
Egypt from High Aswan	63688.42	54822.42	55690.4	56600.43
Deviance From Base Case	0	-8866	-7998.02	-7087.99
Deviance From 5 Years filling			867.98	1778.01
Deviance From 6 Years filling				910.03
Ethiopia	25776.15	112784.31	108729.95	101665.68
Deviance From Base Case	0	87008.16	82953.8	75889.53
Deviance From 5 Years filling			-4054.36	-11118.63
Deviance From 6 Years filling				-7064.27
Over All Basin Energy	151431.08	233447.1	227987.73	219099.85
Deviance From Base Case	0	82016.02	76556.65	67668.77
Deviance From 5 Years filling			-5459.37	-14347.25
Deviance From 6 Years filling				-8887.88

Looking at agriculture from one trace (average)

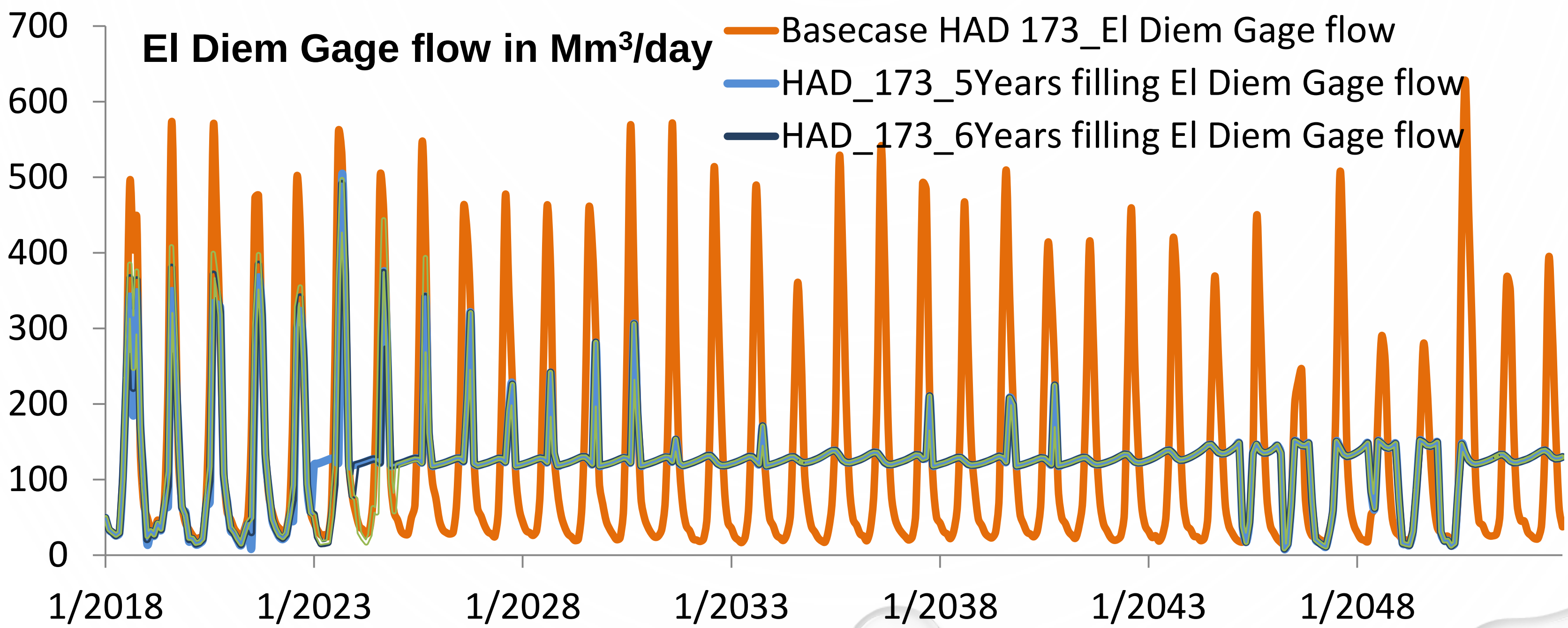
Average annual system shortage in the Main Nile in MCM and associated loss in Million USD. Given as the 13 years average from the start of the filling for the three filling scenarios from baseline until the system fully recovered. 173 masl for initial water level of High Aswan Dam.

Scenario	Average annual system shortage in the Main Nile in MCM.	Average annual value of the agricultural loss in Million USD
Current Situation (Base-case)	0	0
5 Years filling strategy for GERD	129.208	69.612
6 Years filling strategy for GERD	59.1667	31.876
7 Years filling strategy for GERD	0	0

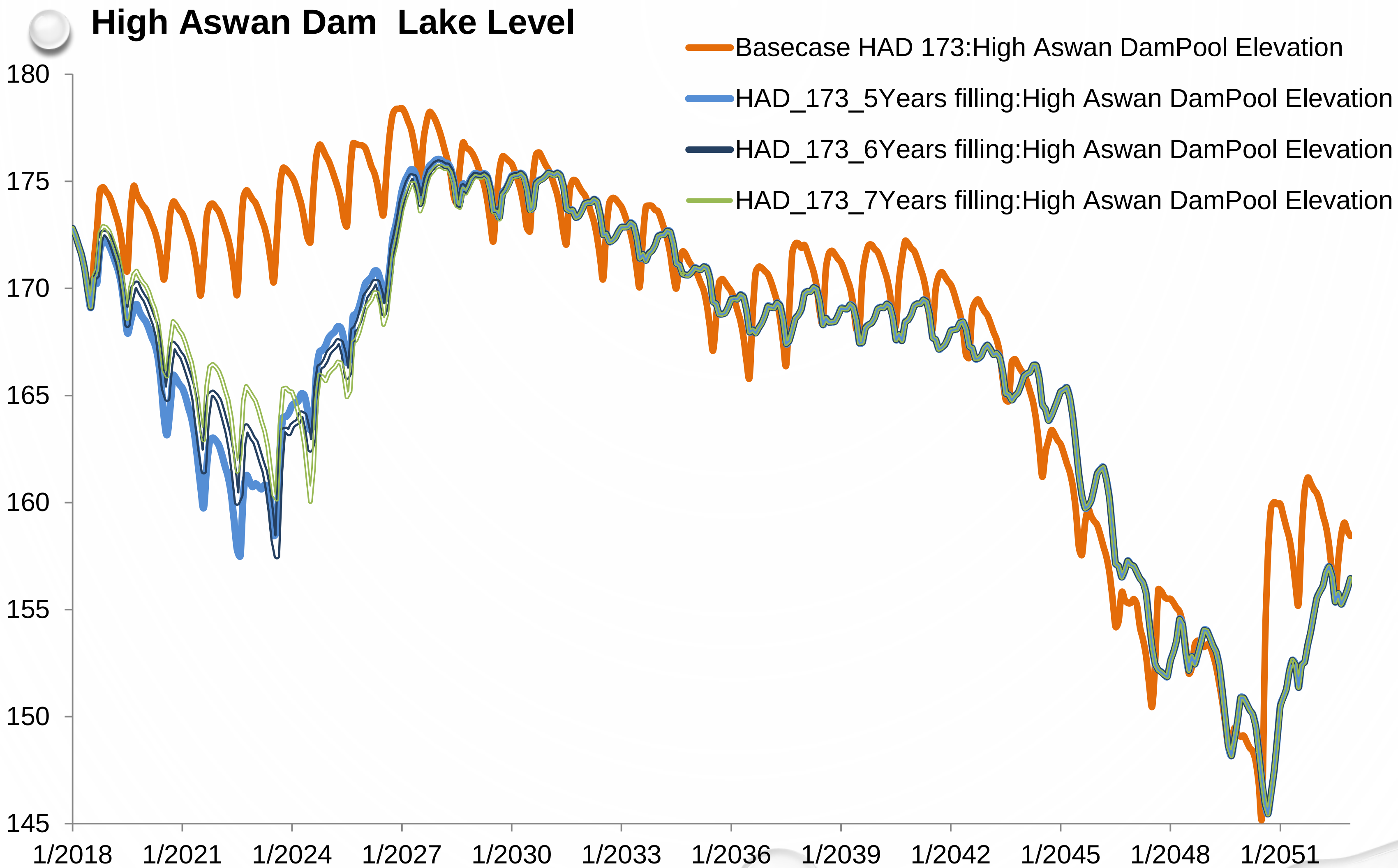
The Agricultural Production Value for Egypt was extracted from FAOSTAT. Net agricultural production of Egypt (for 2012) is 21.901 Billion USD.

Looking at Flood from One Trace (average)

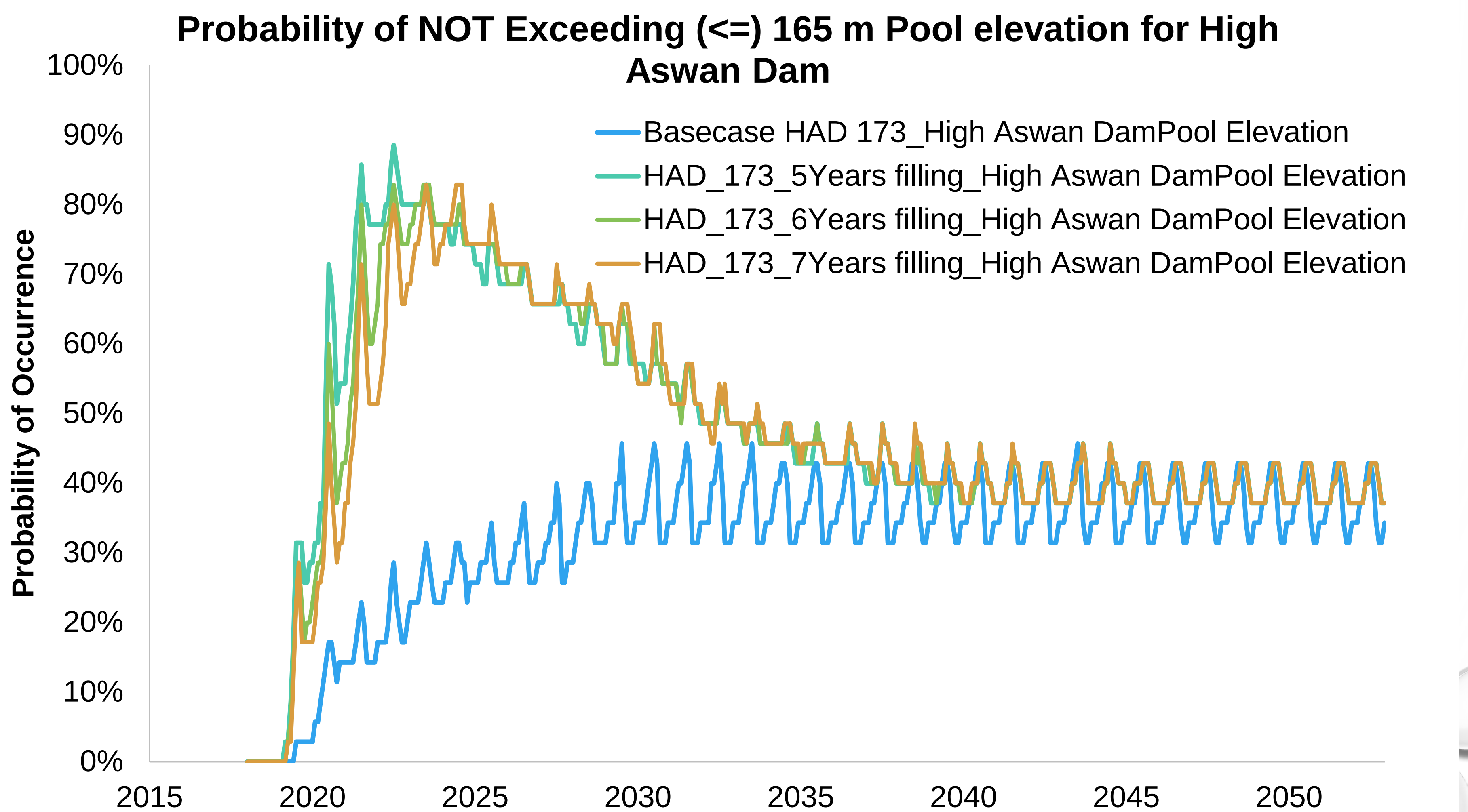
- The estimated average annual damage in rural villages riparian to the blue Nile and Main Nile in Sudan is about 25.77 million USD. After regulation the risk of flood damage in Sudan is almost completely eliminated
- **Note: benefits of the flood plain has not been considered in this analysis**



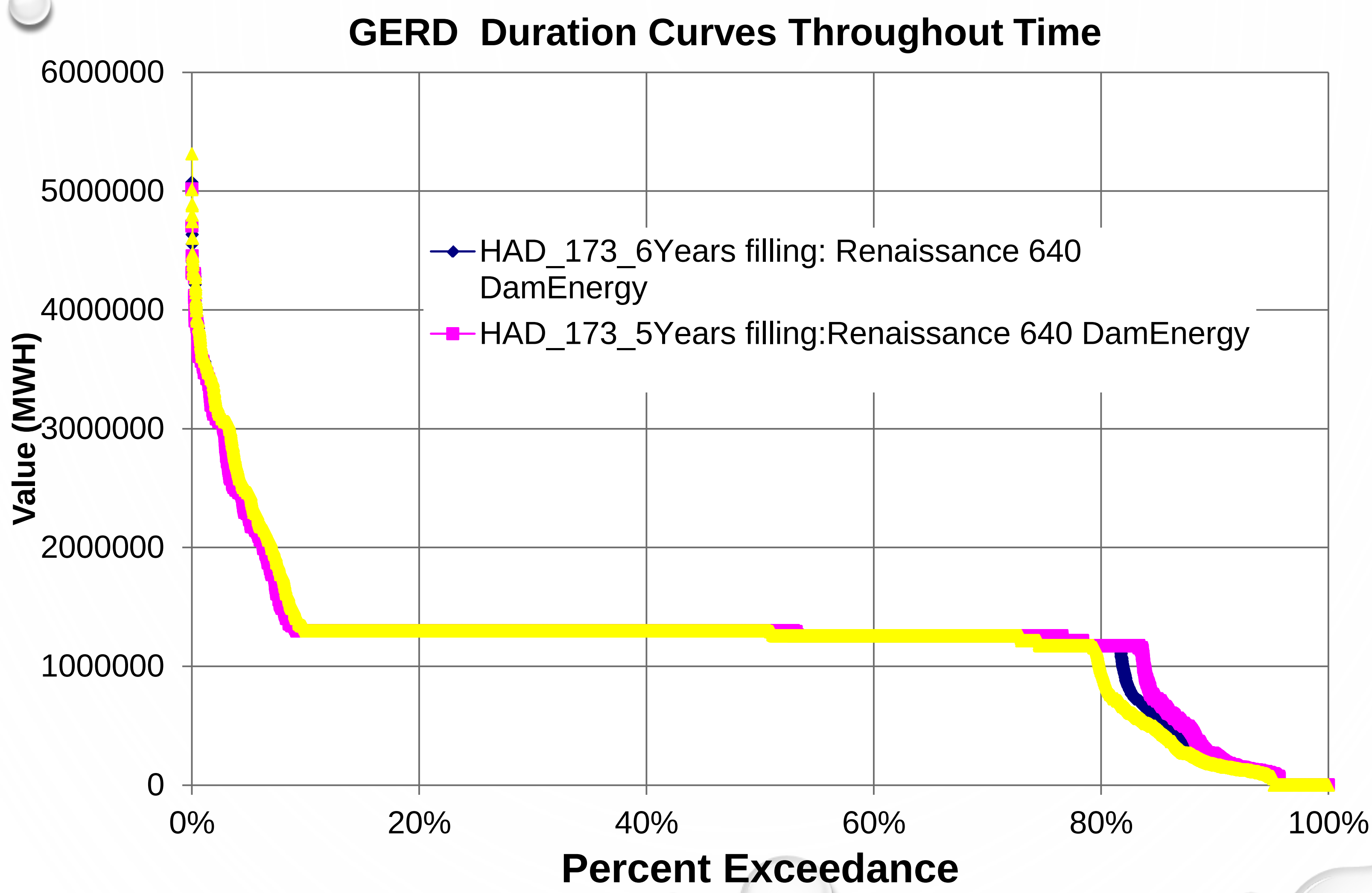
Looking at one structure from one traces



Looking at one structure from all traces (probabilistic plots)



Looking at Cumulative distribution functions for all traces



To conclude…..

- There is a systematic way of addressing the concerns regarding the filling and long term operation of the GERD.
- Downstream impacts can also be managed and well-studied with an all-inclusive process using tools like Riverware and such.
- All the risks and opportunities need to be well understood by all parties
- The long term benefits as a climate shock absorber, flood risk mitigation tool and more importantly a power hub in the region is reflected in the analysis results.
- The Seasonality of the river will be highly reduced which could have positive and negative consequences.
- Riverware because of it’s unique capabilities can serve as the negotiation platforms for the filling and operation of the dam.

Thank You,

Questions ?