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Policy Synthesis Report on Irrigation Development in the Nile Basin

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Document Sheet

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The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

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1 Executive summary

The Nile Basin is a complex and interconnected system crossing ecological, hydrological, socio-economic and political boundaries. This 'transboundary nature' requires collective water management across all the Basin countries (Choudhury and Islam 2015; Paisley and Henshaw 2013; Suhardiman et al. 2017). While tensions between upstream and downstream riparians do occur periodically (Whittington et al. 2014) yet, at the same time, there is substantial cooperation at the bilateral, trilateral and multilateral levels, often with a focus on equity and sustainability (NBI 2019).

The current controversy surrounding the nearly completed Grand Ethiopian Renaissance Dam (GERD) is reconfiguring these relations further (Cascão and Nicol 2016), posing challenges to the wider cooperative agenda. At this critical juncture in the Nile's history, with unprecedented ongoing climate change, *cooperation now and in the future is critical to ensure that available Nile waters can satisfy future demand* and that water-related risks and benefits among the riparian countries can be shared equitably (Blackmore and Whittington 2008).

This report, prepared using the synthesis of a wider set of studies prepared under this project, attempts to find the right pathways, by suggesting the following key policy directions:

1. First, the Nile Basin is **one-system**, through which efforts should be strengthened around achieving greater cooperation and harmonization of water resources policy development and implementation;

2. Second, successfully achieving key SDG goals on poverty and food security requires a constant effort at **improving the functioning and efficiency of irrigation** at all levels — from smallholder farmers to large-scale systems —to be able to maximize the social, economic and environmental returns to water use (in combination with other inputs);
3. Third, **the irrigation economy needs to build coherence and better linkages to other sectors to ensure that investment in irrigation is a structural part of broader sustainable growth strategies** in rural economies, by enabling stronger forward and backward economic linkages.

To achieve these policies, the establishment of an enabling environment is vital:

- Countries need to **capitalize on basin knowledge networks** and existing institutions of cooperation.
- The NBI needs to continue to **invest in hydro-met data and strengthen multi-stakeholders** around emerging themes.
- The NBI could also spearhead efforts to **develop a basin water accounting database**.
- The process of **implementation of policies and investments** by setting out a rationale case for irrigation development based on cooperation, efficiency and linkage to wider development goals needs to be undertaken at a basin level.
- Governments need to take the lead in making this case, but also involve other stakeholders, i.e., **adopting more bottom-up planning and implementation**.
- **Governments and basin authorities to invest in institutional reform, arrangements and incentives** and for such reform to be streamlined within countries and across sectors.
- At the same time, governments cannot do this alone. **Promoting private sector engagement and local agribusiness** industry representation is important.
- **The establishment of multilateral development banks** (not necessarily external — it can be a joint venture of the Basin countries) can act as a catalyst for innovation and promotion of disruptive technologies in the sector.
- Finally, **basin organizations need to establish their convening power** to assert the centrality of agricultural water to the SDG agenda, promote knowledge exchange and transfer and catalyze collective action to address agricultural water challenges.

2 Objectives and scope

The Nile-Sec launched this phase II study in partnership with IWMI to contribute towards generating strategic options for meeting current and future water demands in the Nile Basin more efficiently and sustainably. The **purpose** of the report is to provide strategic and policy directions to guide high-level dialogue on policy and investment in agricultural water management in the Nile Basin.

The study has six interrelated components: i) Refining the baseline irrigation water demand and actual use data (Component 1); ii) Projecting future irrigation water demand scenarios (Component 2a) and mapping irrigation potential (Component 2b); iii) Establishing scenarios for water saving in irrigated agriculture (Component 3); iv) Estimating the economic value of water for irrigation (Component 4); v) Developing a basin-wide approach for benchmarking irrigated agriculture performance (Component 5), and vi) Providing strategic recommendations for improved irrigation water management (Component 6). This report focuses on Component 6 and provides strategic recommendations.

The Nile Basin is a complex and interconnected system that traverses several ecological, hydrological, socio-economic and political boundaries across the reaches of the continent. Keeping in view this 'trans-boundariness', a degree of collective water management across all the Basin countries is crucial (Choudhury and Islam 2015; Paisley and Henshaw 2013; Suhardiman et al. 2017). Tensions between upstream and downstream riparian regions and countries are known to ferment occasionally (Whittington et al. 2014). Nevertheless, at the same time, there is the presence of substantial cooperation at bilateral, trilateral and multilateral levels, often with an accompanying focus on equity and sustainability (NBI 2019). It is within this context that the controversy surrounding the Grand Ethiopian Renaissance Dam (which is close to completion) is not only reconfiguring relations (Cascão and Nicol 2016) but also challenging the more comprehensive cooperative agenda. At this critical juncture in the river's history, with unprecedented climate change, cooperation now and in the future is critical to ensure that the available Nile waters can satisfy future demand and that water-related risks and benefits among riparian countries can be shared equitably (Blackmore and Whittington 2008).

The Nile Basin (NB) is shared by 11 countries and is home to over 257 million people. The total population of all the Nile countries is estimated at 545.8 million out of which 20.3% (114.9 million) and 18.7% (102 million) people live in Ethiopia and Egypt, respectively (World Meter 2020). Around 300 million people rely on the waters of the River Nile, about half the total of the 11 riparian countries. Many parts of the Basin include high levels of poverty and chronic food insecurity. Parts of the Basin are also periodically subject to extreme weather events and other natural disasters which reinforces risks to development and poses major challenges in the quest to lift people out of poverty (Hubacek et al. 2017).

The expansion and intensification of agriculture to allow the growth of more food and cash crops is therefore a vital element in building more sustainable and resilient communities within the Nile Basin. Enhanced irrigation of crops is considered to be a key factor in this strategy alongside improvements to technical and other inputs to farming systems, as well as the changes in land tenure and value chain enhancements to improve the food and income security of farmers. These necessary changes are nonetheless also compounded by two other longer-term, and more structural, shifts — the changing climate of the Nile Basin which in turn is affecting the agro-ecological boundaries in which the mosaic of farming systems are situated, and the structural changes taking place in the demographic profile of countries as populations grow and face significant 'youth bulges'.

To face these varied and complex challenges — embedded within which are significant sociological and political-economic issues surrounding the way systems and institutions function, how gender equality is achieved and how natural resource systems are governed — requires a new generation of policies. Based on the wider set of studies prepared under this project, the purpose of this report is to identify and point towards the right direction. To achieve the same, the following key policy directions are suggested:

1. First, the Nile Basin is **one-system**, which can allow for strengthened efforts around achieving greater cooperation and harmonization of water resources policy development and implementation;
2. Second, successfully achieving the key SDG goals on poverty and food security requires a constant effort at **improving the functioning and efficiency of irrigation** at all levels — from smallholder farmers to large-scale systems —to maximize the social, economic and environmental returns to water use (in combination with other inputs); and
3. Third, **the irrigation economy needs to build coherence and better linkages to other sectors to ensure that investment in irrigation is a structural part of broader sustainable growth strategies** in rural economies, through enabling stronger forward and backward economic linkages.

Based on these three pillars, the final section of this report makes a series of recommendations for the major report audience which includes the government policymakers, representatives of International Financial Institutions, development partners as well as the private sector, including those working at a strategic level on policy design and implementation.

The authors recognize the significant heterogeneity of both agricultural systems and irrigation types in the Nile Basin, as well as the vast range of economic contexts between countries sharing this key resource. ***This report, therefore, does not detail all the complexity and issues of difference, but rather frames the major challenges at a basin level and elucidates the main principles informing a new generation of policies and investments in agricultural water management and development within the Basin.***

The recommendations and policy directions discussed in this report are based solely on the analysis and results of other study components (see appendices).

3 Background context

3.1 Agriculture in national development

The economic significance of the agriculture sector is substantial to all the Nile Basin countries but in varying degrees. It is an important contributor to the gross domestic product (GDP) in nearly all such countries (NBI 2012) and provides a significant proportion of employment and food demands in many of these states (FAO 2000; NBI 2012; Tesfaye et al. 2016). Between the countries, however, the economic structures and trends vary substantially. Egypt has by far the largest GDP [as well as the gross national income (GNI) per capita] and is also one of the countries that are most reliant on the import of food staples.

Persistent pressures on water resources within the Basin have existed and consequently been addressed for centuries. Currently, the situation is critical because of an accumulation of accelerating pressures from a range of drivers, from migration and rapid urbanization to forced displacement, climate change, economic development and transformation, energy demand, volatility of price and food insecurity, and low levels of youth employment. Within this complex of factors, water challenges lead to an ever-growing threat multiplier for the future stability and sustainable development of the Basin. At the same time, the

Nile Basin population has shown reluctance in harnessing emerging innovations, engaging in cooperation and seeking financing for mechanisms to address water-related challenges. Without serious actions taken collectively and cooperatively, the NB countries might forgo critical opportunities for economic development with immense potential impacts on the future well-being and social stability across the entire Basin.

Figure 1 depicts the contribution of key sectors to the national GDP in 10 of the 11 Nile countries. **Agriculture** includes farming, fishing and forestry; **Industry** includes mining, manufacturing, energy production and construction; and **Services** cover government activities, communications, transportation, finance and all other private economic activities that do not produce material goods. The graph shows that the contribution of Agriculture to the GDP is 40% or above in only three countries, with Ethiopia displaying the highest contribution and Eritrean and Egypt the lowest. Five countries have an agriculture sector contributing between 20% and 30% of the total share. However, this is a snapshot only from 2014. The trendlines since then, depicted in Figure 2 below, show a gradual decline in agriculture as a contribution to GDP; notably, however, there is a recent uptick in contribution in the past two years as some countries in the Basin have focused on greater development of the sector after years of neglect.

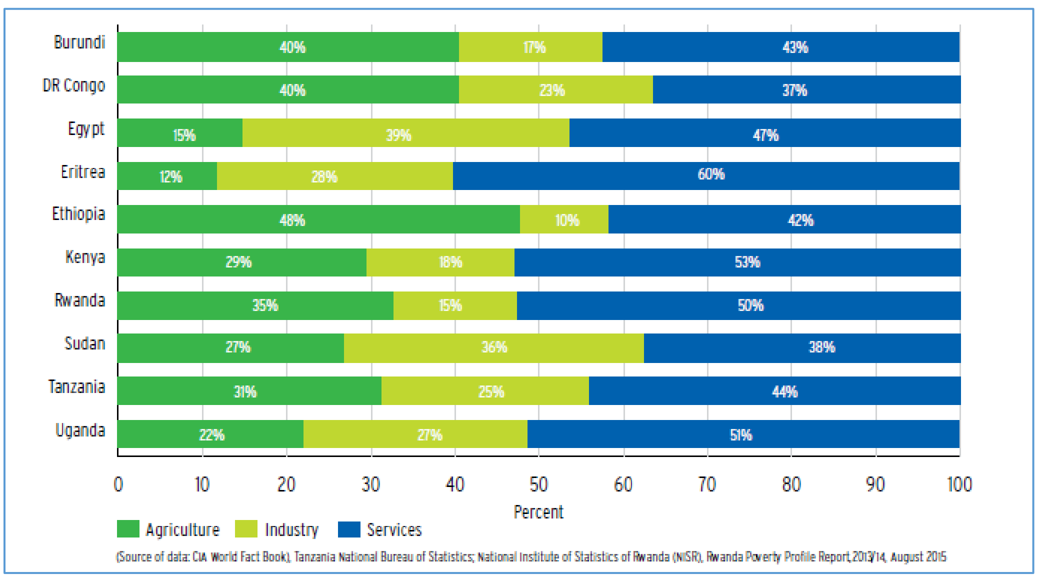

Figure 1. Contributions by sector to GDP, 2014 estimate

Source: NBI 2016

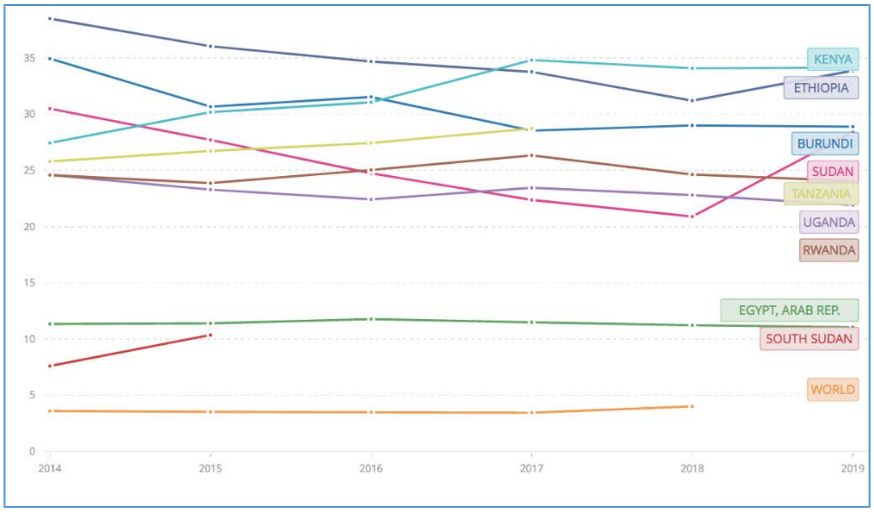

Figure 2. Agriculture GDP trends for Nile countries 2014–2019

Source: World Bank

Of the total land area of the Nile Basin, 49.8 million hectares is deemed suitable for irrigation, of which about 7.5 million hectares (Mha) is deemed 'highly suitable' defined as '*Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level*' (FAO 1976, 1985). In 2018, the total area irrigated (cropped) and equipped for irrigation in the Nile Basin countries was, respectively, about 6.96 and 6.26 Mha, registering an increase of 9.5% and 16.1%, respectively, from a 2015 baseline (Kahsay et al. 2019). Of the cropped (and irrigation equipped) area, the overwhelming majority (97%) is in Egypt and Sudan with the remaining 3% distributed across the other Nile countries. The dominance of these two countries in irrigated water consumption in agriculture is important in the context of the future agricultural challenges and opportunities facing Nile countries as they work towards achieving the Sustainable Development Goals[1]. To help explain the opportunities and challenges associated with this landscape of irrigation in the Basin, a typology of four systems was developed under this project's Technical Report 4 (NBI 2020a) and is discussed briefly in the following section.

In the Nile Basin, agriculture is the single-largest consumer of water. Total withdrawals for irrigated agriculture are about 78% of the peak flow of the river at Aswan (NBI 2012). Improving the productivity in both rainfed and irrigated agriculture is necessary within the Basin to improve the economic and food security situation of all riparian countries, with the emphasis on rainfed agriculture in countries where

[1] https://sustainabledevelopment.un.org/memberstates

this system predominates (principally high rainfall areas in upstream countries). In Sudan and Egypt, in particular, implementing effective water-saving methods and technologies in the large irrigation schemes of the lower riparian countries will enhance water availability to support environmental flows, a significant issue for Egypt's Nile delta, which is in effect the 'end of the system'. Future planned irrigation schemes in the Basin will benefit from considering the water-saving options listed in this report in their effort for furthering irrigation in the Basin (Component 3). Furthermore, this planning also needs to take place in the context of a 'whole system' view — encompassing the planning and development that accounts for the impacts on the Nile system both within and beyond national borders, including virtual water trading accompanied with cropping trade policy and economic diversification.

3.2 A typology of systems (yield and economic values)

A typology of the systems (Table 1) was created under Component 4 of the study to estimate the economic values of investments in irrigation across different contexts. The same typology is used here for connectivity and to align the analysis and the policies, namely an *intensive system in Egypt, a semi-intensive system in Sudan, an extensive highland system in Ethiopia,* and *an extensive lowland system in the Equatorial Lakes region.* This typology captures differences in biophysical conditions (agro-ecology, cropping pattern, irrigation water use in m^3/ha, etc.), productivity (yield in tons/ha), and degree of mechanization. Given the data limitations, including the challenge of data becoming outdated, there are no clear-cut boundaries between different categories, particularly between the extensive equatorial lakes and the extensive highland Ethiopia systems.

Table 2 shows the total yield by typology in the Nile Basin countries (tons/ha), while Table 3 shows the irrigation water applied by crop and typology in the Nile Basin countries (m^3/ha). The two tables are consistent in the result that the intensive system in Egypt reported higher yields of the same crops as compared to all other systems (typology). In addition, the intensive systems are generally marked by high inputs of resources, including water, and higher levels of use efficiency which is defined as the ratio of output over input or the ratio of water used over water diverted. Among the NB countries, Egypt has the highest total water use as well as the highest productivity across most crop categories. It also has the highest level of inputs and farm machinery use. In the semi-intensive system in Sudan, the rates of productivity for wheat, vegetables and banana are higher than what is produced in extensive highland and lowland typologies, except in the case of Kenya. On the other hand, in extensive highlands (in

Ethiopia), wheat, maize, sorghum, cotton, sweet potato, and sugarcane productivities are higher than those in the extensive lowland system. Except for water used in sugarcane in Ethiopia and Kenya, (NBI 2020) indicate that the irrigation water used in the intensive system in Egypt is almost twice that of semi-intensive systems, more than three times that of the extensive highland system and almost four times that of the extensive lowland equatorial lakes system.

In addition to yield and water use analysis, the economic value of crops that are dominant in each typology is also analyzed in this project, with certain limitations. The project only studied 9, 6, 9, 5, 4, 4, 3 and 5 major crops (in total 45 crops) for analysis from Egypt, Sudan, Ethiopia, Kenya, Burundi, Rwanda, Uganda and Tanzania, respectively. Three Nile riparian countries, namely DR Congo, South Sudan and Eritrea were not included in the study due to a lack of relevant data for South Sudan, and the insignificance of irrigated land in the Nile basin area of the other two countries. Compared to the other typologies, four crops were not cultivated in the extensive lowland, namely apple, potato, wheat, and millet.

Table 1. Systems typology in the Nile Basin

Source: NBI 2020a

Region- Country	Typology of systems
Nile Egypt	Intensive irrigation
Nile Sudan	Semi-intensive irrigation
Nile Ethiopia	Extensive highlands
Nile Uganda	Extensive lowland equatorial lakes
Nile Kenya	Extensive lowland equatorial lakes
Nile Tanzania	Extensive lowland equatorial lakes
Nile Burundi	Extensive lowland equatorial lakes
Nile Rwanda	Extensive lowland equatorial lakes

Table 2. Total crop yield by typology in the Nile Basin countries (tons/ha)

Source: FAO 1997

Crops	Intensive system (Egypt)	Semi-intensive system (Sudan)	Extensive highlands (Ethiopia)	Extensive lowland equatorial lakes (Kenya)	Extensive lowland equatorial lakes (Rwanda)	Extensive lowland equatorial lakes (Burundi)	Extensive lowland equatorial lakes (Tanzania)	Extensive lowland equatorial lakes (Uganda)
Rice	9.4			4.0	3.3	2.2	2.5	2.7
Wheat	4.5	3.2	1.7[2]					
Maize	7.4		2.8[2]			1.3	1.5	

Sorghum	4.5	1.5	2.6			2.0		
Cotton[1]	1.4	0.6	0.6				0.5	
Vegetables	24.6	11.2	5.2	13.5			6.8	
Potato	27.2		4.5[2]				5.3	
Banana	43.3	11.0	8.8	18.3		4.7		
Apple	25.7							
Millet		0.3						1.4
Sweet Potatoes			9.6	9.4	6.7			
Sugarcane			132.5[2]	81.7				
Groundnuts					0.5			
Cassava								3.4

Table 3. Irrigation water applied by crop and typology in the Nile Basin countries (M^3/ha)

Sources: IFPRI 2017; Agide et al. 2016

Crops	**Intensive system (Egypt)**	**Semi-intensive system (Sudan)**	**Extensive highlands (Ethiopia)**	**Extensive lowland equatorial lakes (Kenya)**	**Extensive lowland equatorial lakes (Rwanda)**	**Extensive lowland equatorial lakes (Burundi)**	**Extensive lowland equatorial lakes (Tanzania)**	**Intensive system (Uganda)**
Rice	20,038			5,883	455	1,377	2,923	3,746
Wheat	7,881	8,050	4,385					
Maize	6,473		1,972		25		1,175	
Sorghum	5,737	4,677	1,972		1,285			
Cotton	6,001	5,014	3,271				3,850	
Vegetables	5878	4,883	4,382	3,939			3,862	
Potato	8,479		838[2]					
Banana	5,962	4,973	1,863	2,923	1,336			
Apple	6,080							
Millet		5,016						
Sweet potato			838	3,862		334	1,002	1,278
Sugar cane			20,373[2]	11,848				
Groundnut						2,165		
Cassava								1,243

[2] Hagos et al. 2008

Figure 3 shows the value of irrigation water, considering the farm gate price (USD/m^3). In the intensive system, apple (the only crop reported in this typology), has the highest water value followed by banana, cotton, potato, maize, wheat, vegetables, sorghum and rice. In the semi-intensive system, banana and vegetables displayed the highest water value followed by cotton, wheat, sorghum and millet. In the extensive highland system, sweet potato had the highest water value, followed in turn by banana, sorghum, cotton, and vegetables. The value of water for selected crops of smallholder irrigation from the

Koga Scheme and the Finch Sugar Plantation in Ethiopia indicated that sugarcane has the highest value of water followed by potato, maize and wheat. In the extensive equatorial lakes region, the values of irrigation water for banana were USD 990.75/m^3 and USD 0.20/m^3 for Kenya and Burundi, respectively.

Compared across typologies, using the farm-gate scenario, the value of irrigation water for rice, a crop grown across typologies, in Egypt, Burundi, Kenya, Tanzania and Uganda is USD 0.09/m^3, USD 0.07/m^3, USD 0.38/m^3, USD 0.01/m^3 and USD 0.01/m^3, respectively. This value is lower in the lowland typologies compared to intensive typology, except in the case of Tanzania. The value of irrigation water for vegetables in the extensive highland (USD 0.03/m^3) is lower than the one estimated in intensive (USD 0.12/m^3) and the semi-intensive typology (USD 0.09/m^3), as well as in the extensive lowland condition found in Kenya (USD 0.37/m^3) and Tanzania (USD 0.05/m^3). The estimated value of irrigation water in growing banana in the intensive system is USD 0.68/m^3, higher than semi-intensive (USD 0.21/m^3) and extensive highland (USD 0.11/m^3) and in Burundi (USD 0.20/m^3), but lower than lowland typologies in Kenya (USD 0.75/m^3). The value of water for cotton in Egypt, Sudan, Ethiopia, and Tanzania is USD 0.25/m^3, USD 007/m^3, USD 0.04/m^3, and USD 0.01/m^3, respectively, implying that it is more economical to grow cotton in extensive highland and lowland typologies than in intensive and semi-intensive typologies. The value of water for sweet potato in Ethiopia, Kenya, Rwanda and Tanzania is USD 0.25/m^3, USD 0.37/m^3, USD 0.30/m^3, and USD -0.21/m^3, respectively, implying that it is economical to grow sweet potato in extensive highland typologies compared to lowland typologies. This highlights the need for the virtual water policy basis the crops cultivated to reach high levels of value and efficiency.

When looking at the global price scenario, the value of irrigation water for rice in Egypt, Burundi and Kenya is USD 0.15/m^3, USD 1.00/m^3, USD 0.03/m^3, respectively, but it was found to be unfeasible in the case of Tanzania and Uganda. The value of irrigation water for rice is lower in Kenya compared to that of the intensive typology. The value of water for vegetables in the extensive highland (USD 0.03/m^3) is lower than the one estimated in Tanzania (USD 0.05/m^3), in the intensive typology (USD 0.12/m^3), in the semi-intensive typology (USD 0.09/m^3) and in the extensive lowland Kenya (USD 0.37/m^3), implying that it is water-expensive to grow vegetables in the intensive and the semi-intensive typologies in comparison to cultivating the same in the extensive highland.

The water value estimates for the banana in the intensive, semi-intensive, extensive highland and extensive lowland are USD 2.62/m^3, USD 1.61/m^3, USD 3.22/m^3, and USD 2.54/m^3 (average), respectively.

This indicates that it is water-expensive to grow banana in the intensive typology, extensive highland and lowland extensive highland in contrast to the semi-intensive typology. It is still economical to grow banana in Burundi compared to the intensive, extensive highland and semi-intensive typologies. The value of water for cotton in Egypt, Sudan, Ethiopia, and Tanzania is USD 0.26/m^3, USD 0.07/m^3, USD 0.04/m^3, and USD 0.02/m^3, respectively, implying that it is more cost-effective to grow cotton in the extensive lowland typologies than in the intensive, semi-intensive typologies and extensive highland. The value of water for sweet potato in Ethiopia, Kenya, Rwanda and Tanzania is USD 1.65/m^3, USD 0.63/m^3, USD 1.45/m^3, and USD 0.31/m^3, respectively.

Analysis of trends in both the scenarios (farm gate as well as global price) indicated that the value of water for crop categories in almost all typologies is higher under global price scenarios. While the value of water for perennial crops (only banana) is highest in the intensive typology (except for Kenya from the lowland extensive) and lowest in the extensive highland under the farm-gate scenario, the reverse holds true under global price scenarios. The value of water for vegetables is highest in intensive typology (the exception is Kenya from the lowland extensive) and lowest in the extensive highland under both farm-gate and global price scenarios. The value of water for staple crops (including rice), under farm-gate and global price scenarios was the highest for intensive irrigation typology and extensive lowland (particularly Burundi), while the lowest was for extensive highland, semi-intensive and lowland extensive (particularly Tanzania). The water value for root crops was the highest in Uganda and lowest in extensive highland under farm-gate scenarios. Under global price scenarios, water value for root crops was the highest in extensive highland and lowest in Uganda. The water value for industrial crops was the highest under intensive and lowest in lowland extensive (in particular Tanzania) under both farm-gate and global price scenarios. Moreover, the value of the water of many staple crops, especially in the extensive highland and lowland, was negative under global price scenarios.

The economic value of irrigation water (Figures 3 and 4) needs careful interpretation, as crop price, yield and water applied are real contribution factors, and they are prone to seasonal changes. Crop prices also significantly contribute to the differences in the economic value of water across crops within the same typology as well as similar crops in other typologies/countries. Since crop prices positively influence the economic value of water, the producer prices of crops used in this study (which may differ across crops and countries) are expected to have a significant effect on the estimated water values. Accordingly, perennial and vegetable (cash) crops that command higher market prices tend to generate a higher value of water compared to food crops that command relatively lower prices. Besides the yield differences between cash and food crops, the variations in water consumption across crops determine the differences in the economic value of the crops. The novelty of this approach was in estimating the basin-wide economic value of water for 14 crops in the 4 typologies where the level of intensification and the value of water are different. In estimating the value of irrigation water, the economic study used farm-gate prices and global prices, with the latter being utilized to account for the effect of price distortion.

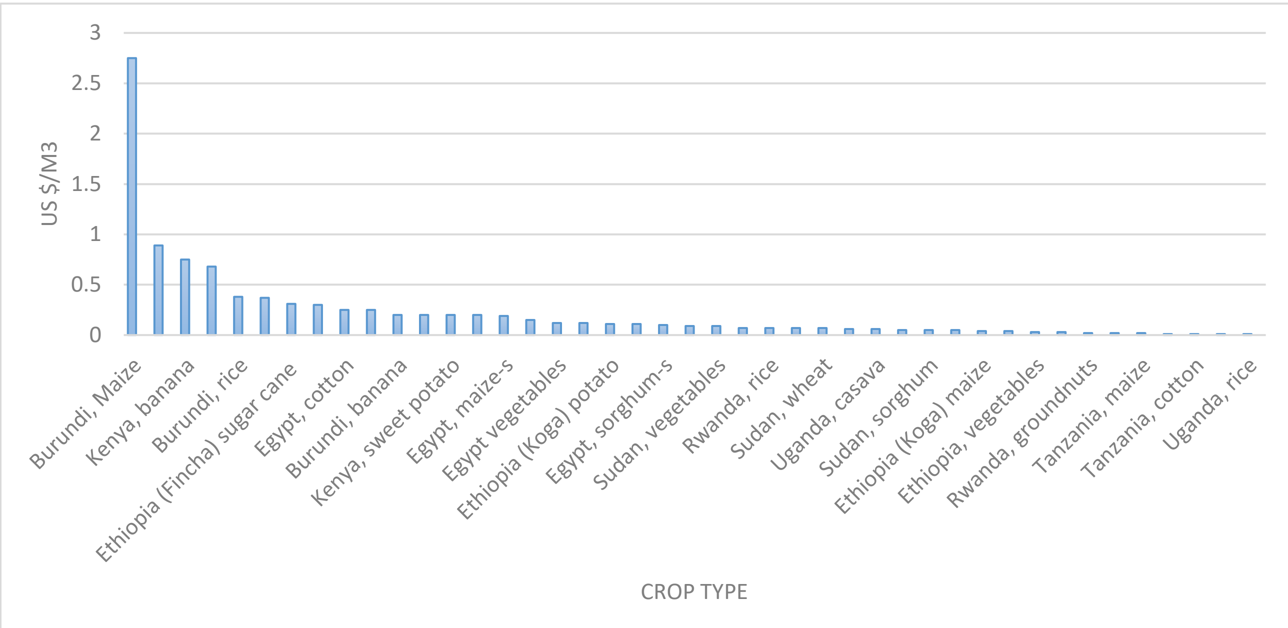

Figure 3. Value of irrigation water considering farm-gate prices in USD/m^3
Source: NBI 2020a

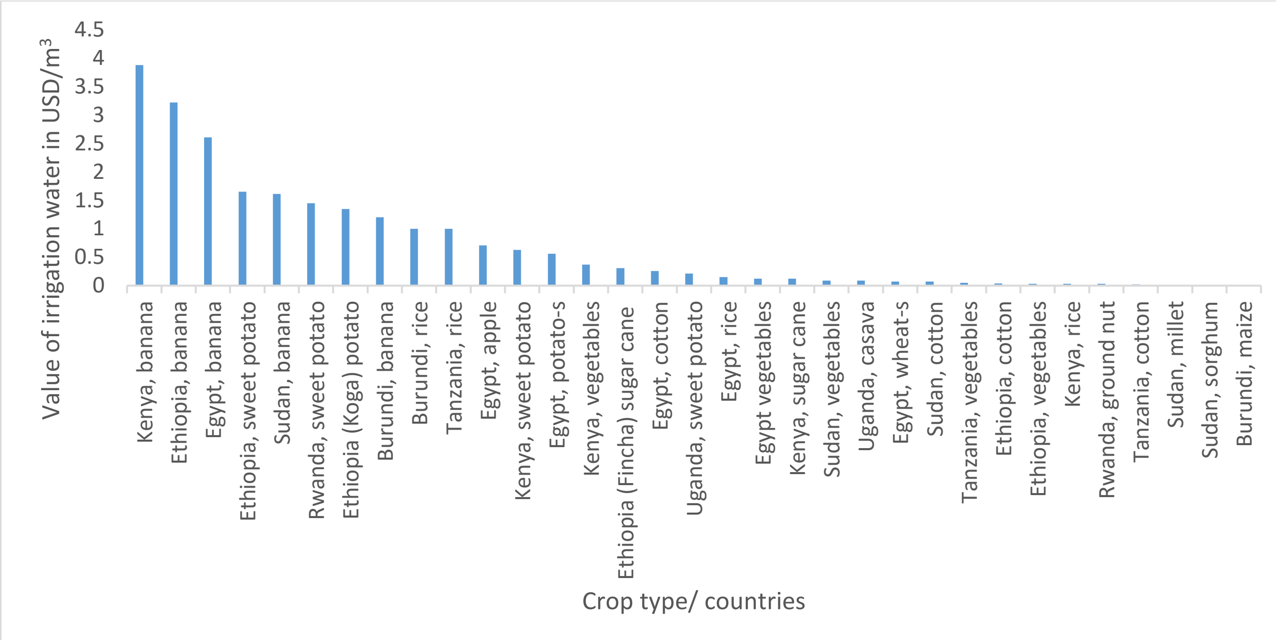

Figure 4. Value of irrigation water considering global prices in USD/m^3 (omitted negative values)
Source: NBI 2020a

3.3 The data challenge

In the study, the value of irrigation water across different systems displayed wide ranges, and the accuracy of the estimation was adversely affected by data availability and documentation. The quality of the data, together with its availability and accessibility, was reported to be a major hurdle. Some of these limitations included the issue of data being rendered obsolete, and the paucity of accurate data on water consumption at the field level, irrigation efficiency, crop yield and productivity per system and topology as well as the crop price at the farm-gate. In addition, irrigated or rainfed areas are also inconsistently demarcated in different reports, policy and strategic documents, between different departments within the same country, and at times even within the same agency/department/ministry. A key future effort essential for enabling stronger comparisons quickly became apparent, i.e., the establishment of an approach and protocol for data collection, archiving, standardizing and sharing. The idea of data integration was also reported within the baseline and benchmarking components under this study.

At present, Nile countries have insufficient documented information on the area of irrigation and associated fields. One of the key tasks of the Nile-Sec is assisting member countries to devise strategies that help balance the available water in the Basin with the ever-increasing irrigation water demand. This requires considerable institutional capacity development to enable data collection, analysis and storage. Nile-Sec should initiate a program to enhance the capacity of the member states' relevant institutions by building on the experience of countries such as Egypt, where a concerted effort of policymakers, practitioners and research institutions has been developing since 1952. The benchmarking study (NBI 2021) under Component 5 of this assignment can be used as a vital entry point to facilitate coordination with relevant institutions, enable joint planning efforts, and undertake co-implementation and co-evaluation of works to improve existing irrigation systems.

3.4 Irrigation in the One-Nile system

A combination of the growing demand for water and climate uncertainty is likely to induce future water stress and absolute water scarcity in parts of the Nile basin. In some regions, there even may be an increase in the overall precipitation (Coffel et al. 2019). In response to the same, in 2015, the Nile-Sec conducted a Strategic Water Resources Analysis (SWRA) to identify sustainable options for satisfying the growing water needs in the riparian countries and to find ways of mitigating current and future water stress.

One common feature across much of the Basin is the changing nature of rainfall patterns and the increasing likelihood of more extreme weather events in the future (Eckstein 2009). Overall, higher temperatures will increase evaporation rates from existing and new reservoirs and the field irrigation, leaving less water available in storage — and in the soil profile — for agricultural, industrial, and municipal use. Higher temperatures will also increase crop evapotranspiration rates. For example, an increase of even 3°C will raise the crop water requirements for the existing crop mix in the Basin by approximately 10%, according to one source (Jeuland 2009).

A combination of increased evaporation, crop water requirements and household water demand will constrict the overall water balance throughout the Nile Basin (Whittington et al. 2014), along with the emergence of specific 'hotspot' areas such as Egypt and Sudan along the basin. With increasingly uncertain precipitation regimes and, hence, surface water availability, this will further skew the mismatch between supply and demand. The Nile Delta in Egypt is one such specific hotspot where the combination of sea-level rise and uncertainty about freshwater availability could entail a potentially catastrophic loss of agricultural land in Egypt. To avert the crisis, massive population resettlement and/or considerable investment in protective infrastructure along the Mediterranean coast would be vital (Whittington et al. 2014).

Tackling this 'demand gap' in parts of the Basin will necessitate innovations at a technical level in terms of both demands- and supply-side measures as well as improvements in management systems. Future measures to help alleviate resource pressures may include more sustainable groundwater abstraction, increased rainwater harvesting and conservation, improved soil water retention in all countries, enhanced productivity and water-use efficiency both upstream and downstream, and increased and safer reuse of wastewater. Pollution control measures are equally significant, as surface and groundwater pollution, soil erosion, and salinity development are already severe in the Basin (NBI 2012). These pose a further risk for further irrigation expansion through depleting the stock of available irrigable water.

In addition, the scenario analysis conducted in this study looked at the seasonally conjunctive use of surface-ground water as one potential technique, which can provide a significant water-saving opportunity in the Basin. In this context, the maximum use of groundwater is during the hot season of June to September and surface water is in winter (within the lower riparian countries of Egypt and Sudan); this allows for saving more water in the cool upland reservoirs, rendering additional water-saving capabilities. It is suggested that 5–10 billion cubic meters (BCM) in Sudan and 10–20 BCM in Egypt’s groundwater could be available for conjunctive use by 2050 (Component 3). Nonetheless, groundwater resources also need to be studied well and incorporated in the water-saving plans of the upper riparian states. Groundwater is a vital resource in the Basin and demands in-depth investigation coupled with conjunctive management with surface water.

The next section explores the need for change amidst a set of competing and complex agricultural development challenges.

4 Common challenges and the need for change

4.1 Economic transformation amidst a climate crisis

Uncertainties surrounding climate impacts include the intensity duration and spatial distribution of rainfall in the Basin. Consequently, some countries are and will face rising physical and economic water scarcity and will need to adapt their water development and management systems to meet the demand. In some cases, substantial transformations in how and where water resources are captured, stored and utilized would be vital. Key points arising from the study components include the following:

- **Nile countries and societies have coped with water scarcity in the past — the new challenges are more predictable but go deeper.** Nevertheless, future population change, urbanization, environmental degradation, agricultural development and climate change dynamics will herald new and more intensive challenges for planners and policymakers.
- **Water availability in the Basin is sensitive to climate change.** Climate projections suggest that, by the end of the century, the amount of rain in the Upper Nile basin could increase by up to 20% (Coffel et al. 2019). Despite more rainfall, devastatingly hot and dry spells are also projected to become the new normal in the Upper Nile basin by a factor of 1.5 and 3 (causing hot and dry year occurrences once every 6–10 years). By 2040, the share of people in the region facing water scarcity could reach 35% (amounting to >80 million people, based on current population levels). These conditions will coincide with rapid population growth, with the basin population level anticipated to double by 2050. This will, in turn, further increase water stress in the region, irrespective of the anticipated rainfall increases (Coffel et al. 2019).
- **Agricultural expansion, including irrigated agriculture, will remain a phenomenon of the twenty-first century**. Alexandratos and Bruinsma (2012) estimate that nearly all further agricultural expansion in the world (both irrigation and rainfed) will take place in developing countries. The overall arable land development is projected to increase by an additional 107 Mha (from 968 Mha for the reference period of 2005/07 to 1,075 Mha in 2050), representing an increase of 11% (Alexandratos and Bruinsma [2012]). The bulk of this projected expansion is expected to take place in Sub-Saharan Africa (51 Mha) and Latin America (49 Mha). Since many Nile countries display high population growth and food demand, hence irrigation expansion is anticipated to grow more rapidly here than in other parts of the world. As a sample indicator of the recent growth of irrigation at the national scale, the NBI Irrigation Assessment Report for Nile Equatorial countries (NBI 2012) registered an increase in the irrigated area of 42,000 ha in Burundi, 338,000 ha in Kenya, 1,012,000 ha in Tanzania, 1,151,000 ha in Uganda and 628,000 ha

in South Sudan within the Basin. Except for Egypt, irrigation has also witnessed an expansion in Ethiopia and Sudan (Section 4.1, Table 7 NBI 2020b). This study also indicates that the total cropped and equipped area in the Basin expanded by 34.2% and 22.2%, respectively, when compared to the 2015 baseline data between 2015 and 2019.

- **By 2050, Africa's population is expected to have reached about 2.5 billion people according to UN median projections (of which the projected population of Egypt, Sudan and Ethiopia alone will amount to some 440 million).** Fast-growing populations will exacerbate prevailing water stress if current land and water management practices remain fragmented and managed only as discrete units, and not as part of a wider Nile system. Tackling the Basin's high rates of population growth (about 2% per annum on average compared to 1.1% at a global level) is important because swift, unchecked growth (in the context of few alternative livelihoods) leads to rapid pressure on fragile land and water resources with concentrations of populations in urban pollution hotspots. Further stress may also be placed on marginal lands where the risk of adverse climate impacts is even greater. As incomes rise, the lifestyle changes may call for different diets which in turn can generate rising demand for water-intensive animal production. As resource pressures increase, land degradation may rise, affecting runoff and generating greater environmental hazards such as declining groundwater, flash flooding and associated sedimentation of reservoirs, which becomes the most common form of 'strategic storage'.
- **High levels of rural, youth unemployment and underemployment help drive internal migration to urban centers.** Rural unemployment in the NB countries is high, averaging at about 13%. These rates are higher for women than men, and even more steep for the youth — 26–53%, depending on the country. The challenge is to harness the growing youth bulge as it becomes economically more prudent to help drive the growth of new industries that can provide non-agricultural occupations. It is at this juncture where the link between investment in irrigation, development of more productive farming and wider economic sector development is of key importance. The need to shift from a situation in which more than 75% of the labor force in the Basin is engaged in subsistence agriculture and about 40% of the population lives below a poverty line of USD 1.25 per day (NBI 2016) to one which allows youth to move into alternative productive livelihoods — whether urban or rural — is indispensable in all the Basin countries.

4.2 Overcoming barriers to achieving the Sustainable Development Goals

- **Droughts and floods create serious social and economic shocks**. The loss of life and decline in the GDP in the developing countries can reach more than 10% on an annual basis due to climatic calamities such as droughts and floods (FAO 2015). The agriculture sector commonly absorbs about 22% of the total damage and losses caused by natural hazards (FAO 2015). For example, agriculture consumes about 85% of the water resources and contributes 20% of the total GDP in Egypt, making it highly vulnerable to changes in the Nile flow as a result of droughts.
- **Chronic food insecurity is an ongoing concern in many Nile Basin countries**. The Nile Basin is one region where per capita food production is either in decline or roughly constant, but at a level that is less than adequate (NBI 2019). Nations facing food insecurity issues can have populations that are under- and mal-nourished. This can have long-term health, morbidity and other major social and economic impacts. This will diminish growth and economic resilience in the enduring future.
- **SDG 1 on eliminating poverty and SDG 2 on zero hunger will be difficult to meet unless agricultural water management issues are addressed, and progress on SDG 6 is made.** In the typology of four systems, increasing water productivity per crop and achieving higher efficiency in all systems (per system capacity) is an important first step. This includes ensuring that the systems maintain good water quality as well, given upstream/downstream water quality challenges. Effective monitoring of both quality and quantity requires more hydrological systems monitoring and data sharing within and between countries. These were reported as limiting factors in Components 1 and 4 in this assignment for baseline data and water values, respectively.

4.3 Managing the intensification-expansion relationship

Most of the Basin countries seek expansion of irrigation to enhance food security and foster economic growth and transformation; others, due to expansion constraints, seek to focus on increasing use efficiency. Component 1 (baseline data) found that the cropped area in Egypt is 174% of the area equipped for irrigation, implying that about 74% of the area is used for at least two or three cropping cycles per year. Sudan, by contrast, seeks irrigation expansion using Nile water due to a loss of oil revenues as a result of the secession of South Sudan in 2011. Upstream countries (especially Ethiopia, Kenya, Sudan and Tanzania) have a cropped area that is less than the area equipped for irrigation due to a mismatch between the available water supply and demand and the planned expansion in irrigation land. This needs rationalizing the expansion and intensification and examining the reuse of drainage water and other sources.

The main sources of funds for management, operation and maintenance of irrigation and drainage systems (including infrastructure, institutions, and information) are government subsidies, revenues from irrigation service fees, and other secondary revenue sources. This involvement of public finance for irrigation has a cost to the central finance ministries and represents a growing fiscal burden, which is leading to a shrinking fiscal space and low financial viability of irrigation authorities. In the intensive irrigation and semi-intensive irrigation systems, a combination of irrigation and drainage infrastructure, soil salinization, and low land and water productivity in these systems suggests that a) there is much room for improving the quality of spending in agricultural water, and b) there is scope to raise the level of spending to cover operation and maintenance needs.

As far as existing conditions are concerned, it is generally recognized **improving rainfed agriculture** (semi-intensive, extensive highland and extensive lowland equatorial lakes typologies) will have a greater impact on developing the economic and food security situation of these topologies. Improving the rainfed productivity can lower the rate of irrigation expansion by 25% and 50% in 2030 and 2050 respectively, (Component 3) as other regional studies have also indicated.

5 Build new policies on a common set of principles

To establish a strong platform on which to build future irrigation development policies, a common set of principles is presented as follows:

1. First, the **Nile Basin is one-system** through which efforts should be strengthened around achieving greater cooperation and harmonization of water resources policy development and implementation;
2. Second, successful achievement of key SDG goals on poverty and food security requires a constant effort at **improving the functioning and efficiency of irrigation** at all levels — from smallholder farmers to large-scale systems — to maximize social, economic and environmental returns to water use (in combination with other inputs); and

3. Third**, the irrigation economy needs to build coherence and better linkages to other sectors** to ensure that investment in irrigation is a structural part of broader sustainable growth strategies in rural economies by enabling stronger forward and backward economic linkages.

5.1 Achieve one-system planning

This notion of a shared river basin system is becoming ever more vital in transboundary water governance, not least in part due to the mounting population and climate change pressures. This involves coordination and harmonization, to the extent possible, of different legal, policy and regulatory systems, eliminating major differences and creating minimum requirements or standards. This is a long-haul task, but one that is ultimately beneficial for the needs of the 'whole system' management, which implies strengthening cooperation not just between states (and sectors), but also vertically, from the farmer and other users to the multilateral level.

A key part of this one-system view is the achievement of inclusiveness, and the fair distribution of costs and benefits among the Basin countries, among sector stakeholders, and especially in terms of gender equality. The major motive for inclusion must be a mutually agreeable and inclusive approach to develop irrigation so as to enable the riparian countries to lift millions out of poverty, and thereby help achieve SDG1 targets. In practice, this means ensuring within the design, implementation, monitoring and evaluation stage of each investment and policy, the inclusion of an explicit poverty-reduction focused approach. This approach should be centered around a strong gender-based understanding of how smallholder producers (farmers, and their organizations) with agribusiness enterprises and supply chains can help achieve more sustainable and effective participation in rapidly changing global, regional and national markets — focusing on support measures for groups affected by transitions in the agriculture sector.

5.2 Increase efficiency

Enhancing irrigation efficiency in the Basin, especially in the large-scale irrigation schemes (such as in Egypt and Sudan) is a key priority because of the huge volumes of water being consumed. It is suggested that a maximum of 20–30% improvement in the overall irrigation efficiency is feasible, and most importantly, in traditional irrigation systems (Component 3). Efficiency improvements of 5–15% and 15–

30% can be targeted to be implemented by 2030 and 2050, respectively (Component 3). However, efficiency improvement needs to be implemented hand-in-hand with other water-saving measures.

Improving the functioning and efficiency of irrigation at all levels requires several important steps. One of the first is to assess scale suitability. This requires governments and countries to assess, design and implement the appropriate policies for specific levels and topographies (Figure 5), with considerations of what works best, how, and where? This calls for cooperation between the Basin countries and individual country-specific policies, taking into consideration local conditions and contexts. The typology of systems presented in this study will require a range of tailored resource use efficiency interventions — given the wide contextual differences, there is no single, common approach.

<table>
<tr><th colspan="4">Scale</th></tr>
<tr><td colspan="4">Basin- Regional</td></tr>
<tr><td colspan="4">Country</td></tr>
<tr><td colspan="2">Rainfed -Irrigation
(Extensive highland and extensive lowland equatorial lakes typology)</td><td colspan="2">Irrigated
(Intensive and semi-intensive)</td></tr>
<tr><td>Old</td><td>New</td><td>Old</td><td>New</td></tr>
</table>

Figure 5. The hierarchy and linkage of scales into the NB

5.2.1 Improving cropping pattern

Improve cropping patterns, which can be achieved by setting a cropping pattern at local and Basin scales. These cropping pattern changes must be implemented on existing large-scale irrigation schemes of high water-consuming crops such as sugar cane and rice by shifting to upper riparian countries or reducing and/or changing to other crops which consume lower amounts of water (i.e., sugar beet). As part of the Basin cooperation and virtual water trade, it is recommended that parts of rice and sugar cane productions can be shifted to humid tropical climate regimes as regional cooperation takes hold in the Basin — considering the political and social contexts of those regions and viability of continuing to cultivate these crops from a Basin perspective. Highland countries with lower evaporative demand (e.g., Ethiopia) and equatorial countries with long rainfall seasons (e.g., Uganda) may be pursued to shoulder this regional responsibility. Expansion of newly planned irrigation areas in all the Basin countries must consider optimal cropping patterns at local and Basin scales through cooperative engagement and discussion.

5.2.2 Application of Water Deficit Irrigation where and when suitable

Promote Water Deficit Irrigation (WDI) for selected and water stress-tolerant crops**.** There is great potential for the implementation of up to 20% deficit irrigation in the Basin and locally without noticeable yield reduction on selected crops in the large irrigation schemes in the lower riparian countries and for the upper riparian countries (utilizing new schemes). Commercial farm developments, in particular, need to adapt to the deficit irrigation system as deemed appropriate.

5.2.3 Wastewater use

Adjusting economic incentives could be a means to promote the expansion of treated wastewater reuse. This has the potential to alleviate the pressure on the surface water in the Basin where the population is registering an increase and at the same time, generate untapped wastewater resources — around 80% of collected wastewater is not treated or reused. Improving and promoting cost recovery in irrigation systems through service fees, extending wastewater management and treatment and developing incentives for water quality management (for instance, polluters pay principles) could contribute to increasing the coverage of wastewater treatment, helping make a stronger economic case for reuse.

5.3 Build coherence and linkages

Building coherence and linkage to other sectors is a key element of ensuring that the irrigation sector development is incorporated within wider growth and development policies and processes. This is essential, particularly in light of the need to **build more resilient economies** and to tackle the 'youth bulge' in demand for employment.

Ensuring coherence involves **avoiding market distortions**, and negative spillovers in agricultural water and crop policies, which have the ability to undermine agriculture's value-added, negatively affect sustainability and compromise food security. In addition, it also calls for careful consideration of each country's policy interactions across the water, agriculture and social protection interface, to incorporate irrigation development into social protection policy instruments. This will help advance specific poverty elimination and other social objectives including, for instance, achieving greater gender equality.

Central to the task of establishing forward and backward linkages in the economy is to **ensure a continuous process of innovation.** This means harnessing new technologies that can bring to light opportunities to access and use new cost- and environmentally-effective sources of water (such as shallow groundwater using solar technology with new methods of reusing wastewater as well as managed aquifer recharge). But equally, if not more important, is the continued innovation in water management and governance techniques both via water data acquisition and analytics and water accounting, as well as by ensuring that the voice and choice of the poorest in resource management remain fundamental.

Establishing **basin-wide tools for measurement, monitoring and evaluation mechanism**, with continuing investment in hydro-met network with standard water and irrigation data measurement, monitoring and evaluation system agreed and approved for accurate water prediction, water-saving and accounting of the regional resources will be critical.

Valuing water is another essential part of the Basin's policy agenda, which can be pursued in many different ways. Measurement underpins valuation, so the first step is to fill in the persistent and glaring gaps in knowledge about water quantity, quality, usage and waste. This can be achieved by a robust and adept usage of the digital revolution, through harnessing developments in water measurement, accounting and modeling technologies. These technologies can also be leveraged to support institutional development for improved governance in the water sector.

At the cutting edge of **innovation in some environments** — particularly the remerging peri-urban and urban agriculture sectors — will be the acceleration in the usage of digital technologies to boost water productivity and increase knowledge on water availability and quality.

A focus on **increasing the productivity and efficiency** in agricultural activities with export potential, such as fresh fruits and vegetables, and a transition away from a self-sufficient food policy towards a Basin-sufficient policy with crop trade policy and Basin subsidizing is important. Given the current disparity in the performance of different irrigation schemes across the riparian countries, short-term initiatives to achieve the same may include experience exchange forums, while in the long run, strengthening and expansion of irrigation benchmarking practices would be key.

Sustainability cuts across all **policy development processes** and, the authors argue, ensuring adherence to the three policy principles will help support long-term social, technical, environmental and financial sustainability.

Private sector engagement requires governments to enable the same (such as in urban and renewable energy sectors), both for financing as well as knowledge transfer and capacity building. This can be undertaken in areas such as agricultural extension, public-private policy dialogue for value chain development and PPPs. More generally, it calls for the existence and proliferation of market-equity policy instruments with a degree of competitiveness that does not crowd out private sector investment.

6 Establish the right environment for implementation

- In applying and pursuing the recommended strategic directions, countries need to **capitalize on basin knowledge network**s and the existing institutions of cooperation.
- The NBI needs to continue to **invest in hydro-met data and strengthen multi-stakeholders** around emerging themes, such as 1) communication between basin management authorities, 2) use of digital technology in agriculture and agricultural water management to help develop new levels of data quality and use, and 3) promotion of stronger public-private policy on engagement in agri-business sector development.
- The NBI could also spearhead efforts to **develop a basin water accounting database** to assist in efforts at strengthening the data environment.
- The process of **implementation of policies and investments** is challenging because it spans multiple stakeholders and various levels of decision-making — often embedded in complex political economies. Indeed, big decisions such as investment in farming and irrigation versus an increasing reliance on external food imports are essentially political in nature. But putting forward a rationale case for irrigation development based on cooperation, efficiency and linkage to wider development goals is yet to be achieved at a basin level.

- Governments need to take the lead in making this case, but also bring other stakeholders to the table along with them, i.e., **adopting more bottom-up planning and implementation**. This will help in strengthening agricultural self-reliance and ensure rationale decisions are taken concerning the agricultural water investments – where they are part of a bigger picture of system management, where they are economically, socially and environmentally efficient, and where they are part of a wider, more coherent, national development vision where the tenets of poverty elimination and equality (including gender equality) are central.
- Implementing these policies and directions requires **governments and basin authorities to invest in institutional reform, arrangements and incentives.** Furthermore, this reform needs to be streamlined within countries and across sectors. The same should be accompanied by governments which should also ensure that the quantity and quality of spending is appropriate and proportionate to the anticipated development outcomes.
- At the same time, it should be noted that governments cannot do this alone. **Promoting private sector engagement and representation of the local agribusiness industry** is essential. The private sector needs to contribute through technical support services by utilizing high-value crop export opportunities and advocating for improved value chain coordination mechanisms.
- **Multilateral development banks** (which may even be joint ventures of the Basin countries and not necessarily external) can act as a catalyst for innovation and promoter of disruptive technologies in the sector. They can help develop innovative financing mechanisms and partnerships to deliver necessary agricultural water investments in situations of conflict and post-conflict.
- Finally, **basin organizations need to establish their convening power** to assert the centrality of agricultural water to the SDG agenda, promote knowledge exchange and transfer and lastly, catalyze collective action to address agricultural water challenges.

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