Long-term economy-wide impacts of the Grand Ethiopian Renaissance Dam on Sudan

Khalid Siddig, Mohammed Basheer, Jonas Luckmann

26th Annual Conference the Economic Research Forum (ERF26th)

Background (1/2) - Motivations

- GERD – a multi-year hydropower storage dam on the Blue Nile River in Ethiopia – is expected to double the Ethiopian electricity generation,
- It is expected to impact water users in Egypt and Sudan, given that the Blue Nile contributes 59 % of the basin's water flow,

- It is expected to start filling in July 2020 and be fully operational in 2027,
- Several studies assessed its effects on water supply and hydropower generation in Sudan and Egypt,
- However, less attention was given to the economic benefits and costs of GERD operation to the downstream countries

Background (2/2) - Literature

- Long-term impacts on water and energy: water resources management in the basin for hydropower generation and irrigation (Digna et al., 2018; Basheer et al., 2018; Habteyes et al., 2015; Jeuland et al., 2017; Dinar and Nigatu, 2013; Digna et al., 2017; Arjoon et al., 2014),
- Other long-term impacts: sediments, evaporation, salinity and pollution of water (Mohamed and Elmahdy, 2017); recharge, seepage to the aquifer (Sharaky *et al.*, 2019)
- Reservoir filling: trade-offs related to filling the reservoir (Wheeler et al., 2016; King and Block, 2014; Zhang et al., 2015),
- Economics: economic impacts on the Eastern-Nile basin countries (Basheer et al., 2018, Kahsay et al., 2015, 2017; Nigatu and Dinar, 2016).

Objectives – Impact on Sudan

- Non-economic assessments: sediments, evaporation, salinity and pollution of water (Mohamed and Elmahdy, 2017); recharge, seepage to the aquifer (Sharaky *et al.*, 2019); cooperative management, positive externalities (Arjoon et al., 2014); water storage during a drought (Jeuland et al., 2017),

- Thin literature on economic assessment on Sudan, specially economy-wide assessments (Calzadilla *et al.* (2011),

- Thus, a detailed analysis of the potential economic impact of GERD on Sudan is missing. This study is to address this gap,

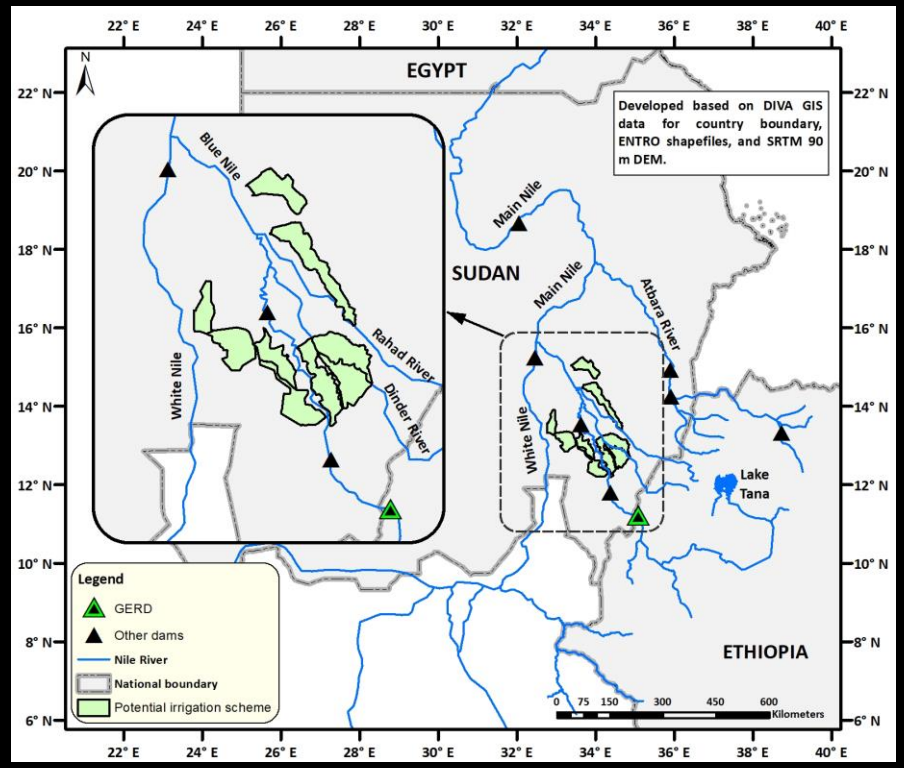
- We analyze the potential impacts of the steady-state operation of the GERD on Sudan and provides recommendations for policymaking.

Description of our Approach

- We feed a calibrated economy-wide CGE model of Sudan with the expected biophysical impacts of the steady-state operation of the GERD on irrigated agriculture and hydropower generation,
- The biophysical impacts are obtained from daily hydrological, water allocation, and crop models,
- The CGE model (Diao and Thurlow, 2012) is calibrated to a 2012 SAM for the Sudan (Siddig et al., 2018), with 14 primary factors (capital, land and natural resources, and 12 labor categories) and 10 household groups,
- We develop a baseline using IMF (2019), World Bank Group (2019), UN (2019) and CBS (2019),

Simulation Setup (1/3)

- General features and potential irrigation schemes in Sudan downstream the GERD,
- Sequential implementation of 9 projects (every 3 years: 2027-2051),
- 7 crops in three different croping patterns,
- Three cooperation states: unilateral actions from Ethiopia, coordination and collaboration between Ethiopia and Sudan
- Additional hydropower generation in Sudan over time under different scenarios.



Crop	Gross margin (US$/ha)	Cropping Pattern 1	Cropping Pattern 2	Cropping Pattern 3
Cotton	4328.5	14.3%	28.1%	20.0%
Sesame	3462.8	14.3%	22.4%	20.0%
Wheat	729.1	14.3%	4.7%	10.0%
Sunflower	253.9	14.3%	1.7%	10.0%
Sorghum	32.1	14.3%	0.2%	10.0%
Sugarcane	6082.9	14.3%	39.4%	20.0%
Groundnuts	541.4	14.3%	3.5%	10.0%

Simulation Setup (3/3)

- Temporal evolution of the total area in Sudan for crops under cropping pattern one and irrigation expansion plan

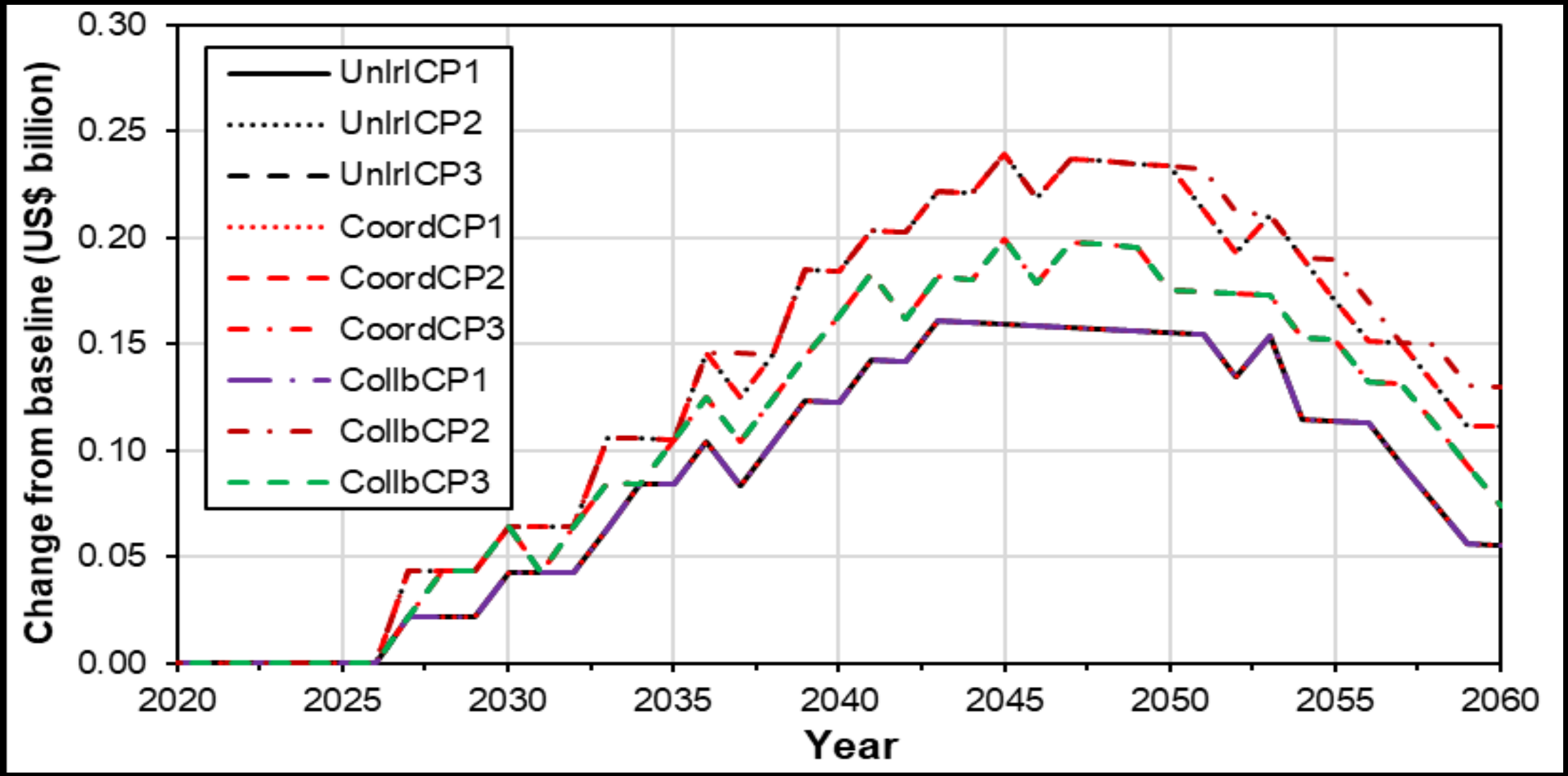
Crop	Initial area (Hectare)	CP's	2027		2030		All years	
			Area (Hectare)	Change (%)	Area (Hectare)	Change (%)	Area (Hectare)	Change (%)
Cotton	147840	CP1	15714	10.6	16857	10.3	139571	94.4
		CP2	30855	20.9	33099	18.5	274049	185.4
		CP3	22000	14.9	23600	13.9	195400	132.2
Sesame	26460	CP1	15714	59.4	16857	40.0	139571	527.5
Wheat	171780	CP1	15714	9.1	16857	9.0	139571	81.3
Sunflower	26460	CP1	15714	59.4	16857	40.0	139571	527.5
Sorghum	407400	CP1	15714	3.9	16857	4.0	139571	34.3
Sugarcane	65094	CP1	15714	24.1	16857	20.9	139571	214.4
Groundnuts	150780	CP1	15714	10.4	16857	10.1	139571	92.6
Total	995814		110000	11.0	118000	10.7	977000	98.1

Simulation Setup (3/3)

Scenarios: a baseline and nine combinations of the three cropping patterns and three cooperation states

1) Baseline (no GERD)
2) Unilateral actions from Ethiopia and cropping pattern 1 => UnlrlCP1
3) Unilateral actions from Ethiopia and cropping pattern 2 => UnlrlCP2
4) Unilateral actions from Ethiopia and cropping pattern 3 => UnlrlCP3
5) Coordination between Eth & Sudan and cropping pattern 1 => CoordCP1
6) Coordination between Eth & Sudan and cropping pattern 2 => CoordCP2
7) Coordination between Eth & Sudan and cropping pattern 3 => CoordCP3
8) Collaboration between Eth & Sudan and cropping pattern 1 => CollbCP1
9) Collaboration between Eth & Sudan and cropping pattern 2 => CollbCP2
10) Collaboration between Eth & Sudan and cropping pattern 3 => CollbCP3

Temporal evolution of crops' contribution to GDP at factor cost



Accumulated discounted crops' GDP between 2020 and 2060 in SDGs and 2012 US$

Scenario	Accumulated values (2020 to 2060)		Deviation from Baseline	
	SDG billions	US$ billions	US$ billions	%
Baseline	1,428.7	324.7	0.0	0.0
UnlrlCP1	1,444.5	328.3	3.6	1.1
UnlrlCP2	1,452.1	330.0	5.3	1.6
UnlrlCP3	1,448.2	329.1	4.4	1.4
CoordCP1	1,444.5	328.3	3.6	1.1
CoordCP2	1,452.1	330.0	5.3	1.6
CoordCP3	1,448.2	329.1	4.4	1.4
CollbCP1	1,444.5	328.3	3.6	1.1
CollbCP2	1,452.7	330.2	5.5	1.7
CollbCP3	1,448.2	329.1	4.4	1.4

SDG = Sudanese pound (in 2012, 1 US$ = 4.4 SDGs)

Accumulated discounted Agriculture's GDP (2020-2060) in SDGs and 2012 US$

Scenario	Accumulated values (2020 to 2060)		Deviation from Baseline	
	SDG billions	US$ billions	US$ billions	%
Baseline	3,738.4	849.6	0.0	0.0
UnlrlCP1	3,750.8	852.5	2.8	0.3
UnlrlCP2	3,758.2	854.1	4.5	0.5
UnlrlCP3	3,754.4	853.3	3.7	0.4
CoordCP1	3,750.8	852.5	2.8	0.3
CoordCP2	3,758.1	854.1	4.5	0.5
CoordCP3	3,754.3	853.3	3.6	0.4
CollbCP1	3,750.8	852.5	2.8	0.3
CollbCP2	3,758.9	854.3	4.7	0.6
CollbCP3	3,754.3	853.3	3.6	0.4

SDG = Sudanese pound (in 2012, 1 US$ = 4.4 SDGs)

Contribution of industry and services to GDP (2020-2060) in 2012 US$

Scenario	Industry			Services		
	Value (US$ B)	Change (US$ B)	Change (%)	Value (US$ B)	Change (US$ B)	Change (%)
Baseline	1,373.9	0.0	0.0	2,586.7	0.00	0.00
UnlrlCP1	1,403.5	29.6	2.2	2,585.8	-0.92	-0.04
UnlrlCP2	1,400.7	26.8	2.0	2,585.9	-0.81	-0.03
UnlrlCP3	1,402.5	28.6	2.1	2,585.8	-0.92	-0.04
CoordCP1	1,403.5	29.6	2.2	2,585.8	-0.92	-0.04
CoordCP2	1,400.9	27.0	2.0	2,585.9	-0.81	-0.03
CoordCP3	1,402.7	28.8	2.1	2,585.8	-0.92	-0.04
CollbCP1	1,403.5	29.6	2.2	2,585.8	-0.92	-0.04
CollbCP2	1,399.1	25.2	1.8	2,585.8	-0.85	-0.03
CollbCP3	1,402.7	28.8	2.1	2,585.8	-0.92	-0.04

SDG = Sudanese pound (in 2012, 1 US$ = 4.4 SDGs)

Accumulated discounted national GDP (2020-2060) in SDGs and 2012 US$

Simulations	Accumulated values (2020 to 2060)		Deviation from Baseline	
	SDG billions	US$ billions	US$ billions	%
Baseline	21,609.2	4,911.2	0.0	0.00
UnlrlCP1	21,737.7	4,940.4	29.2	0.59
UnlrlCP2	21,733.7	4,939.5	28.3	0.58
UnlrlCP3	21,737.6	4,940.4	29.2	0.59
CoordCP1	21,737.7	4,940.4	29.2	0.59
CoordCP2	21,734.3	4,939.6	28.4	0.58
CoordCP3	21,738.2	4,940.5	29.3	0.60
CollbCP1	21,737.7	4,940.4	29.2	0.59
CollbCP2	21,728.2	4,938.2	27.0	0.55
CollbCP3	21,738.2	4,940.5	29.3	0.60

SDG = Sudanese pound (in 2012, 1 US$ = 4.4 SDGs)

Indirect compensation (2020- 2060) in SDGs, US$ and % for all, rural and urban households

Scenario	Accumulated values (2020 to 2060) in US$ billions			Deviation from Baseline (US$ billions)			Deviation from baseline (%)		
	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban
Baseline	4,996.2	2,307.9	2,056.6	0.0	0.0	0.0	0.00	0.00	0.00
UnlrlCP1	5,020.7	2,322.6	2,062.9	24.5	14.6	6.3	0.49	0.63	0.31
UnlrlCP2	5,020.2	2,323.0	2,062.3	24.0	15.0	5.7	0.48	0.65	0.28
UnlrlCP3	5,021.0	2,323.0	2,062.8	24.8	15.1	6.2	0.50	0.65	0.30
CoordCP1	5,020.7	2,322.6	2,062.9	24.5	14.6	6.3	0.49	0.63	0.31
CoordCP2	5,020.4	2,323.0	2,062.3	24.2	15.1	5.8	0.48	0.65	0.28
CoordCP3	5,021.1	2,323.1	2,062.8	24.9	15.1	6.2	0.50	0.66	0.30
CollbCP1	5,020.7	2,322.6	2,062.9	24.5	14.6	6.3	0.49	0.63	0.31
CollbCP2	5,019.6	2,322.5	2,061.9	23.4	14.6	5.4	0.47	0.63	0.26
CollbCP3	5,021.1	2,323.1	2,062.8	24.9	15.1	6.2	0.50	0.66	0.30

SDG = Sudanese pound (in 2012, 1 US$ = 4.4 SDGs)

Conclusions and Policy Implications (1/2)

- Sudan's GDP (2020-2060) increases by between US$ 27.0 billion and US$ 29.3 billion compared to a baseline without the GERD online,
- GDP gains from crop expansion would range between US$ 3.6 billion and US$ 5.5 billion under different scenarios relative to the baseline,
- The contribution of the agriculture to GDP would be between US$ 2.8 billion and US$ 4.7 billion relative to the baseline,
- The industry sector benefits from the GERD, while the services sector looses,
- Benefits to rural households and more than those to urban households,
- The level of cooperation on the steady-state operation of GERD is beneficial only if combined with specific cropping patterns,

Conclusions and Policy Implications (2/2)

- The overall gain to Sudan from GERD is mainly determined by the choice of which crops to be grown in new irrigation schemes.
- Limitations:
  - The negative impacts of the GERD on recession agriculture and ecosystem services have not been included,
  - The positive impacts of the GERD in reducing fluvial floods and reservoir sedimentation are not modeled,
  - We did not account for the economic impacts of the initial investment and operation cost of new irrigated areas.

Thank you…

References

Arjoon, D., Mohamed, Y., Goor, Q. and Tilmant, A. (2014), "Hydro-economic risk assessment in the eastern Nile River basin", Water Resources and Economics, Vol. 8, pp. 16–31.

Basheer, M., Wheeler, K.G., Ribbe, L., Majdalawi, M., Abdo, G. and Zagona, E.A. (2018), "Quantifying and evaluating the impacts of cooperation in transboundary river basins on the Water-Energy-Food nexus: The Blue Nile Basin", Science of the Total Environment, Vol. 630, pp. 1309–1323.

Calzadilla, A., Rehdanz, K. and Tol, R.S.J. (2011), "The GTAP-W model. Accounting for water use in agriculture", available at: https://ideas.repec.org/p/zbw/ifwkwp/1745.html.

Digna, R.F., Castro-Gama, M.E., van der Zaag, P., Mohamed, Y.A., Corzo, G. and Uhlenbrook, S. (2018), "Optimal operation of the Eastern Nile System using Genetic Algorithm, and benefits distribution of water resources development", Water (Switzerland), Vol. 10 No. 7.

Digna, R.F., Mohamed, Y.A., van der Zaag, P., Uhlenbrook, S. and Corzo, G.A. (2017), "Nile River Basin modelling for water resources management – a literature review", International Journal of River Basin Management, Vol. 15 No. 1, pp. 39–52.

Dinar, A. and Nigatu, G.S. (2013), "Distributional considerations of international water resources under externality: The case of Ethiopia, Sudan and Egypt on the Blue Nile", Water Resources and Economics, 2-3, pp. 1–16.

Donia, N. and Negm, A. (2019), "Impacts of Filling Scenarios of GERD's Reservoir on Egypt's Water Resources and Their Impacts on Agriculture Sector", Handbook of Environmental Chemistry, Vol. 74, pp. 391–414.

Elganainy, M.A. and Eldwer, A.E. (2018), "Stochastic Forecasting Models of the Monthly Streamflow for the Blue Nile at Eldiem Station", Water Resources, Vol. 45 No. 3, pp. 326–337.

References

Elsanabary, M.H. and Ahmed, A.T. (2019), "Impacts of Constructing the Grand Ethiopian Renaissance Dam on the Nile River", Handbook of Environmental Chemistry, Vol. 79, pp. 75–93.

IMF (2019), Wrold Economic Outlook Database, International Monitory Fund, United States.

Kahsay, T.N., Kuik, O., Brouwer, R. and van der Zaag, P. (2015), "Estimation of the transboundary economic impacts of the Grand Ethiopia Renaissance Dam: A computable general equilibrium analysis", Water Resources and Economics, Vol. 10, pp. 14–30.

Kahsay, T.N., Kuik, O., Brouwer, R. and van der Zaag, P. (2017), "Economic impact assessment of the grand ethiopian renaissance: Dam under different climate and hydrological conditions", The Grand Ethiopian Renaissance Dam and the Nile Basin: Implications for Transboundary Water Cooperation.

Sharaky, A.M., Elewa, H.H. and Kasem, A.M. (2019), "Impact of the Grand Ethiopian Renaissance Dam (GERD) on Gezira Groundwater, Sudan", Handbook of Environmental Chemistry, Vol. 79, pp. 519–557.

Siddig, K., Elagra, S., Grethe, H. and and Mubarak, A. (2018), "A post-separation Social Accounting Matrix for the Sudan", available at: http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132312.

World Bank Group. (2019), World Development Indicators, Wold Bank Group, United Sates.

UN. (2019), United Nations polulation statistics.