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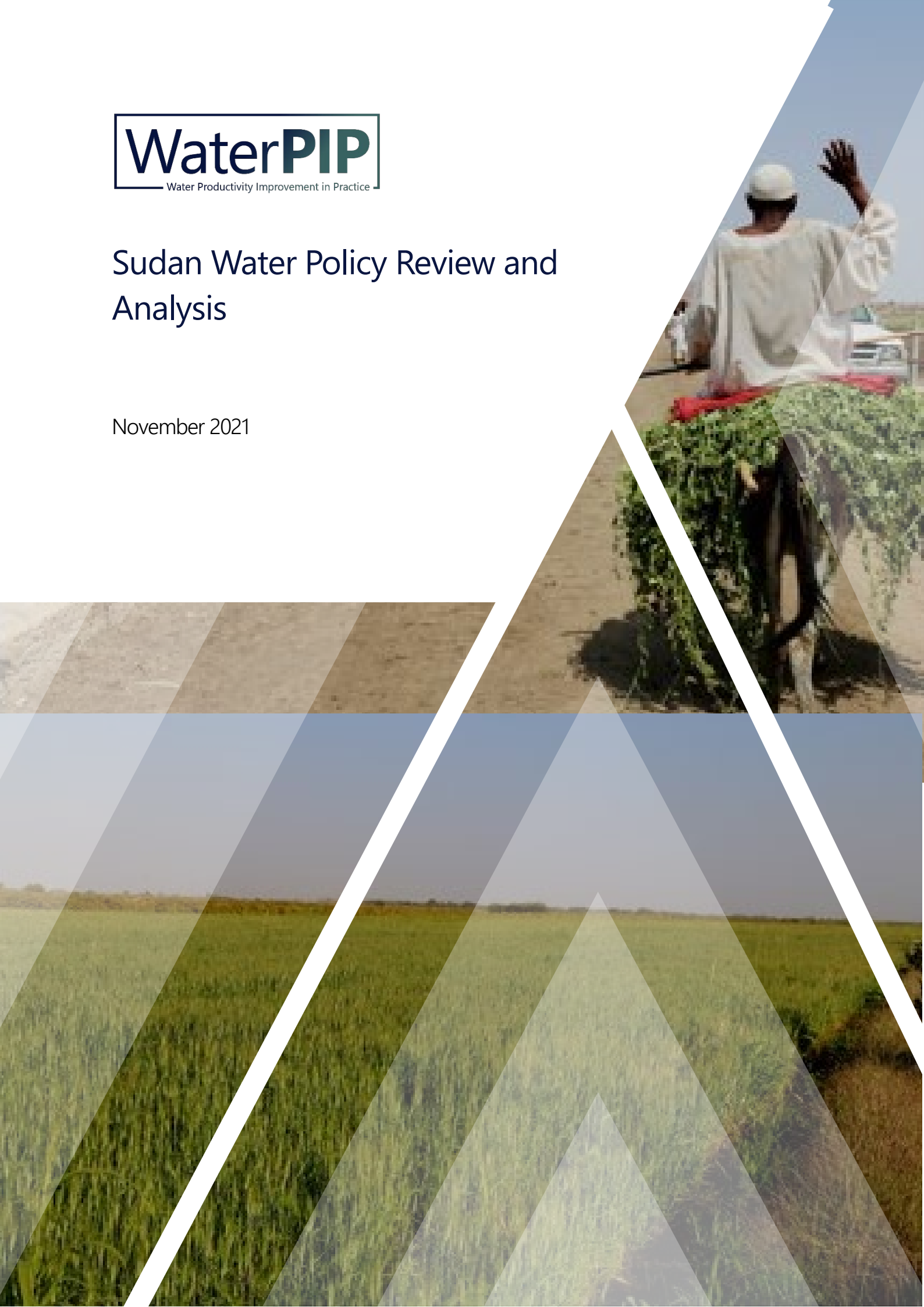
Water Productivity Improvement in Practice

Sudan Water Policy Review and Analysis

November 2021



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Prepared by MetaMeta

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Prepared by Esmee Mulder and Frank van Steenbergen (MetaMeta), duly acknowledging the review by Wageningen University and Research and IHE Delft Institute for Water Education

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The views expressed in this publication are those of the author(s) and do not necessarily reflect the views of DGIS, DUPC2, or its partners.

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Acronyms

ARC	Agricultural Research Corporation
EMC	Earth Moving Cooperation
HRC	Hydraulic Research Centre
FAO	Food and Agricultural Organisation of the UN
FOP	Field Outlet Pipes
GDP	Gross Domestic Product
GSA	Gezira Scheme Act
GSWI	Global Solar-and-Water Initiative
IARP	Irrigated Agriculture Rehabilitation Programme
IOD	Irrigation Operations Directorate
IRWR	Internal Renewable Water Resources
MoIWR	Ministry of Irrigation and Water Resources
NCWR	National Council for Water Resources
NGO	Non-Governmental Organizations
NWAP	National Water Resources Allocation Plan
O&M	Operation and Maintenance
R&D	Research and Development
SIWI	Stockholm International Water Institute
WAP	Water Allocation Plan
WaPOR	FAO portal to monitor Water Productivity through Open access of remotely sensed derived data
WP	Water Productivity
WUA	Water User Association

1 Water resources and agricultural productivity

Sudan is a water scarce country with the Internal Renewable Water Resources (IRWR) estimated at 32 billion m^3/year bringing the per capita water availability below the water stress threshold of 1,000 m^3/year (MoIWR, 2021). The Nile river contributes the largest share – 20.5 billion m^3/year measured at the Sennar Dam on the Blue Nile (Elamin, 2013). This amount is in line with the 1959 agreement that governs the Sudan water share of the estimated 84 billion m^3 annual average Nile river flow recorded at the Egyptian Aswan Dam at the border between the two countries (FAO, 2015). The seasonal streams and groundwater resources provide about 6.7 billion m^3/year and 4.8 billion m^3/year respectively (MoIWR, 2021). Rainfall is marked by erratic intensity, large seasonal variability, uneven distribution and concentration in a short-wet season. Average annual rainfall is 200 mm/year, but ranges from 25 mm/year in the dry north up to 700 mm/year in the south (FAO, 2015).

The agriculture sector is the biggest consumer of water resources at more than 90% (FAO, 2015). It is also the largest potential contributor to the Sudanese economy. It provides livelihoods and job opportunities for nearly 70% of the country's estimated 44 million population. Before the oil exports came on line in 1999, agricultural products accounted for upwards of 95 percent of exports and the sector contributed to nearly 60% of the GDP (Berry, 2015). In the past three decades, however, the agriculture sector has been on a declining trend due to a combination of factors: neglect by the then government as more attention went to the oil and services sectors; lack of up-to-date coherent policies and strategies resulting in inadequate investment, research and capacity building programme (MoIWR, 2019); internal conflicts and instabilities, particularly in the Western and Eastern agricultural hubs (Mahgoub, 2014).

The agricultural production and productivity is currently low compared to global averages or potential local targets from the Sudanese Agricultural Research Corporation (ARC). For instance, the 2.4 tons/ha yield of wheat (FAO, 2019) is 50% of the local target and far below the attainable 6 to 9 tons/ha reported in the FAO AQUASTAT Database[1]. Wheat is the most important staple and commercial commodity in Sudan at the moment. In the 2019/2020 cropping season, the 730,000 tons local wheat production covered just a third of the 2.6 million tons actual consumption. The country is currently filling the gap through import, which amounted to $500 million draining the meagre national hard currency reserve and triggering a cascading negative impact on the economy (Ahmed and Mehari, 2020). Importing wheat is also reliant on international market dynamics, which the country cannot fully control and this has often resulted in short supply of bread, a very essential staple food for millions of Sudanese. The yield of sorghum (< 1 ton/ha), another major food crop is also low as compared to the achievable 3.5 to 5 tons/ha. Sugar cane, a highly commercial crop fares far worse at 10 tons/ha – the optimum yield ranges from 50 to 150 tons/ha.

The Water Productivity (WP) of the major crops is also very low. For instance, as documented by the on-going FAO funded water productivity improvement project in Gezira irrigation scheme, the majority of the farmers apply nearly twice the wheat irrigation requirement or about 8,000 m^3/ha (HRC, 2019). At 2.4 tons/ha, this results in 0.3 kg/m^3, which is significantly below the optimum range of 0.8 to 1.6 kg/m^3. Likewise, the WP of sorghum (0.15 kg/m^3) is just 15 to 25% of the achievable 0.6 to 1 kg/m^3. This sorghum WP analyses is based on the 2017 to 2019 flow measurements conducted in the Gash agricultural scheme, the major source of food and fodder in Eastern Sudan (HRC and MetaMeta, 2020). The Gash farmers supply 6,200 to 7,140 m^3/ha while the yield rarely exceeds 1 ton/ha.

The February 2019 Water Sector Conference that brought together more than 150 international and local professionals (the WaterPIP consortium was represented) highlighted lack of coherent policy roadmap as one of the major factors for the low agricultural production and water productivity. The frequently cited

[1] http://www.fao.org/land-water/databases-and-software/crop-information/en/

draft 1995 Water Law and the draft 2007 Water Policy were never officially endorsed due to mainly neglect by the then Ministry of Water Resources, Irrigation and Electricity. The Conference participants agreed that the policies are out-dated and do not adequately respond to the Sudan water sector needs of the present and the future. They accordingly suggested the development a new water strategy and policy (MoIWR, 2019).

The decline in the performance of the agriculture sector has negatively impacted the livelihoods of millions of Sudanese people, particularly the rural poor farming and herding communities. Sudan currently sits at the bottom-end of the global food security index, 112th out of the 113 countries evaluated[2]. Nearly half of the total population and three quarters of the vast agrarian communities live in poverty (IMF, 2013).

Since the Peaceful Great Revolution of December 2018, the Ministry of Irrigation and Water Resources (MoIWR), the custodian of water resources in Sudan, is working to deliver an inclusive economic growth that improves the lives and livelihoods of the Sudanese people. The Ministry prepared in the fall of 2020, a 10-year Water for the New Sudan – Transforming Livelihoods Strategy. This became operational in March 2021. The Strategy is to be followed by the drafting of a National Water Policy in 2021 as well.

These policy efforts by the MoIWR are also in anticipation of the fact that the desire to achieve rapid economic growth will increase competition for the limited water resources. This is already seen in places like Kassala, Nyala and El Fasher between agricultural and urban water demands. As competition increases between various demands on water, strategic plans and policies are needed to inform decisions on water use, control, protection and development so as to be able to ensure sustainable growth and avoid ad-hoc planning and implementation.

[2] https://foodsecurityindex.eiu.com/

2 Policy review: objectives, process and results

2.1 Objectives and process

The purpose of this review is two-fold. The first part discusses the aspects of the Acts and Policies that contributed to the current poor status of the agricultural production, water use efficiency and productivity as well as food security, job creation and other related socio-economic development issues. This second part presents the future outlook as defined by the ambitions and targets of the National Sudan Water Sector Strategy: Transforming Livelihoods 2021-2031.

2.2 Existing Acts and Policies – Gap Analyses

Sudan has drafted many water acts and regulations over the past decades (Annex 1). Among these, the 1990 Irrigation and Drainage Act and 2005 Gezira Scheme Act have had the most direct impact on the current poor performance of the agricultural sector. As indicated earlier, the country does not yet have an endorsed up-to-date water policy. The most widely cited 1995 Water Law and the draft 2007 Water Policy are analysed here as several of their gaps could be traced to the decline of the agriculture sector in the past three decades.

2.2.1 The Irrigation and Drainage Act

The 1990 Irrigation Drainage Act is very much regulatory in nature. Its most prominent provisions stipulate that any work related to irrigation or drainage needs a permit from the MoIWR and that licensee shall notify the Ministry to draw water for irrigation, whether from the Nile River or any of its tributaries or any other rivers or public canals (UNEP, 2012). The Act is relatively silent on the facilitative and enabling aspects of water management: improved living conditions, providing career paths and capacity development opportunities for irrigation and water professionals and practitioners and mechanisms to improve irrigation and related farming services to farmers and other beneficiary groups. This has contributed to poor operation and maintenance and low crop and water productivity of the four national large-scale irrigation schemes (Gezira, Rahad, New Halfa and Suki) that cover nearly 2 million ha.

The need to strengthen the facilitative roles of Acts and Policies was recognized in the 2016 international conference on revitalization of the Gezira irrigation scheme (MoIWR, 2016). Human Resources and Services (training, improved housing, office and communication facilities) was identified among the top five priority improvement intervention packages.

2.2.2 The 2005 Gezira Scheme Act

The overarching goal of the 2005 Gezira Scheme Act (GSA) was to transfer significant irrigation water management and related farming responsibilities from engineers and agricultural officers to farmers. The specific objectives included ensuring farmers' right to: (i) effectively participate, at all administrative levels, in planning and implementation of projects and programs that affect their production and livelihoods, (ii) manage irrigation operations at field canal level through water users' associations, and (iii) freely manage their production and economic aspects within the technical parameters, and employ technology support to boost production and maximize their respective returns (FAO, 2015).

These rather noble objectives have not been translated into positive impact on the ground and failed to achieve better irrigation management and improved water productivity. The GSA suffered from hasty, poor implementation and follow-up. Many irrigation and agricultural experts were relieved of their duties prematurely as it was then assumed that the WUAs will shoulder much responsibilities. This never materialized. The nearly 1,500 WUAs established, were not given the technical and financial support to evolve into mature and viable institutions – almost all are not currently functional. There was also

inadequate coordination among the farmers and the remaining Gezira staff. The majority of the Gezira farmers started to individually decide what crops, when to grow, and how much area to cultivate. This action of the farmers and the lack of coordination, which is often directly attributed to a wrong-reading of the third objective of the GSA, made it impossible to plan and implement a proper irrigation and cropping schedule. The farmers often cultivated significantly larger area than the design capacity capped at 50% of the command area of each minor (tertiary) canal at any given cropping season. The Gezira scheme has 1498 minor canals feeding 29,000 field canals. As a result of the ad hoc irrigation scheduling and cropping pattern, large sections of the scheme, particularly the tail-end areas, often suffered from delayed and insufficient irrigation (MoIWR, 2016).

Another significant provision of the GSA is the one that granted the private sector the 'opportunity to play a leading role in irrigation water management. This provision lacked two major guiding principles: (1) institutional regulatory capacities of the Irrigation Operations Directorate (IOD) of the MoIWR that oversees Gezira scheme Operation and Maintenance (O&M) activities, and (2) the technical qualifications and material capability preconditions for the engagement of the private sector. Presently, the machineries being used by the private sector and the semi-autonomous parastatal EMC (Earth Moving Cooperation) are not the most efficient: the de-silting and locally produced mowing buckets are rather small and heavy and not suitable for regular maintenance. The administrative system is also inadequate: surveyed bill of quantities, clear measurements or time sheets are not adequately integrated into the workflow. The O&M is poorly supervised by the IOD, which has outdated facilities to work with – modern land survey equipment, such as total-stations and GPS devices are not made available. As observed by Smit (2019), the private companies are often paid by the kilometres cleared of silt and weeds rather than by the quality of the excavation work. This, as also reported during the Gezira 2016 conference, has contributed to over digging in some parts, and shallow and wide cross-sections in other areas along the same canal leading to poor water delivery.

Figure 2-1: Small (1.8 m wide), heavy and ineffective buckets in use by the local private sector in Gezira Scheme (Credit: MetaMeta, 2019)

Figure 2-2: New generation, wide (5.5 m) effective buckets currently being produced by the Netherlands private company Herder that was active in the Gezira Scheme back in the 1990s. The MoIWR has re-engage with Herder to explore collaboration opportunities (Credit: MetaMeta, 2019)

The GSA has since its inception been a subject of much debate and controversy and regularly blamed as a major contributor to the poor performance of the Gezira Scheme. It is the 2016 International Conference on Gezira scheme, however, that effectively marked the beginning of the end of the GSA. The conference participants recommended, among others, to immediately reinstate qualified 70 engineers, 350 gate operators and up to 1,000 unskilled labourers to bring some order to the irrigation and farming scheduling. This has been followed through and the GSA has now ceased to play any official role in the Gezira irrigation scheme management.

2.2.3 The 1995 Water Law

The 1995 Water Law has a number of limitations. It does not embrace the integrated nature of water resources management and provides little guidance on where to put which waters for best use to meet concerted peoples' priorities. There is no emphasis on water management or water productivity as a service or mention of gender provisions or comprehensive definition of water use. Water quality and pollution control aspects only get a passing-mention. Public participation and transparency in decision making does not prominently feature. The Law is silent on the role of States in managing water resources thus leaving ample room for interpretation on where the responsibility boundary lies with the Federal water agencies and institutions as well as the local communities. Lack of clarity at best leads to inefficiencies due to excessive overlap of tasks - it can at worst be a cause for conflicts.

The lack of emphasis on water management or water productivity as a service has had several negative implications (MoIWR, 2021):

- The National Council for Water Resources (NCWR) that was established by the Law to operationalize the Law through among others formulating common water resources development plans and integrated water sector activities, largely remained idle and ineffective institution. It was inadequately staffed and resourced and its impact remained limited also because there were no State and catchment level water councils to partner with.
- National Water Resources Allocation Plan (NWAP) was not developed – there is no such a plan to-date. In the absence of NWAP, the country has not managed to adequately set its water investment agenda, identify and implement specific programmes of strategic importance to boosting agricultural productivity and ensuring food security. The NWAP would have also been instrumental in addressing the priority water resource concerns such as climate change and disaster risk reduction provisions including early warning systems, risk and migration of vulnerable communities during extreme events and; conflict mitigation and prevention needs; agricultural productivity in main agricultural zones; pollution control. Sudan is currently among the 10 most vulnerable and least prepared countries to climate change impact[3].
- Research and Development (R&D), one of the stepchildren of the MoIWR has also been overlooked. Despite the presence of many water specialised research bodies belonging and affiliated with the MoIWR, they have shown little or no leverage for impact due to the lack of coordination and limited available financial sources. Absolute and relative data on R&D investments in the water sector are not available. However, with agriculture being the largest water consumer, also in the Sudan, a proxy of agricultural R&D spending in 2012 (Figure 2-3) is appropriate to paint the big picture of fully insufficient attention to R&D in the Sudan.

[3] https://gain-new.crc.nd.edu/

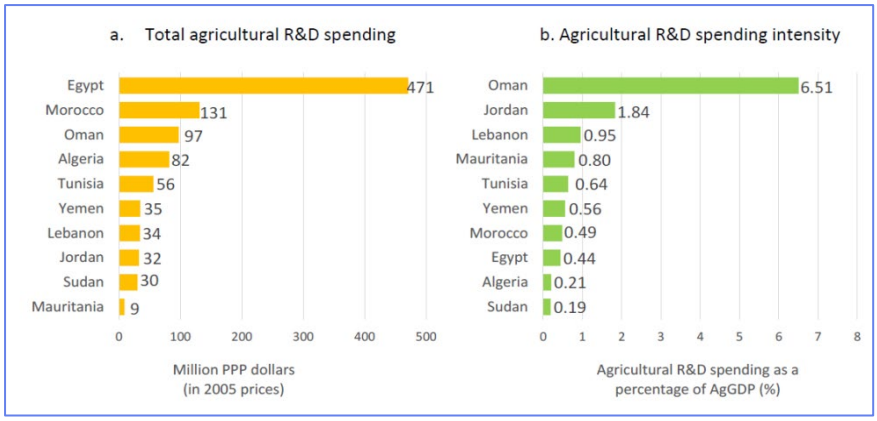

Figure 2-3: Absolute and relative agricultural Research and Development (R&D) spending levels[4]

2.2.4 2007 Water Policy

At a conceptual level, the draft 2007 Water Policy recognizes the need for integrated water resources management, but like the 1995 Water Law, it did not address the lack of clarity and coordination of roles and responsibilities between sectors and across geographic scales, which is prevalent and hampers the optimal use of limited resources for facilitating and regulating the sector. This is often most evident in the management of irrigation and drinking water facilities which often deteriorate functionally because of the lack of clear policies for identifying the responsible entities for O&M.

The inadequate clarity on the roles and responsibilities, coupled with limited provision of resources and budget for O&M has resulted in fragmented and piecemeal rehabilitation efforts with limited strategic planning. This has negatively impacted agriculture productivity and sustainability. One documented example is the deterioration of the infrastructure of the Nile water supplied medium-size pump irrigation schemes. Some 60% of the nearly 570,000 ha pump irrigation schemes that were rehabilitated some years back have now exited the production cycle (Table 2-1) due to mainly poor O&M (MoIWR, 2018). These schemes are nationally significant. They cover a quarter of the roughly 2.3 million ha total area equipped with irrigation facilities in Sudan and provide livelihoods and food-security for some 130,000 households or close to one million farming family members.

Table 2-1: Location and scope of the Medium Size Pump Irrigation Schemes (MoIWR, 2018)

No.	State	No. of Schemes	Total area in ha	Cultivated area in ha	No. of Farmers
1	Blue Nile State	34	132,000	41,000	26,238
2	White Nile State	121	147,000	81,000	27,333
3	Nile State	94	141,000	51,000	49,619
4	Northern State	131	146,000	50,000	26,208
	Total	*380*	*566,000*	*232,000*	*129,398*

Insufficient guidance on prioritizing the limited investment that was available for the water and the agriculture sectors also contributed to the concentration of development interventions in the central parts of the country endowed with the revenue-rich, easy to develop and use water resources available from the Nile and its tributaries. This resulted in considerable socio-economic injustice for large segments of the

[4] https://www.ifpri.org/blog/agricultural-rd-capacity-arab-world-positive-progress-challenges-remain

population, particularly those in the Eastern and Western fragile regions of the country that rely on seasonal streams and groundwater resources. These regions are currently the most food insecure. The seasonal rivers and groundwater resources received meagre investments as they were perceived to be relatively costly and technically difficult to develop and utilize (MoIWR, 2021).

Contrary to this perception, however, there are some evidence-based studies that indicate the viability of productive investments in seasonal rivers and groundwater-based livelihood systems. One example comes from the 80,000 ha Gash seasonal river fed agricultural scheme in Eastern Sudan where low-cost (25 USD/ha) field water management interventions in about 3,000 ha doubled the sorghum production to 2 tons/ha while at the same reducing the irrigation demand by a third (HRC and MetaMeta, 2020). The interventions combined a cross-structure (weir) and improved stone re-enforced field intake to enhance the floodwater supply; internal earthen bunds to cut by half the size of the mesga (irrigation plot) that is now large at an average of 250 ha, and 3.5 km long internal earthen canal to irrigate the lower half of the field (Figure 2-4). The second example draws from the 20 multipurpose (irrigation and drinking water supply) boreholes in Darfur, Western Sudan. As documented in 2017 by the European Commission Humanitarian Aid and Civil Protection (EC-HACP) Department and the Global Solar-and-Water Initiative (GSWI), the shift from diesel to standalone solar pumping could reduce the water delivery cost by up to 80% (Figure 2-5).

Figure 2-4: Low-cost intake and field canals that contributed to improved field water management and productivity in Gash seasonal river based agricultural scheme in Sudan (Credit: Amira Mekawi, HRC)

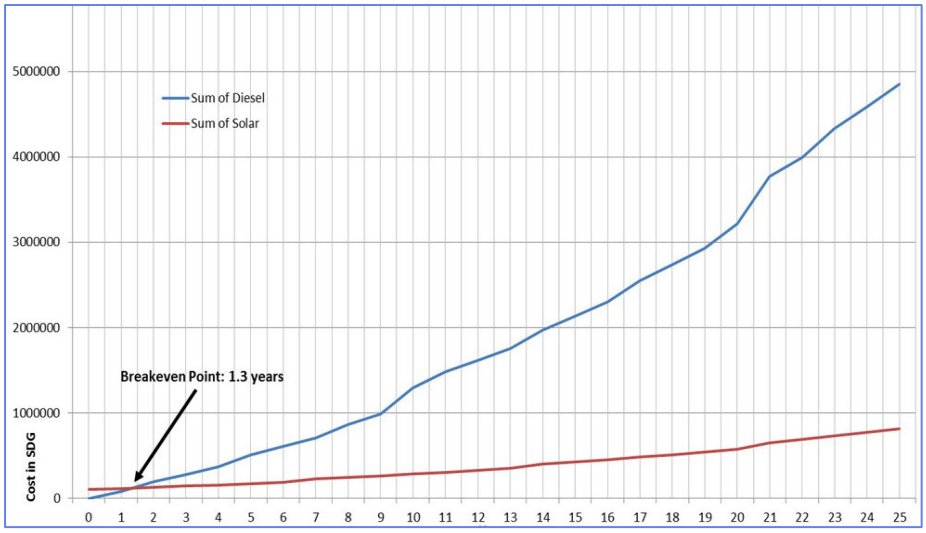

Figure 2-5: Cumulative groundwater pumping cost over the 25-year life of solarized systems versus the existing diesel generator systems (EC-HACP and GSWI, 2017).

Coming back to the analyse of the 2007 Water Policy, while its regulatory component (monitoring and evaluation, licences and permits) is weak, the facilitative arm (creating an enabling environment) is even weaker. As a symptom, human resources development and institutional strengthening has largely been ignored for the past three decades. There have been limited opportunities for staff career development, and sparing investment into improving the working environment (housing, communication, transportation facilities). This eroded the motivation to serve and significantly drained the MoIWR and the country of its killed and knowledgeable human capital.

The inadequate technical and financial attention to strengthen institutional and human resources capacities is among the leading factors for the deterioration of the large-scale irrigation schemes in Sudan. The 2016 Gezira consultative workshop, identified several concrete impacts (MoIWR, 2016):

- A large number of tertiary and field canals are either over dug or heavily infested with weeds and silt as they are rarely maintained;
- Many of the structures, like main canal head regulator gates, intermediate and Field Outlet Pipes (FOPs), are at best only partially operational;
- Poor water distribution is visible in the scheme. While some areas are excessively irrigated, some other regions are deprived of water;
- There is over supply in the main and major canal systems. This has created turbulent flow and erosion of canal embankment, contributed to sedimentation and drainage problems, and exposes the Gezira Scheme and some villages to flood damage risk during the wet season.
- The drainage infrastructure requires major repair and in some locations in need for reconstruction. Three out of the five escape drains within Gezira scheme are non-functional, the majority of the drainage pumps are non-operational, the protective and collective drains along with their crossings and other structures have aged not to mention that they were not designed for the current much higher drainage requirements.

The policy also does not adequately address the economic value of water. There are no principles that govern pricing of agricultural water services. As highlighted during the recent 2019 water sector conference, water is the least priced as it only accounts for less than 1% of the agricultural inputs. For instance, the flat-rate irrigation service fees in the Gezira irrigation scheme is 150 SDG (<$0.5 USD) per hectare, which is very low. As gathered from the field surveys conducted as part of the on-going FAO funded water productivity improvement project, the average cost of farm inputs in Gezira scheme is currently (2020) nearly $150/ha.

2.3 Water for the New Sudan – Transforming Livelihoods Strategy

The 2021 -2031 Water for the New Sudan – Transforming Livelihoods Strategy is a product of multiple internal and external reviews and extensive consultations with various national and international water sector partners of the MoIWR. It has three pillars: Water Resources Management and Irrigation (focus of this policy review), and Water Supply.

The irrigation pillar has specific targets on the expansion of the irrigated areas, the increase in production but also on improved water productivity. The Water Resources Management pillar directly addresses the many gaps of the existing Acts and Policies such as: alignment of roles and responsibilities between Federal and State levels; strengthening the NCWR, implementing catchment plans, and empowerment of water councils; the development of NWAP.

The major impacts expected by 2031 in the Irrigation pillar of the Strategy are:

- Improved food and nutrition security, peaceful symbiotic co-existence for some 7 million farming and herding communities;

- Dignified and rewarding job opportunities for nearly 1.5 million Sudanese, rural youth and women in particular;
- Strengthened institutions and more competent professionals and practitioners will actively support the rehabilitation and development of irrigation systems as well as provide better quality and cost-effective irrigation services to farmers and other clients.
- Solution-oriented and up-scalable research results will enrich and fast-track the expansion, upgrading and modernization of irrigation systems.

The key 2031 interventions to realize the impacts and address some of above discussed current challenges of the irrigated agriculture sector are as summarized below:

- Constructing, upgrading and modernizing some 25,000 gender-sensitive and disabled-friendly basic and safely managed water supply facilities that meet the rural and urban demands and technology option shares;
- Over a million ha of small-holder irrigated land is technically and institutionally upgraded and modernized, and adequate arrangements for effective operation and maintenance are put in place.
- Some 0.5 million ha private sector led new irrigation development;
- At least 50% increase in water and land productivity of 1.5 million ha with 'low-to-no-cost' measures such as improving water distribution rules and optimising irrigation duties and water delivery schedules in terms of water volumes and irrigation intervals. The major irrigated crops in Sudan (wheat, sugarcane and all vegetables and fruits) have the lowest productivity levels when compared to that of other countries with similar socio-economic status (see box 1);
- Increase the cropping intensity by at a least a third to boost production for local consumption and export. Just 40% of the 2.6 Million ha currently equipped with irrigation facilities enters the cultivation cycle annually;
- Some 50% of the 5,000 staff of the MoIWR including 500 young professionals, and 1,000 farmers' representatives have enhanced know-how and skills in the irrigation water resources management and development;
- Institutional capacities of the major directorates of the MoIWR and partner organizations are strengthened through on-the-job trainings and exchange programmes.

The Water Resources Management Pillar of the strategy has the following 2031 targets:

- Multi-sector development scenario Water Allocation Plans (WAPs) to guide the allocation, control, use, development and protection of water resources at national, state, catchment-based community levels;
- Revive and strengthen NCWR and establish state and catchment-level water councils;
- Ministry-wide framework for cost and benefit sharing among varied water users and use is consultatively developed;
- State and catchment-level governance and conflict management mechanisms, particularly in fragile water-stressed basins;
- Priority investment and research programmes that address major water resources management and development issues identified, implemented and upscaled – particular attention will be given to seasonal streams and groundwater resources;
- Comprehensive water quality and quantity data program established; quality data used for current and future projections for allocations and development decisions.

2.4 Comparative Assessment: Current Status and Future Outlook

This section comparatively assesses the current status of the water and agriculture sector, which as discussed in the above, is to a large extent shaped by past acts, policies, strategies and investment decisions; and the future outlook expected to be defined by the New Sudan – Transforming Livelihoods Strategy.

The assessment is done based on six indicators summarized below and a scoring matrix ranging from 1 (very low) to 5 (very high).

Table 2-2: Overview of indicators used in the assessment

Indicator	Explanation
Land productivity (kg yield or biomass/ha)	Relation between agricultural production and agricultural land
Biophysical water productivity (kg yield or biomass/m^3)	Relation between yield (tons) and water consumed (evapotranspiration)
Economic water productivity ($/$m^3$)	Relation between economic value and water consumed (evapotranspiration)
Food security	Access for all people at all times to enough food for a healthy, active life either through sufficient local production or reliable and affordable import mechanism
Employment	Number of jobs generated by the agricultural sector
Environmental sustainability	Responsible interaction with the environment to avoid depletion or degradation of natural resources and allow for long-term environmental quality.

The results of the assessment are given in Table 2-3 and the Spider Diagram (Figure 2-6). The rather brighter future outlook under the New Sudan – Transforming Livelihoods Strategy is informed by the following facts and recent developments:

- The New Strategy mentions specific targets on several of the assessment indicators – this is an imperative first step to ensuring adequate resources allocation – financial and technical.
- In the past two years, following the December 2018 Peaceful Revolution, the MoIWR has aggressively moved to implement the Strategy with some concrete successes:
  - The FAO and MetaMeta supported Gezira irrigation scheme productivity improvement project launched in 2019 has identified a few model farmers who have managed to harvest 4 to 6 tons/ha of wheat and water productivity of about 0.8 kg/m^3, which is close to the optimum reported by FAO[5]. Working together with the farmers, the project documented a compendium of good practices that contributed to such a high yield: 7 to 8 irrigation turns at a two-week interval, which adds up to an average of 5,000 m^3/ha; 3 to 4 times land preparation; 140 to 170 kg/ha seeding rate; 150 to 200 kg/ha and 250 to 350 kg/ha DAP and UREA fertilizer application respectively; sowing during the period of November when the temperature is most conducive for germination.
  - In the Gash flood-based irrigation scheme, MetaMeta and the Hydraulic Research Centre (HRC) have successfully introduced on-farm water management practices that combined internal field bunds and improved intakes and tertiary canals. These interventions in 2,000 ha have doubled the sorghum yield from 0.8 to 2 tons/ha while at the same time reducing

[5] https://www.fao.org/land-water/databases-and-software/crop-information/wheat/en/

the water consumption by 30%. The Ministry together with the Sudan International, A UK-based NGO are working to upscale these interventions into the whole scheme of 80,000 ha.

- The World Bank has approved 300 million USD for Sudan Irrigated Agriculture Rehabilitation Programme (IARP) that is expected to be implemented in the coming five years. The programme will benefit some 50,000 ha in each of the Gezira and medium-sized pump irrigation systems and approximately 60,000 ha seasonal rivers-based irrigation systems.
- With complementary funding from the French Embassy, preparations are being finalized to pilot the compendium of good practices at some 10,000 ha in Gezira scheme. This will also include rehabilitating the tertiary canals most affected with over digging, silt and weed problems to ensure reliable and sufficient irrigation Supply. The semi-parastatal EMC financially supported by the MoIWR will support the rehabilitation work with machinery and personnel.
- With one million Euros grant from the Netherlands Ministry of Foreign Affairs, capacity building of irrigation field staff in Gezira and the other large-scale irrigation schemes is underway. The capacity building is informed by needs assessment jointly conducted with the relevant irrigation departments. The Ministry has already established a Trading and Capacity Building Directorate to strategically guide human resources and institutional strengthening initiatives.
- The Stockholm International Water Institute (SIWI) Water Governance Facility has approved a two-year (March 2021 to Feb 2023), 0.5 Million Euros programme to support implementation of the water resources management priorities identified in the Strategy. Among the specific expected deliverables are the development of a NWAP and three State-level Plans – two covering the fragile Kassala and Darfur regions that predominantly depend on seasonal streams and floods.

To build on these successes and accelerate investment, research and capacity building programmes in the decade ahead, the MoIWR has established a dedicated Resource Mobilization and Partnership Unit. While nobody can predict the future with certainty, the developments in the past two years are indicative of a promising future for a successful implementation of the New Strategy that is already operational.

Table 2-3: Assessment of the current situation and the priorities in the new water sector Strategy

Indicator	Current situation (2020) largely shaped by past policies, strategies and investment decisions		The Water for the New Sudan – Transforming livelihoods strategy: 2031 expectations	
	Score	Explanation	Score	Explanation
Land productivity (kg yield or biomass/ha)	1	As discussed in Section 1, the land productivity of the major crops is currently low.	4	The strategy promotes land productivity improvement as its top priority. The proposed technical and institutional rehabilitation of one million ha is expected to double the land productivity of wheat, sorghum, cotton and other irrigated crops. Several of the investment and capacity building initiatives outlined in the above have the potential to directly contribute to improving land productivity. In the past two years, the irrigation and agricultural services have improved. Consequently, as indicated in the above, the FAO and MetaMeta supported project has

				documented up to 6 tons/ha wheat harvest by some successful farmers, which is close to the optimum productivity reported by FAO[6].
Biophysical water productivity (kg yield or biomass/m^3)	1	Biophysical water productivity of the major crops Sudan is very low (see analyses in sections 1 and 2).	4	Water productivity is one of the highest priority targets of the strategy. It prominently features in the standalone pillar: "Improving water productivity with at least 50% more crop per drop" and also as an integral part of the other two key pillars, namely 'upgrading and modernizing some 1 million ha' and '0.5 million ha new irrigation development.' In partnerships with FAO, MetaMeta and other partners, the Ministry of Irrigation and Water Resources is already implementing water productivity improvement project in the largest Gezira irrigation scheme. Successful on-farm water management improvement field trials have also been conducted in the Gash irrigation scheme that doubled sorghum yield while at the same time reducing water consumption by a third. Furthermore, as gathered by the FAO and MetaMeta supported project some model wheat farmers managed about 0.8 kg/m^3, which is close to the optimum water productivity reported by FAO[6]. These are farmers that adhered to a set of good practices: 7 to 8 irrigation turns at a two-week interval, 3 to 4 times land preparation; about 150 kg/ha seeding rate; 150 to 200 kg/ha and 250 to 350 kg/ha DAP and UREA fertilizer application respectively; sowing during the period of November when the temperature is most conducive for germination.
Economic water productivity ($/$m^3$)	3	High commercial crops (wheat, sugar cane, cotton and several fruits and vegetables) are produced under the large-scale irrigation schemes supplied from the Nile water. The very limited investments in the irrigation sector have mainly been channelled into this Nile water dependent large-scale schemes in the central part of the country. Some of the bright spots that benefited from this investment and hence achieved higher economic water productivity include the nearly 0.2 million ha Menagil section of the		The strategy foremost aims at addressing the prevalent socio-economic disparity between the Nile water endowed Central region and the fragile Eastern and Western parts of the country that mainly depend on seasonal and intermittent rivers, and temporary floods. The strategy thus promotes equal investment to the Nile and non-Nile water resources as well as cash and vital food crops. Assuming the recent successes in resource mobilization will continue and perhaps even accelerate driven by the newly established dedicated Resource

[6] https://www.fao.org/land-water/databases-and-software/crop-information/wheat/en/

		largest (0.9 million ha) Gezira irrigation scheme.		Mobilization and Partnership Unit; the expectation is that investment share of the revenue-rich crops will not significantly decline. Hence, the Indicator score will score higher because the strategy specifically advocates for some low-cost measures that can enhance economic water productivity including market-oriented cropping calendar and cropping pattern, and improved post-harvest techniques and practices.
Food security	1	As discussed in Section 1, the agricultural production and productivity is currently low and Sudan sits at the bottom-end of the global food security index (112th out of 113 countries).	3	Food security is expected to significantly improve in the decade ahead. The strategy outlines several low-cost interventions such as improving irrigation schedules and cropping patterns to improve productivity as well as expand irrigable areas to boost production. Staple at the same time commercially valuable crops such as wheat will get the priority. Already a policy document has been prepared and resources have been mobilized to double wheat production to 800,000 ha in the Gezira irrigation scheme by the end of 2021 and further upscale this to over a 1 million ha by 2023. The strategy also aims at creating rewarding employment for 1.5 million Sudanese, rural youth and women in particular. - this is expected to improve the purchasing power. Finally, the lifting of the international embargo will also likely help in improving the overall economy that may translate to higher purchasing power.
Employment	1	Agriculture provides job opportunities for some 70% of the 44 population of Sudan. The overall unemployment rate steadily increased from about 12% in 2011 to 25% in 2020 – it remained stubbornly high among the rural youth that rely on the agriculture sector at over 30%. The unemployment trend closely correlates with the loss of oil revenue following the secession of South Sudan in 2011 and the weak agriculture sector left behind that has never been adequately revitalized due to a combination of inadequate policies and strategies and insufficient investments to support actionable solutions that boost production and productivity.	3	Employment in the agriculture sector is expected to significantly increase. The strategy has set a target of 1.5 million job creation (especially among the rural youth and women) through increasing water and land productivity in one million ha irrigated land by at least 50%; increasing the annually cropped area by 30% or 0.7 million ha; 0.5 million ha new irrigation development. The 1.5 million target is based on the estimation that every 2 ha with 50% productivity improvement will generate an additional 1 FTE (full time) employment and 1 FTE will be generated from each ha that enters a production cycle. These values are gathered from the various consultations undertaken with farmers

				and other stakeholders during the preparation of the strategy. The 50% productivity improvement is achievable as for example, there are already some model farmers harvesting 4 to 6 tons/ha of wheat, which is more than double the current productivity level. Creating an enhanced work environment (housing facilities, transportation, communication, etc.) is also a key target of the strategy. This is expected to encourage many, particularly the youth, to enter the agricultural sector job market.
Environmental sustainability	1	The need to fast-track agricultural development, which is also symptomatic in many developing countries, has pushed environmental sustainability to the bottom of the priority list. Water logging is evident in some parts of the existing irrigation schemes due to poor drainage facilities and excessive water supply; groundwater depletion particularly in the water stressed Gash Basin in Eastern Sudan has reached a concerning level. This is due to overexploitation and inadequate attention and investment to enhance the recharging capacity.	2	Given the urgency to deliver quick economic growth, environmental issues will struggle to find a front row seat in water sector investments and programmes. That said, several of the low-to-no cost water productivity improvement measures promoted by the strategy will deliver some positive environmental impacts such as reduced water logging, soil fertility degradation and flood damage

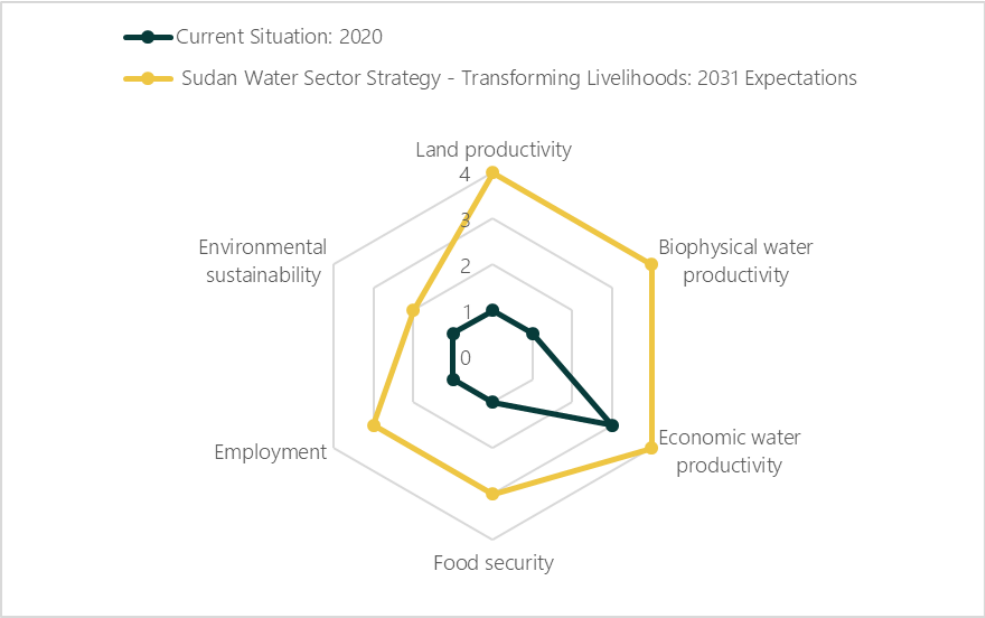

Figure 2-6: Spider diagram comparing the current situation and priorities in the Water for the New Sudan – Transforming Livelihoods Strategy

3 Positioning the new national water policy for improved water productivity

The drafting of the new National Water Policy is at the initial phase of the consultation process. On request of the MoIWR this section is prepared to initiate dialogue on how best to position the New Policy to support the achievements of the 2031 targets in the Spider Diagram, particularly with regards water productivity.

Taking stock of the gaps in the existing policies, the ambitions of the Water for the New Sudan Strategy and the priorities of the Sudanese government, the evolving picture of the new Policy may possibly look as follows:

- Vision – Overarching Goal

Affordable and reliable water resources of adequate quality and quantity for all Sudanese, in its productive sense for agriculture and livestock, in its social sense of creating harmony and cohesion, and in its environmental sense of doing no harm by seeking synergies and complementarities.

- Institutional Goal

The MoIWR and its partner organizations have strengthened human resources and institutional capacity to reflect peoples' needs, enable investments in peoples' institutions and infrastructure, and to mobilise and deliver value-adding inclusive services to the benefit of all.

- Water Productivity: Contribution to Policy Ambitions

To realize visible and wide impact on the ground, the policy will prioritize actionable solutions that adequately respond to and harness the promise of the water sector across four priority pillars of the Sudanese government and the MoIWR: Water for Peace, Water for Food Security, Water for Health and Water for the Environment (Annex 2 has the details).

Water productivity is a main element of operationalizing the four anchoring pillars. A transformed agriculture sector that is water efficient, highly productive and employment generating engine, can make tremendous contribution to socio-economic well-being and peaceful co-existence of the pastoral and farming communities that account for some 70% of Sudan's estimated 44 million population. Water productivity improvement measures such as efficient irrigation scheduling, better drainage and groundwater recharge, can result in a healthy and sustainable environment.

The new National Water Policy aims at effectively facilitating the following water productivity related targets contained in the Water for the New Sudan – Transforming Livelihoods Strategy:

- Over a million ha of small-holder irrigated land is technically and institutionally upgraded and modernized;
- Some 0.5 million ha private sector led new irrigation development;
- At least 50% increase in water and land productivity of the existing 1 million and the new 0.5 million ha.
- Increase the cropping intensity by at a least a third to boost production for local consumption and export. Just 40% of the 2.6 Million ha currently equipped with irrigation facilities enters the cultivation cycle annually.

What is required is to describe how can the policy contribute in practice to making these targets operational and what additional analyses can be done to inform policy decisions. The Water Sector Strategy Identified five categories of institutions that are critical for driving the programmes necessary to realize the

above outlined targets and operationalizing the activities detailed in the next two sections. These are summarized below.

- Federal or state level institutions: These institutions may design, appraise, finance, and commission irrigation and management facilities in accordance with existing standards and menus of technological options. They are required to provide needed capacity building to establish community level management structures that are capable of routine O&M and reporting as per the required standards. Sources of funding may include federal or state-level funds or external funding channelled through the Ministry of Finance and Economic Planning.
- Non-Governmental Organizations (NGOs): Accredited NGOs may design, appraise, finance, and co-implement irrigation and water management programmes in accordance with existing standards and menus of technological options. NGOs can also play a role in knowledge transfer, technology adoption, and institutional strengthening to enhance the capacities of communities and local government to design, implement, and manage programmes. Financing could come from resources mobilized by the NGOs directly or through international donors.
- Community or civil society institutions: Irrigation and water management initiatives that are designed and implemented through community cooperation or civil society engagement are yet another modality. Communities and Civil Societies must inform and report to the local government institutions about the planning and operation of proposed initiatives to facilitate monitoring of functionality in the future. Financing of such initiatives may be through community fundraising or Civil Society contributions. An adequate community level O&M mechanism must be established to ensure continuity and sustainability of services.
- Private sector: Accredited private sector institutions can contribute to improved O&M of irrigation and water management facilities. They can also support the establishment and training of community-level O&M mechanisms. The private sector institutions must engage with federal and state level governments to ensure appropriate oversight

3.1.1 Policy support for water productivity

Achieving 50% increase in water productivity across 1.5 million ha in the decade ahead is a huge challenge as it also has to compete for investments with other priorities such as provision of safe and adequate rural and urban domestic water supply. The policy can play a major role in realizing the target by forcefully promoting low-to-no cost interventions that often yield immediate results without a long gestation period. These are often overlooked as often attention goes to huge infrastructural investments. They include: improving water distribution rules and optimising irrigation duties and water delivery schedules in terms of water volumes and irrigation intervals; improved drainage (also reusing drainage water), and an array of smart measures that promote better water management at farmer field level. Besides improving water productivity, they bring several other benefits: fewer diseases, less back breaking labour, and less environmental degradation through salinity and water logging.

Another area of policy support is the improvement of economic water productivity that is closely linked to job creation – unemployment rate in Sudan is currently among the highest among African countries. The policy could give more visibility to economic water productivity, which is not as explicitly mentioned in the Water for the New Sudan strategy as the biophysical water productivity. It can also help better orient resources to interventions such as market-oriented cropping calendar and cropping pattern, and improved post-harvest techniques and practices (this are contained in the strategy) that can boot economic productivity.

The policy can also make a significant contribution to water productivity improvement by embracing ‘capacity building and institutional strengthening as the regular order of business”. This has for years been

done in ad hoc basis with limited strategic guidance and direction. Inadequate governance and management of water resources due to weak human resources and institutional capacity is one of the main reasons for the water productivity levels in Sudan. The policy can enforce several practical measures to systematically and more efficiently address the issue:

- All investment and development programmes should allocate 5 to 10% of their budget to research and capacity building; and concerted efforts must be made to ensure that donors and development banks abide by this.
- Regularly update the knowledge and skills of the MoIWR workforce and mainstream capacity building in all departments and agencies: each staff member should annually complete at least one training programme to be eligible for promotion.
- Facilitate applied solution-oriented research with dedicated room for innovation and experimentation, and water productivity improvement as integral part of capacity building packages.
- Promote remote sensing, WaPOR and smart ICT technologies for real-time monitoring of water levels and discharges; and facilitating effective water distribution and management through timely and reliable mapping of system-wide (from upstream to downstream) variations in irrigation supply. Other than irrigation water management, the technologies also provide more information for farmers and policy makers to guide agricultural practices at farm level, in particular information on status and health of crop growth (diseases, nutrients, etc.). These are important for boosting land and water productivity. The technologies in particular needed in the mega Gezira irrigation scheme, but also in the medium-size pump irrigation systems where some individual schemes are substantial at about 40,000 ha as well as the large-scale seasonal rivers fed irrigation systems such as the Gash and Toker that cover about 170,000 ha and 100,000 ha irrigated areas respectively.
- Strongly support the initiative by the Water PIP project and similar other efforts to establish dedicated institutions (service hubs) for real-time monitoring as well as developing products and services that improve land and water productivity across the 2.3 million ha total area currently equipped with irrigation facilities in Sudan.
- Facilitate more equitable allocation of financial resources. As discussed earlier, the Gezira scheme, by virtue of its large size and political status, had monopoly of the investments in the past years. The policy should unequivocally recognize the fact that the other irrigation systems are equally important and support the Water Sector Strategy achieve its objective of rehabilitating 400,000 ha pump irrigation schemes (same target is set for Gezira) and another 300,000 ha seasonal rivers-based irrigation schemes. The medium-size pump systems, while they only cover two-third of the Gezira irrigated land, they provide livelihoods and food-security for some 130,000 households or close to one million farming family members – the same number of target beneficiaries supported by the Gezira scheme. Likewise, the seasonal rivers-based systems cover about 55% of the Gezira scheme irrigated area, but they are the major sources of food and fodder for roughly 0.5 million households or 2.5 farmers and pastoralists (MoIWR, 2021). At operational level, the policy should endorse and build upon the criteria for equitable financial allocation outlined in the Water Sector Strategy: a) proportion of inadequately developed irrigation and insufficiently served population, b) poverty, food insecurity and high unemployment rates; c) vulnerability to climate shocks - extreme droughts and floods, d) limited resources or funding provided in last 5 years.

Finally, recognizing farmers, herders and producers as solution providers, not just a target group as they are now often categorised can go a long way in enhancing water productivity. These stakeholders are also being at the forefront of innovation, knowledge exchange and learning. They are reservoirs of local knowledge, harnessed through constant strive to address their problems: many have applied such local knowledge to a greater effect.

3.1.2 Policy Relevant Water Productivity Analyses

In support of the above outlined and related policy measures to facilitate enhanced water productivity, several WaPOR (remote sensing) analyses complemented with field research need to be undertaken. Some of the priority thematic topics include the following:

- Evidence-based documentation of farmers' field water management and farming practices and analysing their impacts on water productivity;
- Better identify the various packages of low-to-no cost measures that could result in the highest possible improvement of water productivity for different crops, agro-climatic conditions, irrigation methods (large, small, perennial, flood-based) as well as rained and flood-based production systems;
- Comparative analysis of various scenarios of low-to-no cost measures and investment intensive infrastructural interventions on water productivity – both biophysical and economic value.
- Impact of various biophysical and economic water productivity improvement scenarios on job creation, food security and environmental sustainability;
- More attention for sustainable use of water – identifying the most water efficient and productive measures to realize the proposed increase in crop intensification and new irrigation development;
- Better understanding of the know-how and skills and institutional strengthening interventions that more significantly contribute to improved water productivity.

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Annex 1: Sudan water acts and regulations drafted in the past decades, but were inadequately enforced.

As summarized below, the Acts are very much regulatory in nature and with the exception of the Environmental Health Act, they offer little guidance on efficient, productive and sustainable use of the limited water resources of Sudan.

1. Irrigation and Drainage Act 1990: It establishes that any work related to irrigation or drainage provided needs a permit from the Ministry of Irrigation and Water Resources. The licensee shall notify the Ministry to draw water for irrigation, whether from the Nile River or any of its tributaries or any other rivers or public canals;
2. Water Resources Act 1995: Is a major institutional reform concerned with the Nile and Non-Nilotic surface waters as well as with groundwater, hence superseding the 1939 Nile pumps control act that was limited to the Nile waters only. It also establishes the National Water Resources Council and the need of a license for any water use;
3. Groundwater Regulation Act 1998: Mandates the Groundwater and Wadis Directorate as the sole government technical organ to develop and monitor wadis and groundwater, and to issue permits for constructing water points;
4. Public Water Corporation Act 2008: Gives authority to central government for national planning, research, development and investment in the water supply sector, as well as the corresponding policies and legislations;
5. Gezira Scheme Act 2005): Effectively transferred irrigation and farming responsibilities from professionals to farmers. Its main objectives include ensuring farmers' right to: (i) effectively participate, at all administrative levels, in planning and implementation of projects and programs that affect their production and livelihoods, (ii) manage irrigation operations at field canal level through water users' associations, and (iii) freely manage their production and economic aspects within the technical parameters, and employ technology support to boost production and maximize their respective returns;
6. Civil Transaction Act 1984: Ties the rights to develop and access water resources with land rights, as long as permission is granted by the respective water authority;
7. Fresh Water Fisheries Act 1954: Is very regulatory in nature and its main provision states: no person shall introduce any non-indigenous fish into the Sudan except under, and in accordance with the conditions of, a permit issued by the Minister of Agriculture, Food and Natural Resources, who may in his absolute discretion refuse such permit;
8. Environmental Health Act 1975: It provides for the conservation of water and the prevention of the spreading of epidemics. It stipulates that the health authorities, in any Department, should regularly analyse water samples to ensure its quality and that it is unpolluted. The Act requires that any person or (institution) responsible for storing or supplying the population with drinking water, whether belonging to the public or the private sector, should conform to the health conditions outlined by the Minister of Health;
9. Gash Development & Utilization Act 1992: Provides guidance on, among others, abstraction and digging of shallow wells licensing; water fees; water resources pollution.

Annex 2: Anchoring pillars of the proposed new national water policy

Pillar I: Water for Peace

Promoting domestic and regional tranquillity, nurturing cooperation within the water sector community and facilitating peaceful co-existence among rural and urban communities is a top priority of the Government of Sudan and the MoIWR. Enhancing food and nutrition security and providing improved water supply services to post-conflict regions is a critical step to addressing grievances of communities that have been disenfranchised and marginalized for decades. Making such services available to historically marginalized communities also presents an opportunity to rebuild the trust and social fabric between government and communities.

Pillar 2: Water for Economic Growth

A transformed agriculture sector that is water efficient, highly productive and employment generating engine, can make tremendous contribution to socio-economic well-being of the Sudanese people. For example, the 2 million ha four national large-scale irrigation schemes (Gezira, Rahad, New Halfa and Suki), if properly performing, directly and indirectly create over 3 million jobs and contribute immensely to the improvement of food and nutrition security, raise national income and exports, and boost import-substitution. Sudan has an estimated 8.5 million ha potential irrigable land. Safe and reliable water supply for human consumption is critical for having a healthy workforce that can contribute more fully to the economy. In addition to human consumption, provision of water supply also has the potential to revitalize the livestock sector and support the lives and livelihoods of millions of herding families.

Pillar III: Water for Health

Severe food insecurity, hunger and undernourishment are direct contributors to poor health including child mortality and stunting affecting nearly half of the Sudanese population. There are significant regional disparities with the peace-fragile water stressed eastern and western (Kassala and Darfur) parts of the country topping the list of the most affected and vulnerable. To address these challenges, there is a need to introduce a new way of doing agriculture – agriculture that supports diversified and affordable dietary value chains while being economical with water, and is highly rewarding and attractive to all people, including women and young people.

Provision of inadequate water supply in both quantity and quality has a profound impact on health outcomes of Sudanese citizens. Consumption of unsafe water supply directly contributes to high prevalence of diarrheal diseases that are some of the leading causes of death in Sudan. They also contribute to malnutrition and stunting in children.

Pillar IV: Water for the Environment

This is a cross-cutting pillar. All new, expansion or rehabilitation programmes and projects for agriculture and water supply facilities must balance the need to fast-tracking socio-economic development and realizing environmental sustainability. To have long-lasting impact on peace, health and the economy, the programmes and projects should adequately identify and recommend mitigation measures for associated environmental and social risks. Pertinent Environmental and Social Impact Assessments or similar assessments must be conducted during the design and feasibility studies of the particular investments.