Aqua 4 Sudan Partnership

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Forwarding to Resilient Food Systems and Livelihoods

Highlights of Good Practices towards Improved Agriculture Productivity using Integrated Water Resources Management in Sudan under the Aqua4Sudan Partnership

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Content

Foreword

Integrated Water Resources Management (IWRM) is not new. Yet, this approach proves to be instrumental to address the challenging objective of sustaining water resources under climate change, desertification and competing growing water demands. The Aqua4Sudan partnership has been meaningful in testifying to the transformative power of properly managing land and water resources in one of the most challenging contexts in Sudan. This documentation of the good practices in IWRM under Aqua4Sudan, with a fair share of cross-cutting insights on impacts and upscaling, is useful and relevant to many: water professionals, local communities, governmental bodies, NGOs, and researchers.

The way IWRM was operationalized and implemented under Aqua4Sudan went beyond two common approaches in land and water management: the pure technocratic approach and the governance-predominant approach in project design and implementation. This document shows that the keys to sustainable impact are: having a strong partnership; establishing connections to local communities; promoting local ownerships; and having a balanced and well-thought through composition of sensitizing, technical and impact-harvesting measures.

With pleasure, the authors invite you to read and reflect on how the practices and insights from the Aqua4Sudan partnership can contribute to your day-to-day practices in sustainable land and water management.

1 Background and Introduction

1.1 Sudan and the grand challenges around water and agriculture in the dry lowlands

With a total landmass of 1.886 Km^2 and a growing population of 42 Millions, Sudan is the third-largest country in the African Continent. For decades, the country experienced multiple critical challenges in land and water resources: desertification, droughts, soil erosion, degrading rangeland resources, disbalanced water supplies and demands, and many more. Every year, about 420 billion m^3 of rainwater fall on Sudan's soils, (Salih, 2017)[1], however observation data shows a decreasing trend, and increasing variability between the seasons and years[2]. As a result, severe droughts increasingly affect the pastoralists and agro-pastoralist communities, which make up for largest share of the population of the country. About two-third of Sudan's landmass is arid or semi-desert zones, making the country highly susceptible to increasing desertification. Various studies show growing desertification, together with rapid decline of the rangeland resources such as livestock forages, water sources and wildlife habitats. Depleting rangeland resources now represent the most important limitation to livestock production and agriculture crops – which contribute to about 30% of the national GDP. Precious soil and water resources of Sudan likely experience growing pressures, caused by multiple factors. On one side, climate change and desertification further limits the available soil, and water resources. On the other side, population growth, people displacement and unsustainable rangeland practices like over grazing increases water demand and exacerbate resources depletion.

In the context of Sudan, strong links between increasingly limited water resources and conflicts are inherent. History shows that a large part of major conflicts in Sudan are related to water, mostly water shortages and conflicting uses between pastoralists, agro-pastoralists, and farmers. Sharing the limited water – a basic source for lives and income is inherently challenging. Damages to agricultural crops caused by livestock moving and accessing water sources are often the main source of conflicts between farmers and pastoralists. Dry years often experience more of these conflicts, as water availability is further squeezed, rangeland is getting limited and livestock have to migrate southwards earlier, crossing agricultural fields. On the other hand, conflicts often result in mass movement of the population. This process can then create extra pressure on the land and water resources at the new resettling areas. Strong interlinkages between water shortages and conflict highlight the relevance of a holistic approach to both issues at stake.

1.2 IWRM approach helps achieving multiple management objectives

Traditionally, water management in Sudan as well as in many other countries focused on balancing supplies and demands. The geographical scope often limited to specific scales e.g. villages, cities and the balance between different water uses (domestic, livestock, agriculture, etc.) was often overlooked. However, limited water availability and competing demands that grow by the day make it extremely challenging to balance supply and demand. This conventional approach became obsolete, calling for a new management approach that effectively balance water supply, demands in an integrated way, considering the water availability and a diverse set of management objectives posed by different users and stakeholders – Integrated Water Resources Management IWRM.
In essence, IWRM is about a coordinated approach for development and management of water and related resources (rangeland, soil, etc.) that accounts for, and optimally balance all water uses within the ecologically sustainable limits of the water availability. For this objective, IWRM's geographical approach is the catchment area or water basin, and the focus is on balancing multiple, often competing, water uses within the hydrological boundaries. As such, IWRM differs fundamentally to the conventional water management approach.

[1] Salih, H. H. (2017). Non-Nile surface water resources in Sudan. In an Overview, Opportunities & Challenges, Integrated and Sustainable Management of Non-Nile Water Resources in Sudan Conference, Khartoum.

[2] Integrated water resources management good practices in Sudan, UNEP 2020.

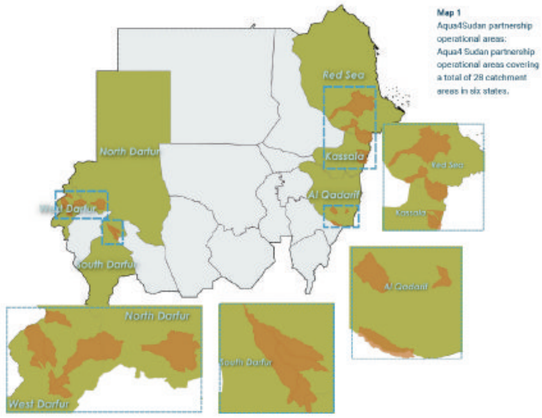
A distinct feature of IWRM compared to e.g., demand-supply oriented water management is in the combination and integration of specific measures to optimally balance demands and supplies within the limited water availability. Technical measures concerning water infrastructures are implemented in coordination, based on the IWRM plans. These plans and the underpinning water resources technical assessment ensures that all infrastructure can operate together without impeding each other's performance. Furthermore, infrastructural measures are implemented in combination with development of institutional and capacity for water management. In some cases, institutional and capacity mobilisation was done prior to infrastructures to ensure feasibility and avoid creating conflicts between user groups. Institutional assessment informs and sometimes motivate to halt infrastructure interventions as these likely worsen conflicts, e.g., in the case of Wadi Burei, West Darfur (Corbijn & Hassan, 2021[3]). This example shows the relevance of IWRM in conflict situations.

The importance of IWRM in the context of Sudan

Given the growing challenge of water scarcity in large parts of Sudan, the Integrated Water Resource Management approach is much needed. This helps to systematically balance the limited water supply with increasing demands from agriculture, domestic uses, industries, livestock, and other uses. While climate change, population growth and severe conflicts makes IWRM highly challenging, the merits and real results are gained from bringing different water users and stakeholders together to codevelop IWRM plans and implement these in different regions with adequate consideration of the local climatic, hydrological, societal and economic conditions. As such, IWRM helps managing water resources in sustainable manners and addressing water related conflicts.

1.3 The Aqua4Sudan Partnership

In the context of Sudan, IWRM represents a highly suitable approach for land and water management. Potential uses of IWRM not only limit to meeting the growing water demands, but expand to sustainable rangeland management, improving livelihoods and living conditions, all the way to conflict resolution and collaborations between actor groups. Acknowledging these huge potentials, the Aqua4Sudan partnership was designed and implemented for IWRM in Sudan.



Map source: [4]

Aqua4Sudan makes a difference with tailoring IWRM approaches to the context of Sudan

Aqua4Sudan shows some distinctive features in the program design, approaches, and methods for impacts. Regarding geographical focus, the project covers different regions with a larger coverage than typical projects: 28 catchment areas in six states, covering large rural areas across Sudan. Central in the project design is strong partnership, for mobilizing resources and building on alliances for IWRM. Previously, many projects and efforts have been investing on IWRM in Sudan, but experience shows difficulties to roll out the

[3] Corbijn, C. and Hassan Mohamed Elamen, M. "IWRM and Peace - The contribution of the Integrated Water Resource Management approach to conflict reduction and peace – the case of the Rural Water for Sudan project." Aqua4Sudan Partnership, 2021.

4 Corbijn, C. and Hassan Mohamed Elamen, M. "IWRM and Peace - The contribution of the Integrated Water Resource Management approach to conflict reduction and peace – the case of the Rural Water for Sudan project." Aqua4Sudan Partnership, 2021, p.3.

activities and investments in large areas. Strong partnership and resources allow Aqua4Sudan to cover more regions and create systemic impacts.

The Aqua4Sudan partnership in Sudan consists of International Aid Services (IAS), Islamic Relief Worldwide (IRW), Practical Action, Plan Sudan, SOS Sahel, World Relief and ZOA. This partnership implements the Rural Water for Sudan project in Red Sea, Kassala, Gedaref, North Darfur, South Darfur and West Darfur with funding from UKaid and the EU. To strive for impacts, all partners follow the same approach of working on the three fronts: promote local adoption; invest in cost efficient measures; and ensure effectiveness of the measures.
Conflict sensitivity is another distinctive feature of Aqua4Sudan. The project applies the principle of conflict sensitive IWRM, which requires all interventions to take into account the issues of:

1. **Understand the context in which it is operating.**
2. **Understand the interactions between its interventions and that context.**
3. **Act upon the understanding of these interactions, in order to minimise negative impacts and maximise positive impacts on conflict.**

2 Overview of measures for Food Security and Livelihood activities in IWRM

Integrated Water Resources Management entails a large range of measures, covering the whole spectrum of managing water supplies, demands and availability. In essence, IWRM measures can be structured into three main categories, namely 1) infrastructural measures; 2) measures for institutional and capacity building; and 3) supporting measures. Water infrastructures directly influence water availability, improve supply to match with demands. These includes different water harvesting methods, water transfer and diversion, and protection soil water conservation. Institutional and capacity measures bring together different actor groups and mobilize their capacities and resources to jointly develop and implement IWRM. Lastly, supporting measures compliment the above measures and helps maximizing the effectiveness of IWRM.

Infrastructural Measures in IWRM

Water harvesting & storage	**Hafir** Also known as valley tanks. Larger excavations for water storage on flat to gently sloping lands **Ponds** Natural or manmade areas filled with water, typically smaller than a lake or hafir. **Managed aquifer recharge** A group of techniques to supply water to groundwater aquifers, such as riverbank filtration, infiltration ponds and injection wells **Road water harvesting** Use of road and related infrastructures to collect, guide and concentrate water for different uses.	 Canal to divert water from the Gash river  Pond
Soil water Conservation	**Deep chiseling (1 L)** Special ploughing practice to make deep tillage with relatively limited soil disruption. This helps loosen the soil without turning the soil – keeping crop residue and organic matter in the top soil.	 Deep chiseling

Soil water Conservation	**Soil mulching** A practice to close off openings and even out the soil surface after ploughing. This helps to store and conserve the residual soil moisture until the planting season. **Moon-shaped terracing** Terraces are made using the shapes of a half-circle or a crescent, to improve soil water availability and ability to capture surface flows. **Grass strips** Planting and maintaining of grass in strips within and around the farming areas. Grass strips improve microclimate conditions for farming, by breaking winds and retain moisture in the soil. **Rangeland seeding** A practice to restore degraded rangeland by re-seeding, often combined with water harvesting. Reseeding rangeland helps improving rangeland while providing forage for animals. **Use of compost** Make compost from crop residue and natural forages to help improving soil organic matter and structure.	 Soil bunds (credit: Mathias Gurtner)  Soil mulching with straw
Protection & restoration	**Check dams** Small dam constructed across the stream to slow down streamflow, reduce erosion and enhance water infiltration to deeper aquifers. **Sand dam** A reinforced concrete wall built across a seasonal sand river. It captures soil and sand, and this accumulated sand helps storing water onsite.	

Water transfer & diversion	**Water spreading weirs (WSWs)** WSWs are walls, built from natural stones and cement to spread floodwater over the adjacent land area. This helps to slowdown the flows, spread, and redistribute floodwater and sediment around the structure. **Soil/stone bunds** Elevated structures built along the natural contour of the land to a height of 20-30 cm using stone or soil. The bunds form a barrier to help slow down surface runoff, distribute water over the land and improve infiltration. **Canals and other water transfer infrastructures** Canals for diverting surface water, wells, and pumps for groundwater extraction.	 Water spreading weir (credit: GIZ)
Hydrological assessments	Technical assessment of water availability, seasonality, and other relevant aspects to support design and planning in IWRM.	

Institutional Measures in IWRM

IWRM Plan	A jointly developed plan by stakeholders at the catchment level, providing guidelines for water management including infrastructure, resource allocation and mitigating (potential) water related conflicts.
Water Resources Management Committee	A formalized forum with participation of water users, government, men and women, farmers, nomadic pastoralists etc. The committee jointly assesses the different water needs in the catchment area, consider water needs and understand the needs and concerns of other water users. This process creates mutual understanding and efficient solutions.
Training and capacity building	A wide array of activities to increase local capacities in IWRM including training sessions, development of manual and guidelines, establishment of piloting sites and promoting good practices.

Supporting measures for FSL in IWRM

Rangeland management	A wide array of measures to restore degraded rangeland or improve the system, including re-seeding, water harvesting, controlled grazing, etc. One effective measure is establishing pasture seeds production farm, currently promoted by the Ministry of Production and Economic Resources, department of rangeland.
Farming improvements	Improving agricultural inputs such as fertilizers, combined with improving farming practices. The main focus is on Improved seeds, adoption of modern agricultural techniques, use optimal seed rate, plant spacing, early weeding, and use of organic fertilizer (compost) and pest control.
Fodder production	Grow, process and store fodder to improve fodder availability for animals and benefits the local soil and water condition.

3 Highlight of success stories and good practices from Aqua4Sudan partnership

3.1 From manual to motorized irrigation, West Darfur

I. Introduction of the area

In West Darfur, dry season farming remains a largely unexplored potential due to limited water availability. With a semi-arid climate and limited rainfall amount of about 400 mm per year, productive farming represents a grand challenge. Farming is especially difficult during the dry season when the field receive very little, if not at all, rainfall. In fact, many farmers do not farm in the dry season due to a strong dependency on rain. The International Aid Services (IAS) agriculture program as part of Aqua4Sudan Partnership aims to unlock the region's farming potential, through transitioning from manual to motorized irrigation. The main focus is on dry season vegetable farming – improving both household food security and income from selling the vegetables.

Case at glance

Aqua4Sudan partners introduced motorized pumps, to replace the traditional hand-irrigation. Under coordination of International Aid Services, the project served 37 groups in three catchment areas in West Darfur. Motorized pumps help to save time, increase the irrigation capacity and areas, and release a large part of labor needed for dry season irrigation. Improved irrigation water supply for dry-season farming helps farmers to grow non-staple crops like cucumbers, okra, onion, watermelon and more. The new systems were quickly picked up by the farming groups and many are replicating the intervention by investing in their own irrigation system.

Figure 1. Onion being harvested after changing to motorized pumping.

II. Technical background of the intervention

Central of the project intervention is introduction of the motorized pump, to replace the traditional hand-irrigation. This helps to save time, increase the irrigation capacity and areas, and release a large part of labor needed for dry season irrigation. Improved irrigation water supply for dry-season farming helps farmers to grow non-staple crops like cucumbers, okra, onion, watermelon and more. While the motorized pump and irrigation system is the main focus, the project was motivated to aim at a broader scope. Firstly, the project goes beyond the conventional scope of 'safe drinking water supply' in typical water for development projects, and targets the agriculture and water for livestock sectors, as well as other sectors. The intention is to increase crop production in sustainable ways and address the bottlenecks in crop production – being limited rainfall and a strong dependency on rainfed systems. Furthermore, improved crop irrigation is expected to bring out positive impacts on food security, health, market supply and social cohesion thanks to the various collaborations created in the project.

III. Technical design and relevance

Figure 2. Farmer operating water pump for his crop

In essence, the diesel-powered motorized pumps were provided to supply water from the wadies wells to the surrounding agricultural fields. Along the wadies wells, farmers jointly dug wells at the depth of 2 to 3 meters and reach the water source. The pump and connected water tubes are operated to supply irrigation water across the whole farming site. Regarding fuel, farmers were supported with quota on diesel, provided by the Ministry of Production and Economic Resources – through local authorities. Through this arrangement, farmers could have access to price-controlled diesel and more or less cover their fuel needs for irrigation.

The project was designed and implemented in a holistic way. While the motorized irrigation is the focal intervention, project activities cover the whole range of agriculture development:

- Raise awareness of farmers and catchment committee on modern agriculture practices focusing on using motorized pumps
- Training on setting up, operate and maintenance of the irrigation system. From the wadi as main water sources, farmers were trained to dig wells of between 2-3 meters deep and install the pump. From this source, water is pumped using the diesel-powered pumps towards the fields locating around the wadies wells. Farmers were also trained on good practices for digging wells along the wadi.
- Provision of farming equipment, seeds, fertilizers, and farmer trainings on the modern agricultural techniques facilitated by the Ministry of Production and Economic Resources.
- Coordination and collaboration with various stakeholders. The project is not a mere technical intervention. Instead, stakeholder coordination plays a crucial role in ensuring adoption and effective use of the irrigation system. In this regard, farmer-farmer collaboration within the farming group, and farmer-catchment committee-government (local authority and Ministry of Production and Economic Resources) are essential.

IV. Community preference and take up of the intervention

Largely thanks to the comprehensive approach in project design with complementary measures, the motorized pump systems were quickly picked up by the farming groups. Farmers particularly appreciate the created access to price-controlled fuel, and a significant boost to their water supply for crops. Many farmers are motivated to establish new farming groups and they are willing to co-invest. A farmer, who is a member of the established group, bought his own pump and support another new farming group with the same farming approach.

Members of the farming groups came up with a creative solution to cover operating costs and maintaining the irrigation system and pumps. A sandug - a voluntary agreed contribution system to collect money for fixing and operating the pumps were established by farmers to cover irrigation expenses. This collective action shows good example of farmer collaboration, and their strong motivation to the communal irrigation system.

Figure 3: Preparing enough fuel for irrigating the winter season vegetable crop

V. Impact and results

Introduction of the motorized pumps and complementary measures bring about many positive impacts, both directly and indirectly. Direct impacts are shown through a rapid boost in the farming capacity and agriculture output in the targeted communities. Farmers acquired useful knowledge for farming and received support in terms of agricultural input such as water pump and improved wells.
Thanks to the irrigation water from the wadies wells, farmers were able to cultivate in a much larger areas (up to 5 feddan) compared to their previous system based on rainfed and traditional irrigation system using ropes. Improved water availability helps to increase crop quality, but also diversify from staple, home-consumption crops towards cash crops especially for vegetable. A much more diverse cropping composition is reported in all the farming group, where farmers are now growing cucumbers, okra, onion, watermelon etc.

In direct impacts are also plenty. The household and community level food security, and income benefit greatly from the improved farming system. Farmers were able to produce and sell more diverse food items in the local market – this helps to boost their income and to create financial resilience. Farmers are better oriented towards market and cash crops. The money gained from moving from staple crops only towards mixed staple and cash crops improve income stability. Parts of the improved income was used to purchase agricultural inputs, and to cover day-to-day expenses such as schooling fees for children, and non-foods items costs.

Figure 4. Happy farmers and gratitude to Aqua4Sudan for making it possible

Farmers also report good relationships between the members of the farming groups. From working individually, farmers moved to working in groups to irrigate larger areas. This promotes collective actions, collaboration between farmers. The group gets more visibility and credibility to approach market and the government for support.

The role and contribution of the catchment committee is remarkable for achieving the impacts in this project. Catchment committee plays a binding role. This has been instrumental to secure fuel supplies with affordable price. Good linkages between farmers groups, catchment committee and the government were established.

VI. Scalability and sustainability

The Aqua4Sudan project intervention with motorized irrigation show good potential for upscaling beyond the current targeting areas. The main motivation for upscaling is grounded from positive impacts and strong

commitments of the farming groups. Individual farmers who participated in the project indicate strong motivation to continue with the motorized pump and farming groups. Notably, a farmer invested in his own pump and organized a new farming group following the same approach introduced in the project. This shows good signs that the intervention is well received by the targeting community.

Additionally, the local authorities in the three catchment areas are also convinced by the improved agriculture production, as well as the new possibility to expand agricultural production without having many, uncontrolled wells along the wadies wells. The motorized pumps and improved irrigation capacity allow to expand irrigated areas while keeping the number of wells under control. This is remarkable as it helps to focus on improving water use efficiency at a limited number of good wells instead of having many, uncontrolled wells that pose a risk to aquifer depletion as well as pollution through boreholes.

Despite many positive impacts and potentials, upscaling of the motorized irrigation approach requires careful planning and assessment. assessment. Practitioners e.g., NGOs and planning authorities need to consider the following three factors when upscaling irrigation. Firstly, upscaling is only advised if sufficient water is available in the beds of wadis/khors, where there is access to markets, and where the risk of conflict is low. Water extraction from the wadies wells at a certain level will affect ground water recharge and water table, which might negatively affect water availability in downstream catchment areas. Upscaling of irrigation therefore requires having a good grip on the water table and downstream impacts.

The current hydrological assessment with the assessment scale at catchment level is useful for planning of intervention, but the results are not detailed enough both spatially and temporally to monitor impacts of on-going irrigation. Localized groundwater monitoring is therefore advised as an element of the upscaling process. Secondly, the role of the catchment committee should be emphasized and put in the centre of the intervention. Experience shows that the catchment committee plays a central role in communicating information with downstream catchment areas and establishing collaborations.

In this context, the catchment committee links farmers through their farming groups with the government bodies, which help to address important issues in project implementation such as the fuel shortage on the market. Fuel is currently limited and is a big challenge for farmers. Black market price for fuel can be much higher than the official price. A strong dependency on fuel requires attention. A strong link to catchment committee to help access to ministry of production and economic resources – the providing body of fuel. Lastly, moving towards the solar panel system is recommended for powering irrigation, but this is more technically demanding. Spare parts are in general not available in the market. A comprehensive solution would need then to focus on the whole process of setting up, financial support, training, maintenance and fixing. The technical know-hows for farmers would be appreciated to address the trade-offs between sustainability versus adoptability.

VII. Discussion & Recommendation

The motorized irrigation system introduced by IAS under Aqua4Sudan partnership represents a highlight of IWRM in the context of agriculture development in West Darfur. This is a technical intervention at the surface, but much more is happening on many other aspects of IWRM including stakeholder coordination, collaboration, and joint operation of the irrigation system.

3.2 Water spreading weirs for irrigation

Figure 5: Farmer harvesting from her farm with supplied irrigation

> Before this intervention we only grow crops in the rainy season, mainly millet and sorghum. Now we can plant vegetables throughout the year like tomato, Ajour, aubergine, Okra. We never dreamed of producing these vegetables here. We have met our own village demand and selling to more than ten neighboring villages, last year we made a 60 thousand Sudanese Pounds.

I. Introduction of the area

Dordieb is an old town, with the Sheigs as the majority of population. During the rainy season, the region experiences a lot of movement of people and livestock as people move from the areas of Gunub and Olieb into Dordieb. The Haya catchment, also known as the Khor Arab, with a majority of the population belonging to different Hadendowa groups are part of the Beja. Traditionally, the population shows gender biases in labor and access to water, where the roles and accessibilities differ between men and women. Much like many other regions in the Red Sea State, the Dordieb and Haya catchment areas have a semi-arid climate with a short, variable rain season. The limited rainfall and semi-arid climate in the regions are the main challenges for agriculture development and represent a long-term bottle neck.

Figure 6: On-field water diversion from the water spreading weir

II. Technical background of the intervention

For both regions, rainfall is highly limited with an annual average of only about 100mm, with a large portion (above 80%) of the precipitation occurring during wet season months between July and September. This represents a major challenge for agriculture and food production. The seasonal flows in the wadis and khors are the main water sources in the region. During the flood season, it is crucial to make best use of the surface flows using water-spreading weirs, diverting structures and terraces.

Under the Aqua4Sudan partnership, the SOS Sahel Sudan and International Aid Services Sudan NGOs in collaboration with the Ministry of Agriculture and local stakeholders implemented a project to build and restore a series of water spreading weirs and complementing measures in two catchment areas of

Dordieb and Haya. In total, the project provided support with 17 diversion weirs in Haya and 3 in Dordieb catchment. In combination, a total of 64 terraces were also constructed to help boosting up water harvesting for farming.

Case at glance

Crop production in the Dordieb and Haya catchment areas is highly challenging due to limited water availability. Water spreading weirs were identified as an effective solution to boost crop production in a semi-arid climate with a short and variable rainy season. Under the Aqua4Sudan partnership, the SOS Sahel Sudan and International Aid Services Sudan, in collaboration with the Ministry of Agriculture and local stakeholders, implemented a project to build and restore a series of water spreading weirs. The project also carried out complementing activities. About 7600 farming households in Khor Arab and 415 farming households in Dordieb participated and benefited from the project's various activities. The local populations specially appreciate the improved water availability – which significantly improved the farming area and crop harvest quality.

III. Technical design and relevance

Walls are built from natural stones and cement to spread floodwater over the adjacent land area. The main aim is to slowdown the flows, spread and redistribute floodwater – including its sediment load around (both upstream, downstream and adjacent) the structure. In general, water spreading weirs (WSWs) are relatively cheap to build, and require little effort for maintenance. As the floodwater flows down from the highlands, they bump against the weirs and flow backwards or sideways, depositing both water and nutrient rich silt on the ground up-slope from the weir. Over time, the sediment builds up and generates fertile soil. More water is also stored in the soil, groundwater is recharged with floodwater. All these effects create good conditions for agriculture, and soil water conservation.

Figure 7: Field visit with farmers to make the best use of water supplied from the water spreading weirs

While the main effect of the water spreading weirs is to increase local water availability, the project was determined to take a holistic planning and implementation approach. This helps to make sure that the WSW works the fullest capacity – through land preparation (terracing) and through mobilizing labour especially women to join the labour force. As such, impacts of the WSWs are enhanced. In this regard, the role of the catchment committee is highly important. The committee consult the technical advisors from the ministry of agriculture for proper design and consult farmers on determining suitable locations for the weirs to be built. Furthermore, the committee mobilize local population to participate and contribute with labour to constructing and restoring of the water spreading weirs.

To maximize the benefits of the weirs, they were complimented with establishing farmland, terraces and water diverting structures. This helps to evenly distribute the water flow on the whole farming area, increasing the local soil water conditions. Additionally, the project also provides agricultural inputs, tools and training to improve farming practices. A strong focus is also put to encouraging women participation in farming. For the first time, women in the regions actively involved in agriculture – at least 200 individuals were observed to join the labor force.

IV. Community preference and take up of the intervention

About 7600 farming households in Khor Arab and 415 farming households in Dordieb participated and benefited from the project's various activities. The local populations especially appreciate the improved water availability – which allow significant improvement of farming area and crop harvest quality. Farmers were actively involved in the whole process of planning, construction, operation, and maintenance of the water spreading weirs and supplementary measures.

V. Impact and results

Outcomes and impacts of the constructed and restored water spreading weirs are plenty and strong. Most directly, the weirs allow rapid expansion of irrigated areas, with significantly improved soil and water conditions for farming. In Dordieb the cultivated areas increased compared from 400 feddan in 2017 to about 775 feddan currently. Irrigation expansion and improved farming conditions have strong spill over effects on crop production, household incomes and food security. Farmers were using small farming plots before having the weirs and produced mostly sorghum. Now farmers are moving towards vegetable, and this attracts labour in farming specially to grow cash crops. In some cases, farmers were also able to grow two crops per year thanks to the increased water availability coming with the weirs. An emerging farming pattern seen in Haya and Dordieb is that farmers grow a first crop with sorghum and then move on with vegetable right after harvesting. This significantly increases farming productivity, food supply and income for farmers.

Introduction of the water spreading weirs and supporting measures also have remarkable impacts on the local food chain, market and labor distribution. It is observed that farmers actively transition from sole staple crop farming to complementary cash crops with higher value agricultural produces. Crop diversification, especially vegetable farming, increases food supply and has positive impacts on the market in two ways. First, the local community now has access to more abundant and diverse food items – which likely benefit nutrition intake and health. Second, market prices of many agricultural products are stabilized thanks to sufficient supply. Labor wise, for the first time, women are actively involved in agriculture – about 200 were observed to join the labor force. This is due to the strong focus of the project on women involvement, but also thanks to the increased attractiveness of farming for income.
All in all, positive impacts brought about by the water spreading weirs are widespread, and not only limited to improved water availability but also to agriculture intensification, food security, health and gender equality.

VI. Scalability and sustainability

The market demand for agricultural products, especially vegetable is a strong incentive for sustaining and upscaling the water spreading weirs. The local community and food chain directly benefits from the additional, diverse food items coming from the farms. Households benefit from increased income from growing cash crops and therefore they are motivated to continue farming and maintaining the weirs.

Sustainable operation and maintenance of the water spreading weirs requires attention to a few factors. First, it is important to realize that proper maintenance and timely fixing of small defects are important to sustain the weirs. Much of the maintenance is about organizing roles and responsibility amongst local farmers, the catchment committee, and the government bodies. While frequent check-ups and small fixes should be implemented by farmers, it is advisable to include major check-ups and maintenance into the budget and routine activities of the local authority as well as of the ministry of Agriculture. Lastly, attention has to be paid to floods as strong flows can damage the weirs and create erosion. In this regard, rainfall observation and early warning for floods should be put in place.

VII. Discussion & Recommendation

Experience from the promotion of water spreading weirs in the Red Sea state shows that comprehensive planning, implementation and coordination is key to harness the benefits of infrastructural measures in IWRM. In this case, water spreading weirs are designed and operated in strong links to soil water management, improving farming practices and strongly embedded into existing institutional arrangements for land and water management. This is characterized by a leading role of the catchment committee and organization of farming groups. Lastly, coordination between project partners, farmers, and other organizations working in the areas are of special importance. Meetings, and sharing experiences with partners working on the food security theme including the United Nations agencies, international and national organizations proved highly effective to share and improve project activities and management.

To further promote water spreading weirs and optimally use them, maintenance is crucial. While technical fixes are important, a large part of maintenance is about organizing roles and responsibilities amongst stakeholders. It is recommended that the regular check-ups and major maintaince should be integrated into routinized procedures of the catchment committee and the Ministry of Agriculture. Small fixes, however, should be the responsibility of the farmers and this requires coordination. Also important is that water spreading weirs and other related water harvesting techniques are mainstreamed into policy agendas for development. In this regard, the Red Sea State's agriculture development strategy until 2030 and the State IWRM Council that was formed during this project are important opportunities to up-scale the activities (and with it the positive impacts) of this project.

Ahmed Mahmoud from Dordeib expressed his gratitude to this intervention and said "this project has brought stability and settlement to the area. In addition, our livelihoods are enhanced financially. We are willing to contribute to more similar projects because we have felt the impact in our lives.

Figure 8: Farmer visiting his farm that receives water from the water spreading weir

3.3 Um- Hugar women's farming group

I. Introduction of the area

The Um-Hugar village is amongst several villages in North, South and West Darfur where the Aqua4Sudan partnership supports local communities with establishing women farming groups. Farmers in Um-Hugar, as well as many of the rural areas in North Darfur, are dependent on rainy season farming between October and May. Farmers mostly cultivate cereal and vegetable for home consumption. Very limited rainfall and lack of irrigation infrastructures discourage farmers to grow crops during the winter season between December and March. Notably, women participation in farming and farming decision making is rather limited as traditionally men are in charge of the family responsibilities. Amongst the women in rural North Darfur, divorced women and woman-headed households are especially vulnerable to shocks like droughts or delayed rainy season as they often do not have land for own farming activities. In this regard, unlocking the irrigation potential with a focus on women farmers represent an opportunity for community development, women empowerment and building resilience.

II. Technical background of the intervention

Establishing women groups for vegetable farming in North Darfur were driven by several motivations. Firstly, the project aimed to address the largely unexplored potentials of dry season vegetable farming. Secondly, women empowerment through self-organized groups and livelihood creation can be achieved by forming farming groups where women collaborate with each other and organize joint farming activities. This helps to create labor, providing extra food for home consumption as well as extra income from selling the agricultural products in the local market. Additionally, the collaboration also strengthens social relations and peaceful co-existence between the local inhabitants.

Case at a glance

Just as many other villages in Dafur, the Um-Hugar village has significant, yet unexplored potential in farming and in rural labor, especially regarding women's participation in the workforce. Aqua4Sudan partnership tapped on this potential by establishing women farming groups and support them with vegetable farming inputs and tools.

The intervention showed several direct results in the targeted community: a remarkable increase in the cultivated land during the winter season, and extra food supply, both domestically and in the local market. At the community level, the project contributed to women participation in the labor force and farming activities. The project also created a new source of income for participating farmers, and this helps to cover daily expenses.

Figure 9: A member of the vegetable farming group prepares her harvest for selling at the market

Figure 10: Farming tools provided by project are well received and appreciated by farmers

In Um-Hugar, some community members own relatively large land areas that they either do not have capacity to farm or do not have interest to farm on all locations. These members are willing to lend part of their land to other community members, under arrangement and facilitation of the local authority, community leaders and catchment committee. In this area, a promising opportunity lies in a proper arrangement for sharing uncultivated land with less-advantaged farmers such as divorce women and woman-headed households.

III. Technical design and relevance

The main intervention was to establish women farming groups and support them with vegetable farming inputs and tools. The intervention was implemented following several steps. Firstly, the project members engaged with the catchment committees – which help to connect to farmers and other relevant stakeholder including the land owners. Secondly, the catchment committees nominate members of the farming groups and form different groups – each consisting of about 10 members. Under facilitation of the catchment committee and local authorities, some land owners came to an agreement to lend their uncultivated land for vegetable farming, for a prolonged period of about 10 years.

In Um-Hugar vegetable farms were established close to the village, with participation of about 130 to 140 households, mostly allocated 2 Km away from the center of Kabkabyia town. On each farm, which is typically 2.5 Feddan (2 Mukhamas), there there are 10 women household farmers who cultivate in the winter season starting from October up to June next year.

After forming the farming groups, the project collaborated with the catchment committee and Ministry of Agriculture to provide training, agricultural inputs, and tools to all group member. Farmers were trained on different aspects of dry season vegetable framing, with topics ranging from land preparation, climate requirements, cultivation techniques such as seed rate and spacing, use of organic fertilizers, early weeding, pest, and disease control measures. This help to provide farmers with practical knowledge and skills to grow vegetable.

Figure 11: Technical training and field visit with project members

Furthermore, the project also provides farmers with tools (pumps with full accessories) and seeds, and pesticides at the beginning. In each group, an older member will take the lead and organize a plan for farming. Each woman is allocated several plots and she will take care of the farming responsibilities on those plots.

The size of cultivated area varies depending on the capacities of each member, and this is jointly discussed by the members in the group. Agriculture inputs and tools are also distributed to the member based on the size of allocated land. The project's support with motorized pumps was particularly important for the farming groups as they can extract groundwater for crop irrigation. The group members share the costs for fuel and for maintenance and repair of the pumps.

IV. Community preference and take up of the intervention

Community members, especially the participating women are very happy with the newly established vegetable farming groups. Many groups expanded from originally 10 members to 12 or more, as farmers saw direct benefits from their farming activities. Furthermore, the guidance and coordination of the catchment committee were also positively received by the farming groups, as the committee plays a binding role to link farmers to technical support and farming inputs provided by the project and by the Ministry of Production and Economic Resources.

Figure 12: Happy farmers with improved crop productivity

V. Impact and results

The intervention showed several direct results in the targeted community. These include a remarkable increase in the cultivated land during the winter season between December and March. This is seen as a radical change in agricultural practices in Um-Hagar since cultivation was largely impossible due to limited irrigation capacity. Other direct results include extra food supply, both domestically and in the local market. The harvested produce is more than sufficient for home consumption and farmers organize groups to take turns to bring products to the local markets twice a week.

At the community level, women farming groups bring about several positive impacts. Firstly, the community sees an improvement in women participation in the labour force and farming activities. Women also show their self-organization and leadership skills by communicating and sharing tasks within the groups. Secondly, the project created a new source of income for participating farmers, and this helps to cover daily expenses in the households such as clothes, medicines, and school fees. Farmers are also keener on adopting good farming practices such as proper land preparation, optimal spacing, understanding seed rate, and efficient use of fertilizer.

VI. Scalability and sustainability

Experience from the women vegetable farming groups in Um-Hugar shows that the potential for upscaling is substantial. The intervention provides landless farmers with access to farming land and additional support – showing a working solution to unlock the potential of uncultivated land available in the area.

The sustainability of the intervention mainly depends on the presence of the catchment committees and the technical support from the line ministries and the INGOs working on the same field of the intervention

So far, irrigation using pumps is the deciding factor for cropping area and intensity. Farmers expressed their needs for more pumps that allow farming on larger areas. This needs to be addressed in careful consideration of the limit for sustainable groundwater extraction in each catchment area.

The catchment committee is important for sustaining and establishing new farming groups in several ways. The committee stays close to the members of the farming groups and ensure that the group functions well in their joint farming activities. The committee also helps farmers to access technical support and fuel from the local authority and ministry of agriculture.

VII. Discussion & Recommendation

The vegetable farming groups in Um-Hugar represent a good example of how a comprehensive IWRM package of intervention can be implemented to unlock the potentials of land and water resources for agriculture, using irrigation and women labour. The positive impacts go well beyond improved land and water management, and cover social cohesion, women empowerment, and participation in the workforce.

A number of factors were identified for further upscaling of this good practice. Fuel is a limiting factor as the price is often too high. A strong link to the government is important for accessing fuel for irrigation. In the long-run, solar energy systems for water pumps is the solution. This has been implemented by private sector, so exchanges with this group is helpful. The high cost for solar system currently makes it impossible for farmers to invest themselves. A financial mechanism to support this is needed.

"Aqua4Sudan has given us the first kickstart of the project (the inputs, land, and pump), but now we are totally on depending on ourselves. We pay for all the inputs, fuel, and rent. This intervention has enhanced our livelihood significantly. From the profits we were able to buy land and livestock, to fix our houses, and to pay for school's fees." Fatimah expressed her gratitude by saying: "in the past we used to be daily laborers on other people's farms, bearing a lot of humiliation and disgrace. Sometimes we got beaten. Now I work with

3.4 Mesga Algash: Alternating spate irrigation with semi-canalization system

Case at glance

The Gash Agricultural Scheme (GAS) is the largest and most important spate irrigation system in Sudan. Improvement in the irrigation efficiency of the GAS means direct benefits for the regional food security and economy. Under Aqua4Sudan, this improvement was done through canalization of the irrigation channels, focusing on the Matatieb block within the scheme. The Matatieb block has multiple favorable conditions relating to topography and shape regularity, good condition of the off-take structures, good accessibility, and limited spreading of Mesquite trees. The newly canalized irrigation system shows immediate results, which were quantified through an extensive monitoring and evaluation program put forward by the project. The intervention results in a remarkable improvement in soil water content. The total number of irrigation days decreased from 21 days (current practice in GAS for 1500 feddans) to 17 days (the experiment case). This means 27% of irrigation duration (4 days) is saved in terms of irrigation water. This opens concrete opportunities to either expand the irrigated area, or to grow a second crop with the newly available irrigation water.

I. Introduction of the area and the case

Gash Agricultural Scheme (GAS), located in Eastern Sudan, is the largest spate irrigation scheme in Sudan, where it significantly contributes to the food security and regional economy. Over 80% of the Gash people depend on agriculture for their livelihoods, being irrigated agriculture, or livestock keeping. The GAS was established in the 1920s for production of crops, mainly Sorghum. The arable land in the Gash reaches more than 80,000 ha, while the actual cropped area hardly exceeds 30,000 ha due to poor field water management. At the same time, water productivity in the GAS, is low compared to global averages or potential local targets from the Sudanese Agricultural Research Corporation (ARC). Other than the little rainfall of less than 200 mm/year, the Gash River is the only source of water in the area, it is a seasonal river that commonly flows from July to October. The groundwater table in Gash is also declining at alarming rates. However, many believe that the gloomy picture of the Gash can be reversed through better management of the available water resources. That is through a comprehensive and integrated approach, which considers technical and non-technical factors.

The case of Mesga 15 in Matatieb block, was first piloted under the research project "Africa to Asia and Back Again: Testing Adaptation in Flood-Based Resource Management Project" since 2015. Given good performance of the initiated canalization intervention, Aqua4Sudan program supported resources and expertise with scaling up and continuation.

II. Technical background of the intervention

The GAS scheme is divided into six blocks, namely Kassala, Makali, Degain, Matateib, Tendalai and Hadalya, from south to north as shown on figure below. Generally, the flood water is diverted into the main canal systems through seven off-take structures located on the left bank of Gash River. The main canals directly convey spate water to irrigated farms (called Mesga) of areas that range between 1000-2000 feddans. Masonry intake structures, with suitable angles, along the length of the main canal system serves to ease flood water supply into Mesgas. A simplified layout of GAS is shown in the figure below including river off-take structure, main canal system, and Mesgas.Based on the two-year rotation, half of all Mesgas are irrigated each year. As more floodwater is available during the first half of the flood season, about 70% of the Mesgas are irrigated in the first irrigation (it starts in July and continues to the beginning or the middle of August depending upon the flood stage). The remaining 30% of Mesgas are irrigated during the second irrigation starting from mid-August until mid-September. Within each Mesga, floodwater is distributed from the upstream to downstream, depending on the field topography and slope, for a period of 25 to 30 days. Crop cultivation usually starts about one week after irrigation when tractors can enter the Mesgas. Sorghum is considered to be the main crop in GAS, with its two types (Tabat and Aklamoy).

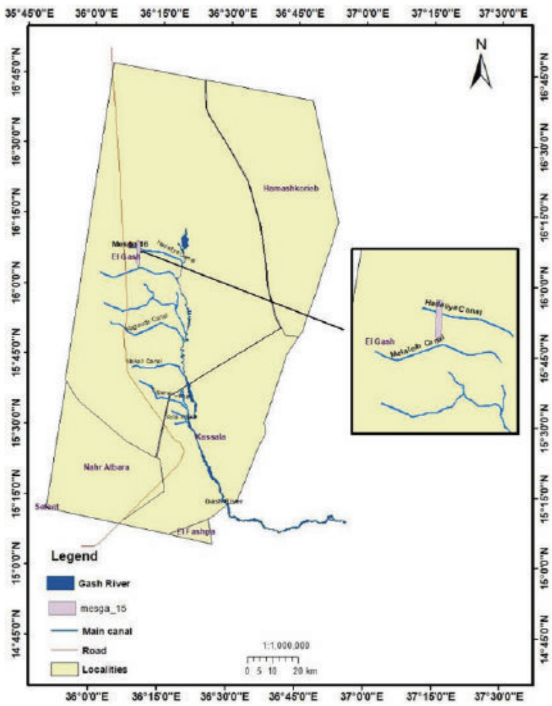


Figure 13. Layout of GAS and location of mesga 15 in Matatieb block

To allow for optimal water distribution over the whole irrigation system, the Mesga was divided into two sections with two distinct irrigation mechanisms. The first (upstream) section is irrigated directly from the main canal, while the second half is irrigated through a carrier canal.

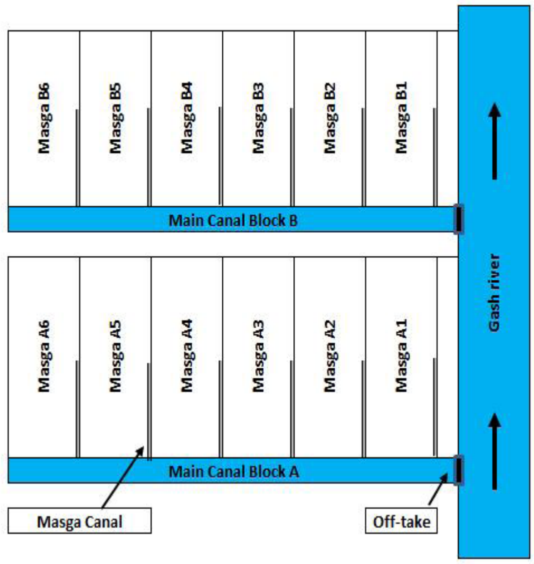


Figure 14. Layout of the water distribution system in GAS

III. Technical design and relevance

The canalization process focused on the Matatieb Block, as this block has multiple favorable conditions relating to topography and shape regularity, good condition of the off-take structures, good accessibility, and limited spreading of Mesquite trees. The Mesga is about 1500 feddan (6.3km2) with a semi-rectangular shape. The length and the width of the Mesga is about 7000 and 1000 meters respectively. The flow is about 4.5 m^3/s and water depth of 710 mm. The irrigation period is about 21 days. The Mesga is served by two offtakes abstracting water from Matatieb main canal. The first one is offtake Mesga 14 in the southeast corner, while the second offtake of Mesga 15 is in the south west corner, starts from Matatieb main canal and goes on straight alignment up to 2.3 km on the western part of the Mesga.

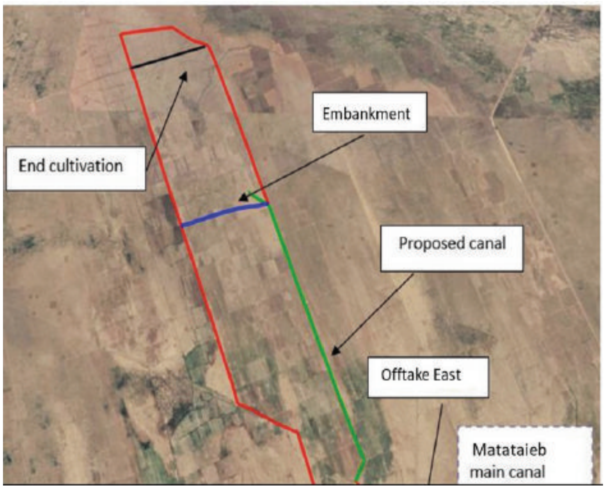


Figure 15. general layout of the intervention illustrating the locations of the embankment and proposed canal

To irrigate an area of 700 Feddans, the discharge is estimated at 2 m^3/s for 17 days, this results in application efficiency amounting to 75%. The set of interventions included a carrier canal and an embankment to split the Mesga. The embankment has a length of 900m.

IV. Community preference and take up of the intervention

The design and implementation of the irrigation canal experienced radical changes in terms of preference and up take. It is interesting that at first glance the farmers were not convinced and rejected the intervention, especially the construction of the carrier canal. According to farmers, the carrier canal will be constructed on part of the field area, taking away a portion of their farming land. In this case, sensitization by project members and explaining the long-term benefits of improved irrigation was regarded as highly important to gain understanding and support from the farmers. The project implemented two pilots and demonstrated an improvement in the crop yield thanks to improved irrigation, and the good results helped convincing farmers to accept and join forces in upscaling efforts. At the later stage in the project, farmers requested support for scaling up the canalized irrigation system in other areas. Local farmers have confirmed the improvement of water distribution within the field level, which is also confirmed by statistical results derived from remote sensing analyses by the Hydraulics Research Centre (HRC Sudan).

V. Impact and results

The newly canalized irrigation system show immediate results, which were quantified through an extensive monitoring and evaluation program put forward by the project. To quantify flood water entering Mesga 15, intensive measurements of water levels were carried out. Flow velocity measurements were carried out on multiple sites. The total incoming flow volume to the Mesga15 was found to reach 4.5 Million m^3.
The intervention also results in remarkable improvement in soil water content. It was found that a water depth of 6.62 cm/90 cm soil depth is representative to the entire Mesga. The below figure shows improvements in the soil moisture condition as observed from satellite images. Soil moisture improves significantly both in terms of the water distribution and of the moisture content.

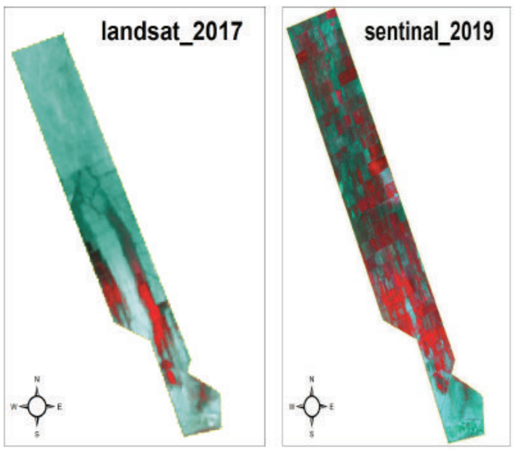


Figure 16: Soil moisture content derived from satellite images during 2017 (left) and 2019 (right).

Apart from changes in the bio-physical conditions, irrigation performance and crop yields also show important improvements. The total number of irrigation days decreased from 21days (current practice in GAS for 1500 feddans) to 17 days (the experiment case). This means 27% of irrigation duration (4 days) is saved in terms of irrigation water. This opens up concrete opportunities to either expand the irrigated area, or to grow a second crop with the newly available irrigation water. The significant improvement in the crop yield has increased as indicated by data records shown in the table below.

Variety	Average yield in GAS (Sacks per Feddan)	Yield in pilot farm in 2019 (Sacks per Feddan)
Tabat	10-12	13
Aklamoy	5-7	7

VI. Scalability and sustainability

Sustainability of the Mesga canal for future use and its condition regarding siltation is significant aspect to consider. As these interventions have proved their success from the above results, a viable question is how to sustain and further improve these interventions. The Sudan Ministry of Irrigation and Water Resources MoIWR has included the operation and maintenance of the GAS in its 2021-2031 strategy plan for rehabilitation of the spate irrigation schemes. Excessive de-siltation works were carried in the season of 2021-2022, which has been absent for many years ago.

The farmers as targeted beneficiaries have committed to contribute to the costs of the operation and maintenance, in return to adequate water delivery to their fields which is the main purpose of this intervention.

The GAS is a large spate irrigation scheme, since this intervention has proved its success and adequacy, scaling up to the other blocks and the scheme as whole would require proper planning from the relevant administration and stakeholder. The MoIWR has prepared a rehabilitation plan for the scheme, hence proper preparation for such intervention is an essential component to improve water productivity and production.

VII. Discussion & Recommendation

Canalization of the spate irrigation in the Gash system has shown remarkable results and impacts. In order to maintain the system and further increase its performance, there are some aspects to be considered. First, the Mesga was not levelled before the growing season. Levelling of flooded land would have good impacts on water distribution. Concerning the manmade breaching on the outer bund to enable water flowing to the first half of the Mesga, it tends to be increased in width due to the loose soil. Hence, strengthening of these water intakes sides has to be considered by using local materials.

3.5 The Baba Dam - the Peace Dam

I. Introduction of the area

Baba dam is considered to be one of the most unique cases, not only for its technical intervention idea or the water availability it has contributed to, but for the peace building aspects and being a significant cause for settlement of local immigrants after 17 years of fleeing to IDF camps. Baba dam, which is named after Baba village, is located few kilometers east of Nyala city in the south region of Darfur, falling in the downstream part of Wadi Endur catchment. After the conflict of 2003, many people have escaped from these villages to displaced camps. One of the largest IDF camps is the Kalma IDF camp hosting 128000 IDPs at that time. People from Baba village have fled to this camp and after 17 years of displacement, they finally flew back to their home villages and farms due to the Baba dam intervention. People of these areas are diverse with farmer groups, semi pastoralists and pastoralists groups. Baba villages people are mainly farmers, before 2003 they had farms where they grew different types of fruit trees, for example mango, lemon, grapefruit, guava, oranges. After the displacement due to war, most of these trees have dried out and died, trees have dried out and died, fortunately now they are reviving back

Case at glance

The Baba Dam represents one of the highlights of the Aqua4Sudan partnership, where many remarkable results were achieved with a relatively moderate budget. To help restoring flows to a non-functioning irrigation canal, a dam was constructed in Baba khor, benefiting from outcrop layer in khor bed. This intervention has led water to rise to a level above canal bed level and water can now enter into farmlands smoothly. It has also increased the retention time of the flow, leading to recharge of groundwater. This has been recorded clearly in the farms far from the khor and the diversion canal. The Baba dam is considered to be one of the most unique cases, not only for its technical intervention and improvement on water availability, but also for the peace building. The inspiration is that the dam allows for the resettlement of local immigrants, since they fled to displacement camps 17 years ago.

Figure 17: Tress are coming back to life in the landscape thanks to Baba dam.

II. Technical background of the intervention

Wadi Endur catchment is a relatively uniform landscape with a semi-arid climate. The area is mostly flat or slightly undulating plains, with clear sandy khors draining the catchment. At the catchment outlet in the south lies a large floodplain (also known as Talata area) which gets regularly flooded.

Due to upstream landscape changes driven by interrupted socio-agricultural practices; Wadi Endur has witnessed increased runoff volumes recently. Thus, intensified upstream highlands erosion and downstream khors sediment deposits have occurred dramatically. This situation has increased flood hazard, specifically, downstream in Kalma camp. Additionally, natural flow magnitudes in downstream khors were altered by these morphological changes leading to irrigation shortage in downstream farms. Baba canal, which was previously used for irrigating downstream farms, have been blocked by fluvial deposits causing water to divert and erode Baba khor.

To help restoring flows to this so-called irrigation canal, a dam was constructed in Baba khor benefiting from outcrop layer in khor bed. This intervention has led water to rise to a level above canal bed level and water now can enter

Figure 18. Diversion canal upstream Baba dam

farmlands smoothly. It has also increased the retention time of the flow leading to recharge of groundwater. This has been recorded clearly in the farms far from the khor and the diversion canal.

Figure 19. Diversion canal downstream Baba Dam

III. Technical design and relevance

The main objectives of the Baba dam are two, namely to reduce the flood intensity and to divert water into Baba canal. Before the dam was constructed, the left banks of the khor have always witnessed erosion called locally as land haddam, where large areas of farms lands are washed away. In addition, water could not enter the diverted irrigation canal. The technical design of the weir consists of a fixed weir crest level at 644.6 m while Baba canal bed level at the offtake location to be cut down to level of 645.5 m, where sediment removal along the canal is required at average gradient of 5% starting from canal off take at 645.5m. The total length of the dam is about 45 m with top width of 1 m and bottom width of 1.5 m, the sediment depth is 0.5 m.

Figure 20. View from upstream of the dam

Figure 21. View from downstream of the dam

IV. Community preference and take up of the intervention

Baba dam is currently acting as a source of life for livelihoods activities and a source of life saving from floods for the local villages and areas downstream. There is a committee formed by the local citizens where women participation is highly respected. The committee is responsible for monitoring of the intervention and maintenance where and when needed. Other responsibilities of the committee are managing other interventions within the catchment, hence came the name catchment committee.

V. Impact and results

The main impact can be seen in the resettlement of baba village after 17 years of displacement. People have immigrated back to their homeland and farms after being abandoned and left merely to dry out. The groundwater table has risen due to the recharge from the dam, hence supplementary irrigation is now possible for many areas. In the past, people only cropped seasonally depending on rainfall for water, where crops are limited to sorghum. The yield of rainfed agriculture for sorghum is recorded to be less than half a sack per feddan, while after the dam construction, it has increased to 7 sacks per feddan. This high yield is mainly due to supplementary irrigation from wells in addition to more water being available in the sub surface. Also, there is expansion in vegetables farming using irrigation water from wells. In this intervention we noticed the integration of Aqua4Sudan project. The vegetable women groups intervention mentioned above are also benefiting from this intervention and farming a land using wells and they are supervised by the catchment committee. This has demonstrated the holistic approach in these interventions.

Figure 22. Water available in wells due to recharge from the dam

Figure 23. Water supply from wells allows for vegetable farming

VI. Scalability and sustainability

The scale of the impact is simply unmeasurable, yet a person can say and see it is significantly huge. The diversion canal acts as a spate irrigation for some of the fruit farms in the right bank. Which also recharges the groundwater. The dam has prevented the left bank areas from erosion, hence now people can use this land for farming. To ensure sustainability, operation and maintenance of the dam must be adequate and on time. The catchment committee with the local beneficiaries can set a system where a small amount of water fees are applied to water users and this amount can cover the costs of regular maintenance, salaries for the committee, removal of silts in the diversion canal, of developing more vegetable farming groups, and of having a surplus for emergencies. The dam acts as a pillar for development in this area.

VII. Discussion & Recommendation

Baba dam, once again the peace dam, represents that vision of Aqua4Sudan and simply the quote 'Water is Life". It is one of the most successful projects with relatively low budget while massive impacts from all aspects. This dam can act as a pilot cases for future similar projects for the settlement of immigrants and developing new agricultural land. It could also promote the idea of supplementary irrigation whether spate irrigation or groundwater irrigation.

Awad Allah, a farmer from Baba village, expressed his gratitude for the Baba dam. From the Baba dam he irrigates his mango farm, plants vegetables, and now raises sheep. He says: "there is no reason for me to go back to the city anymore. I have built my tent here and buyers come to my place. I am happy and satisfied.

Figure 24. farmer Awad Allah, behind is his tent and goats

4 Conclusion

The grand quest for managing Sudan's water resources is straightforward: balancing rapidly growing demands and securing sufficient water for all. Over the past decades, this has proved a highly challenging vision, owing to a plethora of underlying factors: climate change, limited resources and capacities, and prolonged conflicts. The roadmap to realize such a future has been a long and winding one, however the vision is highly rewarding, and the future pathway is well laid with the concept and practice of integrated water resources management IWRM.

The Aqua4Sudan partnership puts forward the operational concept and large-scale implementation of Integrated Water Resources Management across six states of Sudan. The unique scale of intervention, and envisioned impacts present a challenge, yet rewarding programme. Central in the project design is strong partnership, for mobilizing resources and building on alliances for IWRM. A strong partnership under the Aqua4Sudan allows for a wide range of interventions covering 28 catchment areas across the country. Interventions are diverse, from large-scale improvement of irrigation systems in the Gash Agricultural Scheme, building water spreading weirs, establishment of women groups to cultivate commercial vegetable crops, all the way to improvement of farming practices, e.g., deep chiselling.

In a majority of cases, intervention results are highly visible, and the impacts are systematic and long-lasting. Immediate impacts are improved soil and water condition for farming and water for livestock. Improved water availability and introduced a repertoire of opportunities, which were picked up by the local community. Improved farming productivity directly boost household food supply, nutrition uptake and health. This impact widely reach the whole community as farmers quickly reach local markets and increase food supply and options with their produces. Infrastructures improvement and innovations in agriculture systems are also remarkable, including higher irrigation efficiency thanks to canalization of the irrigation schemes, increasing farming intensity (more crop per year, on larger farms) thanks to motorized pumps, and arrangement of women farming groups. Long-term, indirect impacts include women empowerment and active participation in the workforce; improvement of the local economy and food chain; and a stronger connection between the government, farmers, and local institutions e.g., the catchment committee. All in all, these impacts testify the transformative potential of IWRM to build a sustainable and resilient future in Sudan. While more in-depth assessments are needed to draw stronger conclusions, a number of driving factors for impact at scale stand out from the Aqua4Sudan approach.

First, strong engagement with the local communities, through the pivotal roles of the catchment committee, proved highly effective and crucial in driving intervention and impacts. The catchment committee coordinates and represents the interests of the communities and integrate these with the IWRM intervention framework of the project and governmental bodies.

Second, promotion of local ownership and adoption of IWRM intervention is essential for long-term sustainability beyond the project life cycle.

Last but not least, the approach of sensitizing, introducing the IWRM intervention combined with local coordination and well-thought measures to pick up and post-intervention impacts proved to work well in many cases.

Quite often the intervention centres around an infrastructure or innovation (weirs, pump, group organisation); but the approach has always been comprehensive and systemic – meaning there are supporting measures and measures to ensure that the infrastructure or innovation are best utilized. For instance, terracing and vegetable farming were introduced after construction and rehabilitation of water spreading weirs, which allows to effectively harness benefits of the increased water availability.

These driving factors are relevant for future projects, as they help to ensure that IWRM interventions reached the intended impacts, contributing to better management and utilisation of the Sudan's precious land and water resources.

Colophon

Aqua4Sudan Partnership
Al Manshiya, House no. 30/3 H
Khartoum, Sudan
Facebook: IWRM.Sudan
Twitter: @iwrm_Sudan
LinkedIn: IWRM in Sudan
Email: info@zoa.ngo

Text
Long Hoang & Mehammed Yasir (MetaMeta)
https://metameta.nl

Photography
Aqua4Sudan, Mohammed Yasir, GIZ,
Mathias Gurtner

Layout & Design
Madiha AlJunaid (MetaMeta)
https://metameta.nl