International Journal of Nile Basin (IJNB)
Energy, Water, Environment & Economic

Volume 3; Issue 5;
December 2019, Page 1-11

Grand Ethiopian Renaissance Dam (GERD) Filling Scenarios: Analysis of Energy and Revenue losses

Dr Mintwab Bezabih[1]* and Dr Belachew Tesfa[2]

1. Introduction

In 2011, Ethiopia began building the Grand Ethiopian Renaissance Dam (GERD) on the Blue Nile River in a place called Guba, 60 kilometres from Sudan mainly for the electric power generation. In addition to the electric power supply, GERD benefits the downstream countries mainly Sudan and Egypt by removing up to 86% of silt and sedimentation, regulate the steady water flow throughout the year, avoid un-expected flooding to downstream countries and also conserve the water in Ethiopian highlands by having lower evaporation and water recycling mechanisms (Tesfa, 2013).

The status of the project has been such that the two turbines in the left powerhouse were half completed, and could start generating 740MW of hydroelectric power as early as 2020 and the entire project is now 68% completed (Belay, 2019).

In terms of cooperation with downstream countries, a series of discussions between Ethiopia, Sudan and Egypt have been progressing, with the principles of filling GERD being one of the top most agenda. of the tripartite talks are being out in Washington DC, Cairo, Khartoum and Addis Ababa. So far, while the discussions have constructive tones, the three countries are yet to reach a joint agreement on the length of time it should take GERD's reservoir to be filled.

An important piece of information that could aid the negotiation process is quantifications of the losses and gains (if any) from delaying the filling. For such purposes, understanding the gains/losses from a dam like GERD in different scenarios is important. Accordingly, the purpose of this discussion note is quantifying the losses in terms of energy/power and revenue across different filling scenarios, using financial and cost benefit analysis method. The note will answer what is the optimum year to fill the dam given circumstances with the assumption of wet, normal, dry and extreme dry scenario.

2. Literature review

On GERD filling policy number of academic papers have been published and workshops have been carried out. Strzepek (2015) had evaluated the effects filling policy for both Ethiopia and Egypt using Montecarlo modelling risk based approach. He evaluated four rates of filling: unconstrained, 3 years, 5 years and 10 years scenarios. He concluded that, for Ethiopia, slowing the GERD filling will loss hydropower revenues & repayment and slowing of economic growth. However, the economy-wide impact on Egypt are very minor due to substitution in the economy

[1] Economist, Policy Studies Institute, Addis Ababa, Ethiopia; Corresponding Author, mintibezabih@gmail.com
[2] Chartered Engineer, EIPSA, United Kingdom, contact@eipsa1.com

and limited role of water in GDP. But impacts on low income and farmers is a very politically volatile segment for Egypt.

The potential impact of the water resources due to GERD have also been investigated using SOBEK model by Abdelhaleem and Helal. As per the authors reducing Egypt water use more than 15% induces superficial effects on the drinking water stations, by 10% induces no effect on the irrigation, and industrial pump stations and by 5% produces small effect on the safe navigation (Abdelhaleem and Helal, 2015).

By employing a multi-region and multi-sector computable general equilibrium (CGE) modelling framework Kahsay et al (2015) reported the direct and indirect economic impacts of GERD on the Eastern Nile economies evaluating the impact of the dam under three different climatic and hydrological scenarios, taking into account both the transient GERD impounding phase and the long term operation phase. They concluded that that the GERD offers several benefits to all the Eastern Nile countries and would not inflict significant harm on the downstream countries. Sudan has, but also show that some negative effects for Egypt may be expected during the impounding phase for dry scenario.

Wheeler et al analysed the strategies for filling the GERD and implications for downstream water using a river basin planning model with a wide range of historical hydrological conditions and increasing coordination between the co-riparian countries. The analysis finds that risks to water diversions in Sudan can be largely managed through adaptations of Sudanese reservoir operations. The risks to Egyptian users and energy generation can be minimized through combinations of sufficient agreed annual releases from GERD and a drought management policy [Wheeler et al].

Almost all of the reviewed researchers have agreed, GERD does not cause any significant harm in filling in 5-7 years. Most of previous studies were focused on the power loss due to the filling policy. However, in addition to the power loss, the delay in the dam feeling will cause additional cost such as silt removal cost, operation overhead costs, maintenance cost, repayment (depreciation costs) and social cost benefits.

3. Methodology

Analytically, of the paper involves the approach of assessing energy and revenue losses. The alternative filling years are coupled with the hydrology and filling demand matrix to compute the energy/revenue losses corresponding to the conditioning the four scenarios.

Table 1. List of assumptions

Parameter	Value	Source
Total power generated from GERD (GWH)	15692	Current GERD project office report
Price of power ($/kwh)	0.07	Market research
Energy loss associated with delayed filling	Based on year dependent energy loss equation	Model based predication

The benefits of the project mainly consists of the value of the electricity produced throughout the dam's lifetime. The GERD has a production capacity of 15,692 GWh and is projected to output an average annual revenue of 1.1billion USD per year, with energy expected to be sold at $0.07 USD/GWh. Unlike previous dams in the country, this one is mainly meant to export energy to neighbouring countries particularly the Sudan and South Sudan. The revenue associated with energy loss is calculated based on the energy loss equation in accordance with the GERD's estimated energy loss patterns associated with the filling schedule.

4. Results and Discussion

The analysis in this note focuses on the impact of choice of filling years on energy generation and the yearly flow of energy and revenue losses

An essential element of the filling schedule is that it is governed by natural outcomes associated with the availability of water. Hydrologically, these outcomes are categorized as the extremely dry, dry, moderate (normal) and wet outcomes, which in turn are governed by varying yearly rains and the flow of the Blue Nile River. The filling schedule also factors in various water release volumes by taking into account water release demands in downstream countries. The combined considerations of these two parameters result in the following matrix of hydrological outcomes, downstream water volume demand, and filling year as presented in Figure 3.

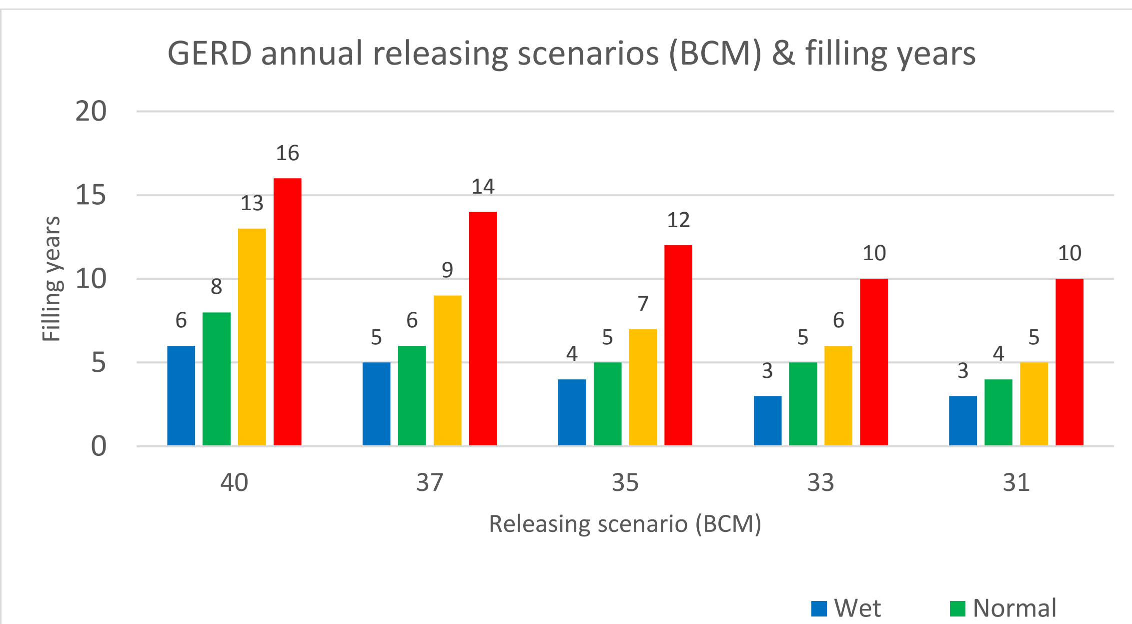

Figure 1. Filling year options as the outcome of weather conditions and downstream water volume demand.

Figure 2 presents the energy loss (in Gwh) based on the filling year. The results show increase in Gwh with increase in filling years, indicating that increase in filling years leaves costs that are not recuperated through energy generation associated with early filling.

The results in Figure 2 and Figure 3 are based on a flat assumption that the filling rates could vary between 3 and 16 years. However, with information from Figure 4, the filling schedule could be qualified by varying the weather conditions and downstream water demand. The following patterns emerge.

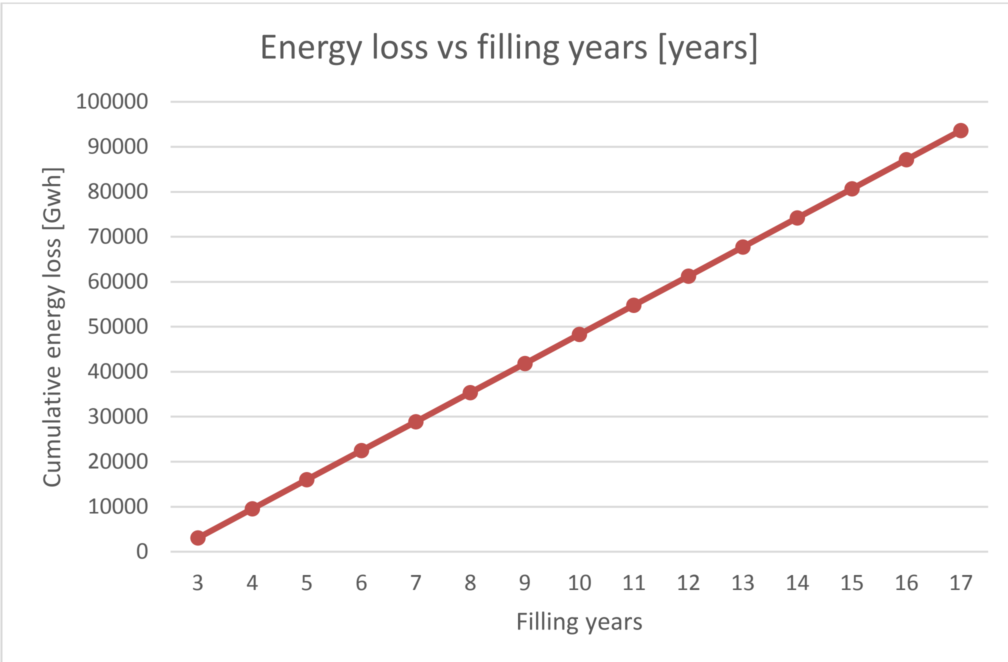

Figure 2. Energy loss verses filling years

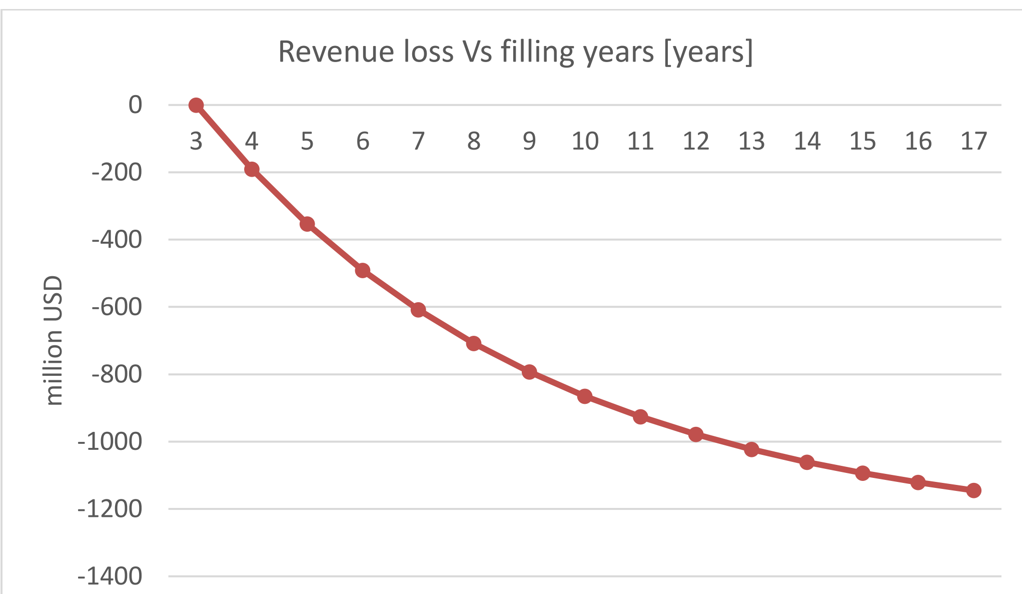

Figure 3. Revenue loss verses filling years

Figure 4 and Figure 5 show the energy and revenue loss due to GERD filling with different hydrology conditions and releasing scenarios. As it is expected, in wet and normal scenario, the optimum GERD filling time is 3-5 years. However, in dry and extreme scenario, the filling time extends to 6 – 9 years

.

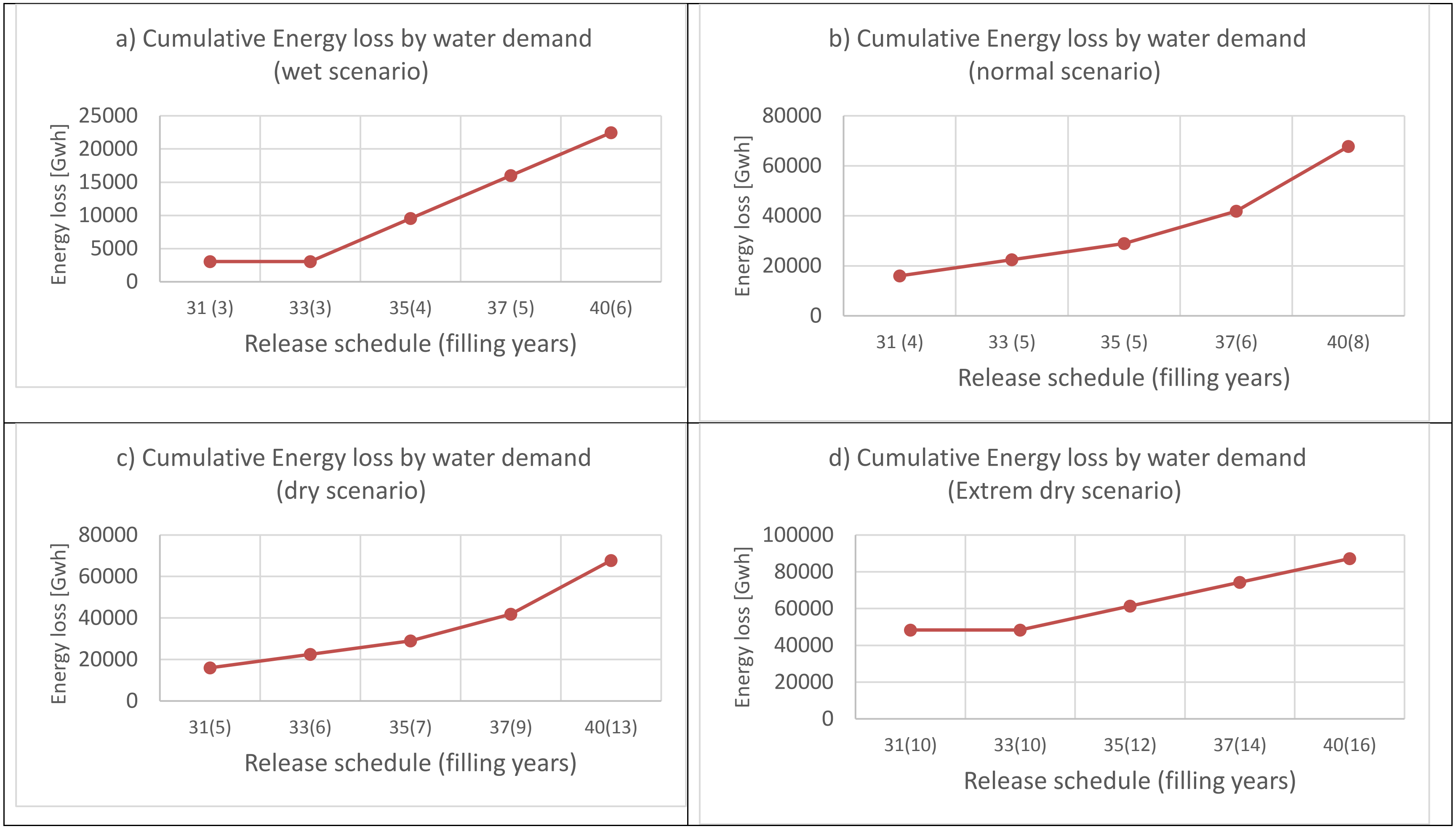

Figure 4. Energy loss of GERD filling with different Hydrology conditions and releasing scenarios

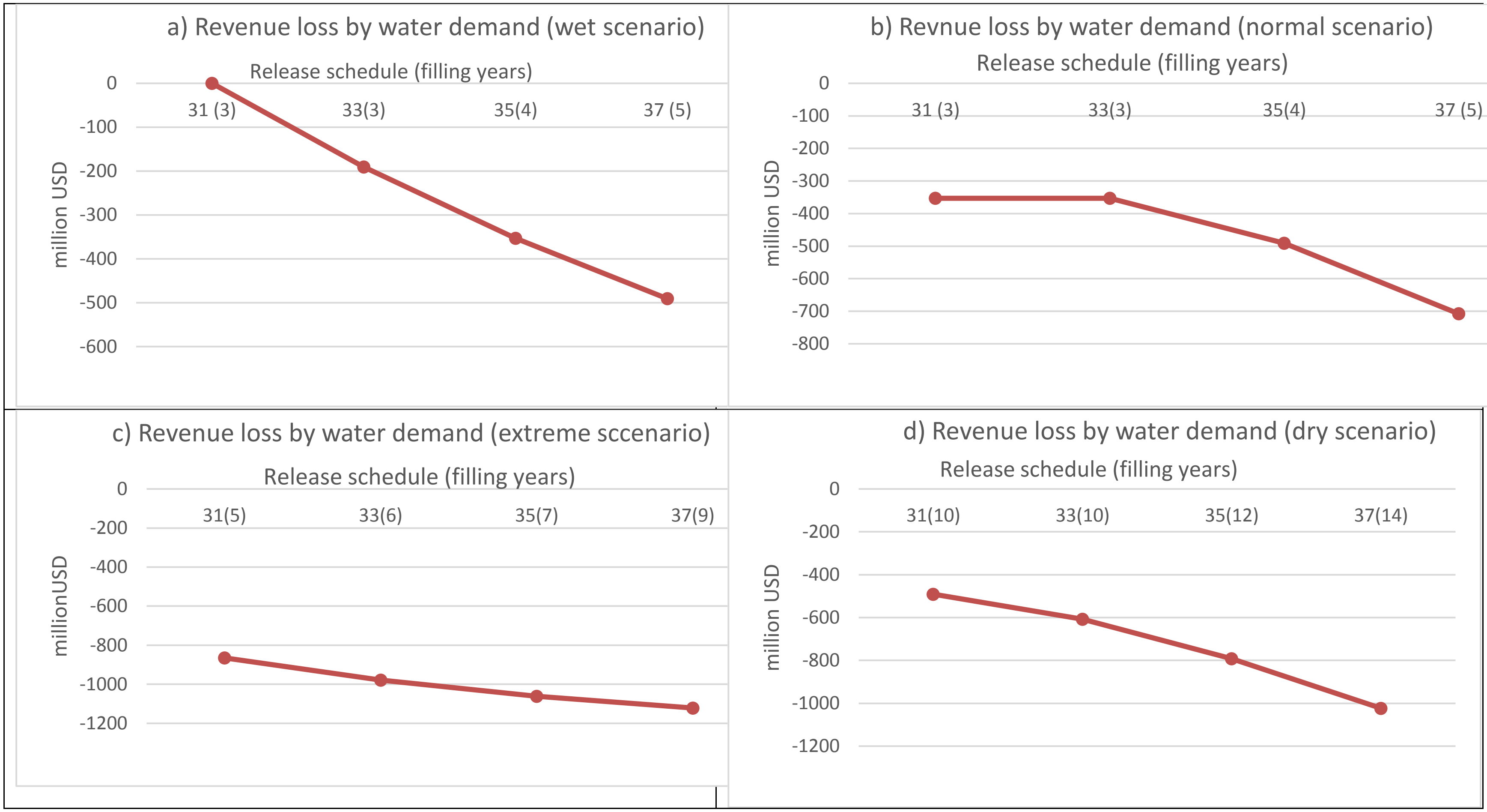

Figure 5. Revenue loss of GERD filling with different Hydrology conditions and releasing scenarios

4. Conclusions

The central hypothesis tested in this paper is to what extent varying the filling time of the GERD leads to changes in overall benefits of the project. The main objective of the GERD has been to bring to meaningful use the Nile waters in Ethiopia that have otherwise been left unused, through simultaneously reducing the negative environmental impacts associated with their unregulated flow.

The results suggest that, in accordance with expectations, delaying filling time has a negative impact on energy and revenue generation. Furthermore, our empirical analysis shows the revenue and energy losses corresponding to filling year are considerably sensitive to filling demand from downstream countries and hydrological scenarios. The cost analysis showed that, in wet and normal scenario, the optimum GERD filling time is 3-5 years. However, in dry and extreme scenario, the filling time extends to 6 – 9 years.

An important future direction is extending the current exercise to include financial, economic, and social cost benefit analysis. This would be imply computation of the social benefits and social costs which enables adjusting the net present value of financial benefits of the project to calculate the net economic benefits of the project. Finally, savings and income distribution considerations of the project would lead to computing the social net present value benefits of the project.

References

1. Belay, Abreham. Press conference on the Status of the Grand Renaissance Dam. Wednesday (25 September 2019),
2. Bezabih Mintwab, Instruments for optimal management of transboundary resources: lessons for the Nile Waters? EIPSA Communicating Article. Vol 3. Issue 3.
3. Tesfa, Belachew, 2013. Benefit of Grand Ethiopian Renaissance Dam Project (GERDP) for Sudan and Egypt. EIPSA Communicating Article. Vol 1. Issue
4. Tewodros Kahsay, Onno Kuik, Roy Brouwer, Pieter van der Zaag, 2015. Estimation of the transboundary economic impacts of the Grand Ethiopia Renaissance Dam:A computable general equilibrium analysis. Water Resources and Economics Volume 10, April 2015, Pages 14-30
5. Fahmy Salah Abdelhaleem and Esam El Deen Y. Helal, 2015, Impacts of Grand Ethiopian Renaissance Dam on Different Water Usages in Upper Egypt. British Journal of Applied Science & Technology 8(5): 461-483, 2015.
6. Pathak, Rishi. .Social Cost-Benefit Analysis: A study of Power Projects. PMI-NTPC, Noida
7. Social Cost Benefit Analysis-UNIDO Approach, Coal Plant, Hydro Plant, Power Project http://atlas.nilebasin.org/treatise/irrigation-in-the-nile-basin/
8. Ekierman, C., J. Mejia, C. Rodrigues. The Construction of the Baihetan Dam: A Cost-Benefit Analysis. (accessed October 2019) http://franke.uchicago.edu/bigproblems/BPRO29000-2015/Team15-CostBenefitAnalysisoftheBaihetanDamProject.pdf

9. Li, X., J.Zhang, L. Xu.2015 .An evaluation of ecological losses from hydropower development in Tibet. Ecological Engineering.76: 178-185.
10. B.Fu[ab]Y.K.Wang[ab]P.Xu[ab]K.Yan[ab]M.Li[bc].2014.Value of ecosystem hydropower service and its impact on the payment for ecosystem services. Science of The Total Environment. 472: 338-346.
11. Briones-Hidrovo, A., J. Uche, A. Martínez-Gracia. 2019. Estimating the hidden ecological costs of hydropower through an ecosystem services balance: A case study from Ecuador. Journal of Cleaner Production. 233: 33-42.
12. Moran, E., M. Lopez, N. Moore, N. Müller, D. Hyndman. 2018. Sustainable hydropower in the 21st century. Proceedings of the National Academy of Sciences. 115 (47) 11891-11898.
13. Stephen, B., G. Tolley. 2015. Economic Cost-Benefit Analysis of Nebskra Hydropower Project: Summary Report University of Chicago Fall 2015 BPRO 29000
14. UNIDO. 1986. Guide to practical project appraisal social benefit-cost analysis in developing countries project formulation and evaluation series, no. 3. United Nations industrial development organization Vienna.
15. Global Construction Review. As tensions rise, Ethiopian minister says Grand Renaissance Dam could begin generating next year (accessed on Sep 2019). http://www.globalconstructionreview.com/news/tensions-rise-ethiopian-minister-says-grand-renais/
16. K Strzepek, 2015. Responding to the Crisis of the Filling of the GERD: An International Insurance Approach? (accessed on Sep 2019). https://www.iwra.org/wp-content/uploads/2017/03/GERD_Presentation8.pdf
17. Abonesh Tesfaye, Nitsuhe Wolanios, Roy Brouwer, 2016. Estimation of the economic value of the ecosystem services provided by the Blue Nile Basin in Ethiopia. Ecosystem Services 17 (2016) 268–277.
18. Kevin G. Wheeler, Mohammed Basheer, Zelalem T. Mekonnen, Sami O. Eltoum, Azeb Mersha, Gamal M. Abdo, Edith A. Zagona, Jim W. Hall & Simon J. Dadson (2016) . Cooperative filling approaches for the Grand Ethiopian Renaissance Dam, Water International, 41:4, 611-634, DOI: 10.1080/02508060.2016.1177698