Economic and hydrological impacts of the Grand Ethiopian Renaissance Dam on the Eastern Nile River Basin

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Online Appendix

1. Specification of irrigation demand function

The inverse demand equation is expressed using $P = \beta(D^{IR})^{\alpha}$, where $\alpha < 0, \beta > 0$; β is a coefficient of the inverse demand function and α is an exponent of the inverse demand function standing for demand elasticity; and D^{IR} and P denote the quantity of irrigation water demanded (measured in cm/month) and its price ($/cm), respectively. The consumer surplus (CS) can be traced back using the integral equation where at a certain level of water consumption, D^{IR}, the welfare value can be represented by $\frac{\beta\,(D^{IR})^{\alpha+1}}{\alpha+1}$. In addition, such demand has a constant price elasticity, θ, that can be defined using $\theta = \frac{1}{\alpha} = \frac{dLn(D^{IR})}{dLn(P)}$.

2. Interpreting Nile water allocation

For 'with GERD' scenario, 10.8 and 11 bcm would be used for irrigation and hydropower production out of 13.5 and 55 bcm diverted to irrigation and hydropower projects in Ethiopia, respectively. 2.7 bcm (20 per cent) from irrigation and 44 bcm (80 per cent) from hydropower would return to the river system and be available to Sudan based on its geographic location and on allocation schemes. In Ethiopia, 2.4 bcm of water would be accounted for evaporation loss at the various reservoirs. The same interpretation applies to Sudan. In Egypt, first water would be diverted to hydropower generation and 80 per cent of water would return to the system. Then, the irrigation sector would use the remaining water by assuming no return flow to the system.

3. Trade result for specific countries

The economic benefits as well as the allocation schemes for GERD situations and trade scenarios for individual country are shown in appendix table A1. For the without GERD situation, Egypt is the only country that could use more water with trade than without trade

scenarios. But for the with GERD situation, Ethiopia (for WRA I) could also join Egypt (for WRA II and WRA III) in using more water with trade than without trade. For the without trade scenario, whenever Ethiopia is assigned more water such as in WRA II and WRA III, it could use the Nile water similar to the unilateral use arrangement, and the remaining water would be used by Sudan. Hence, for the without trade scenario, Sudan could use more water in WRA II and WRA III than the assigned amount. In the case of water trade, with its lower shadow value of using water than either country, Sudan would use less water and could experience a loss of economic benefit.

As expected, whenever, Egypt is assigned too small a volume of water, as in WRA II and WRA III, it would become a buyer of a large volume of water at a lower average price. This indicates that Egypt has the highest shadow value for using additional water for different WRAs. With its economies of scale, Egypt has the comparative advantage in using Nile water more efficiently than the other economies in the region. Whenever Egypt is assigned more water (for instance WRA I), less water is involved in the volume of trade at higher average price. This is because other countries would not be able to use the additional water more efficiently to compensate Egypt with more than its shadow value.

Table A1. *ENRB countries' water allocation and economic benefit for GERD situation and trade scenario for different WRA*

GERD Situation	Trade Scenario	Country	Nile Water Use (bcm) WRA I	WRA II	WRA III	Economic Benefit (billion $US) WRA I	WRA II	WRA III
Without GERD								
	Without Trade							
		Ethiopia	12.0	12.4	12.4	1.4	1.4	1.4
		Sudan	21.7	35.4	35.4	2.7	3.2	3.2
		Egypt	64.8	50.7	50.7	5.4	4.5	4.5
		Basin	98.5	98.5	98.5	9.5	9.0	9.0
	With trade							
		Ethiopia	9.5	12.4	9.7	1.4	2.6	2.3
		Sudan	21.7	23.1	23.7	2.8	2.3	2.5
		Egypt	67.3	63.0	65.1	5.4	4.7	4.7
		Basin	98.5	98.5	98.5	9.6	9.6	9.5
With GERD								
	Without Trade							
		Ethiopia	12.0	24.2	24.2	1.5	2.5	2.5
		Sudan	21.7	28.7	28.7	2.7	2.9	2.9
		Egypt	64.8	45.6	45.6	5.5	4.1	4.1
		Basin	98.5	98.5	98.5	9.7	9.6	9.6
	With trade							
		Ethiopia	20.7	19.2	18.9	1.7	3.0	3.0
		Sudan	12.9	17.6	19.2	2.9	2.4	2.3
		Egypt	64.8	61.7	60.4	5.3	4.5	4.5
		Basin	98.5	98.5	98.5	10.0	9.9	9.8

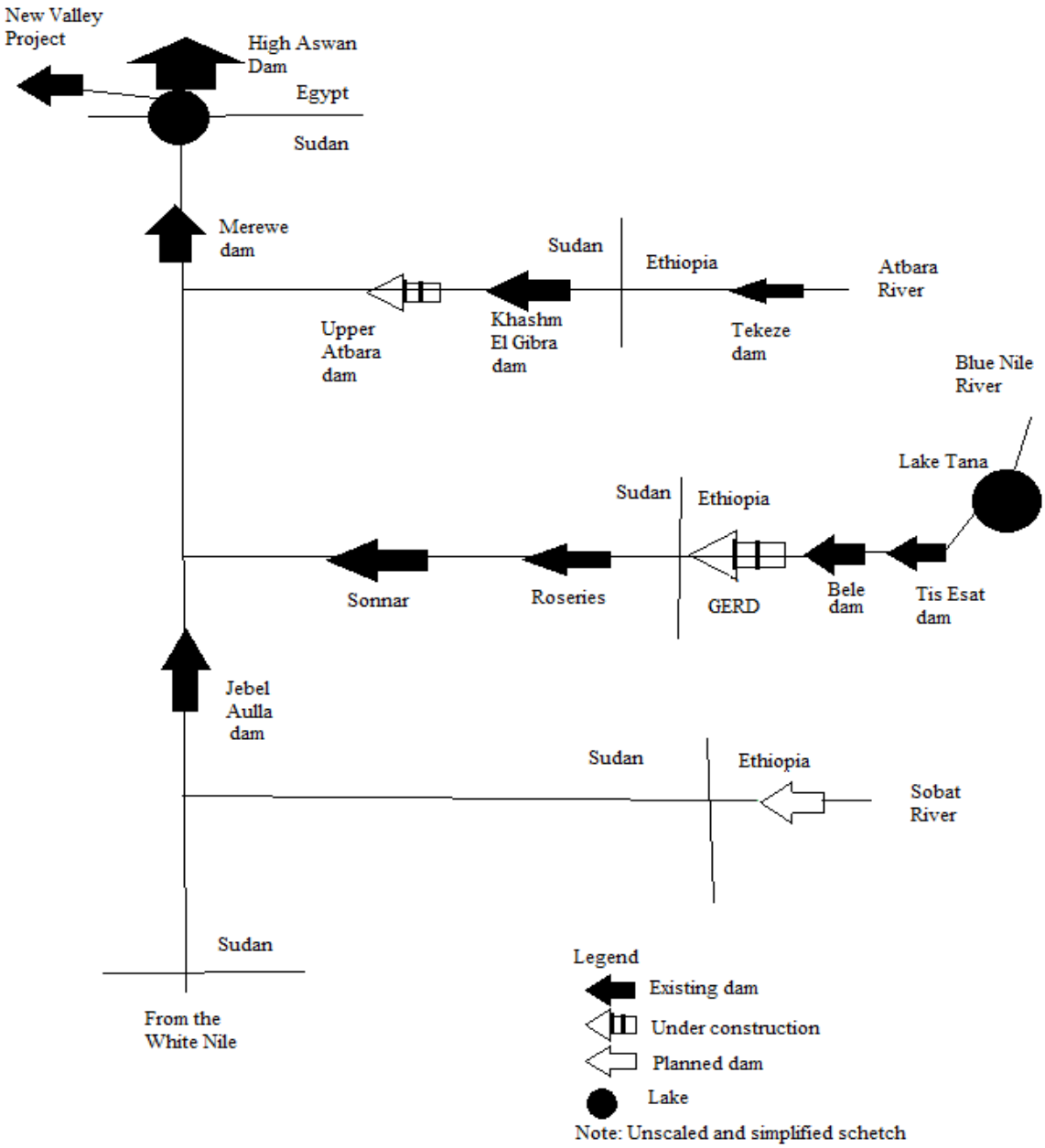

Figure A1. *Schematic map of the ENRB*