Aqua4Sudan Partnership

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Putting catchment-level IWRM into practice

Aqua4Sudan Partnership

Rural Water for Sudan

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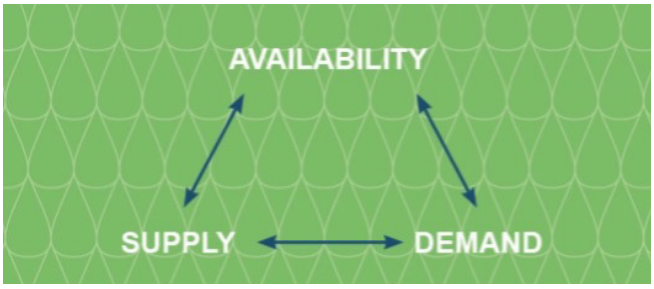
INTRODUCTION

Water sustains Sudan and its people. Rainfall in Sudan is low and varies significantly from year to year. The demand for water increases over time as Sudan's population grows. Because of this, water will become increasingly scarce in the future. Dry periods and dry years cause problems for people, crops and livestock. Water scarcity often contributes to conflict between different water users. At the same time, floods cause serious damage almost every year.

Traditional approaches to water supply focus on balancing supply and demand for specific villages or specific water uses (people, livestock, crops, etc.). This is not enough anymore. Water resources must be managed in an integrated manner to minimise scarcity and to increase resilience to drought and floods.



This means that a balance is needed between demand (how much water is needed for all uses in a catchment area), supply (how much water is produced by water infrastructure) and availability (how much surface water and groundwater is available). Finding and managing this balance is the heart of integrated water resources management (IWRM).

Over the past decade, significant work has been done to promote IWRM in Sudan. However, it has been difficult to put IWRM into practice in large areas. With funding from UKaid and the European Union, the Aqua4Sudan Partnership has developed an approach that can be replicated in rural areas across Sudan. Through a series of technical papers, the lessons learnt are made available so that others can use them elsewhere. The documents in the series describe how IWRM for rural catchment areas in Sudan (and broader, in the Sahel) can be made practical.
This is the first technical paper in the series. It describes the IWRM approach that the Aqua4Sudan Partnership has developed.
The document can be used by managers and programme departments in government agencies and by humanitarian actors for the development of IWRM programmes. The other technical papers deal with specific topics that are relevant during the implementation of IWRM programmes.

The paper was developed by Brendan Bromwich and Timmo Gaasbeek. The authors would like to thank all those who provided input, especially DFID Sudan and UNEP Sudan. Thanks also to UKaid's ICED project, which made Brendan's involvement possible.

The structure of this document is as follows:
Chapter 1 describes what makes IWRM different from traditional water interventions.
Chapter 2 explains key concepts that are used in the document.
Chapters 3-6 describe the IWRM approach of the Aqua4Sudan Partnership:

- Stage 1 (chapter 3) is about preparations that need to be made at the start of the programme;
- Stage 2 (chapter 4) deals with establishing a water resources management committee.
- Stage 3 (chapter 5) describes the steps to be followed in developing a water resources management plan.
- Stage 4 (chapter 6) documents what needs to be done after the plan has been approved.

Chapter 7 discusses risks that need to be considered when implementing IWRM programmes.
Chapter 8 gives five case studies, each of which highlight key aspects of the IWRM approach described in this document.

WHAT MAKES IWRM DIFFERENT?

IWRM principles

The idea behind IWRM is to have a collective, representative approach to making decisions on water so that all of the water resources are managed sustainability.

The IWRM approach is based on a set of four principles, also known as the 'Dublin Principles':

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
2. Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.
3. Women play a central part in the provision, management and safeguarding of water.
4. Water is a public good and has a social and economic value in all its competing uses.

There is an important logic that holds these principles together. Once we consider that water resources need to be managed as a whole, not just as individual water demands, then it follows that a participatory approach involving all water users, including women, is useful.[1] It is also important to link water users to other stakeholders, such as traditional leaders and government. The governance arrangement needs to be representative both of different groups of users (e.g. different villages) and of different types of use (e.g. agriculture, livestock, household). Only in this way, all the competing demands for water will be brought together.

There are several differences between the IWRM approach based on the four Dublin Principles and traditional demand-based water management. A useful comparison of the two was made in a series of discussions and exchanges that the United Nations Environment Programme (UNEP) facilitated in Sudan[2]:

Demand based water management	Integrated Water Resources Management
Driven by one type of water demand	Management of the entire resource
One or few institutions involved	Many institutions involved
One sector objectives addressed	Multiple sector objectives addressed
Decisions made in one sector	Collective decision making with multiple sectors and representatives of water users
Managed on political boundaries	Managed on hydrological boundaries (the river catchment or groundwater basin)

In their foundational study on IWRM in Sudan, Water Resources of the Sudan, Dr. Adam and Dr. Abu Bashar Ali emphasise that IWRM is a process, not a product.[3] IWRM does not provide a specific blueprint for a given water management problem, but rather a broad set of principles, tools and guidelines which must be tailored to the specific context of a country, region or river basin. IWRM decision-making employs a combination of scientific analysis and democratic governance. This is crucial since every catchment area is different from a social, political, economic and hydrological perspective. For developing IWRM plans a standardised approach can be followed (like the one explained in this document), but the solutions will be different for each catchment area. This means that it is not possible to develop standard plans and roll them out over a large area.

[1] In Sudan, there is another category of people which is often left out of decisionmaking around water: (semi-) nomadic pastoralists. The seasonal movement of livestock creates large demands for water and fodder during part of the year. This often leads to conflicts between nomadic pastoralists and local residents, especially in dry years. In order to address these conflicts, it is important that pastoralists are included in the IWRM process, even if they do not live in the area.

[2] The document 'Some for all, forever' (UNEP, 2016) explains this in more detail.

[3] Ahmed M. Adam and Hassan Abu Bashar Ali, Water Resources of the Sudan, University of Khartoum, Water Research Centre, 2017.

3 KEY CONCEPTS

This section clarifies the key IWRM concepts and interpretations of the Aqua4Sudan Partnership.

Water resources and water sources

The term water resources refers to all the available water in a specific area. This includes groundwater and surface water. Water sources are places where people and animals can get water from. Water sources include hand-dug wells, water yards and hafirs. These two terms are very similar, but must not be mixed up.

Water balance

The water balance is the balance of all the water that comes into an area, and the water that moves out of it. Rainfall adds water, whereas evapotranspiration, outflow and water use (for different purposes) take water away. Only the water that moves through an area as surface water or ground water flow can be managed. In most of Sudan, this is only a fraction of the total rainfall. The rest evaporates. Because of this, it is important to have realistic estimates of how much water can be used.

Water budget

A water budget indicates how the water resources are used. Just as in monetary budgets money is divided, so in water budgets water is divided between different usages. These different usages include water for households, livestock, crops, grazing areas (in the floodplains), and downstream flow. It is key to understand that if one uses more water for one thing, one can use less for other things.

Catchment areas

Another term that causes much confusion is the term catchment area.[4] A catchment area is an area from which all runoff flows out through the same point. Other terms that are used include 'watershed' or 'basin.' The boundary between two catchment areas is where the land is relatively high. On one side of the boundary, the water flows into one stream, and on the other side of the boundary the water flows into another stream (see figure 1).

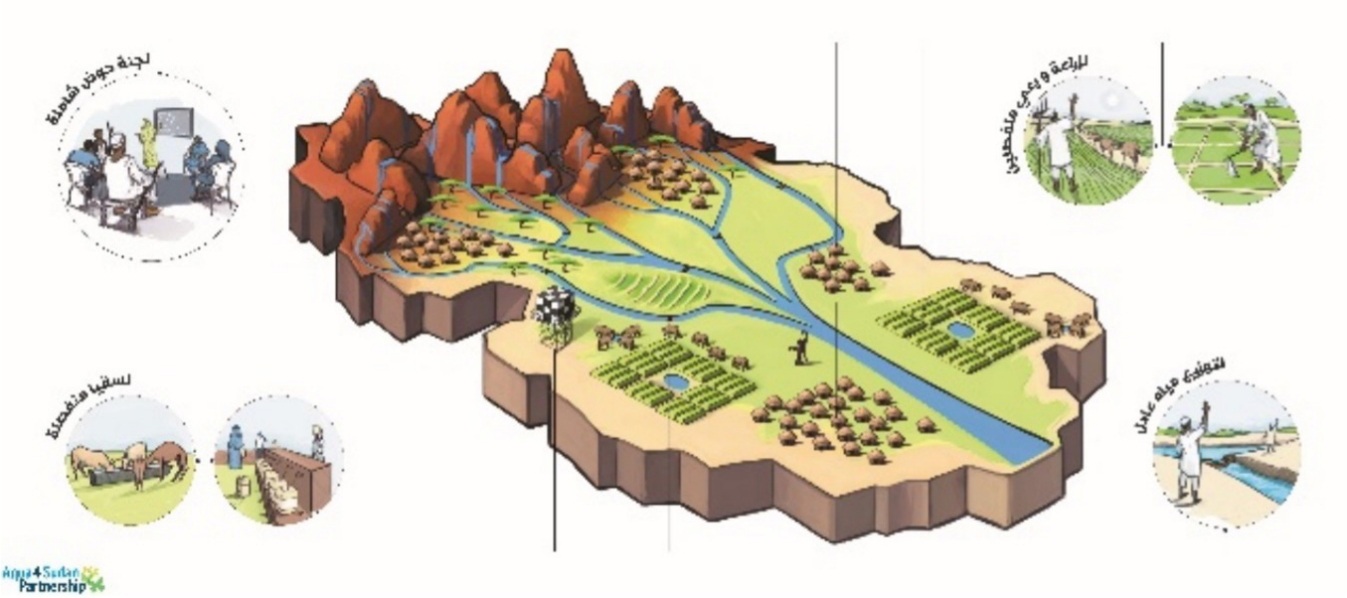


Figure 1 Catchment model developed to show the concept of a catchment boundary and some features needing integration

[4] In Sudan, the English term 'catchment' is often used for hafirs and other reservoirs, which catch water. This causes a lot of confusion. A catchment area is not where you catch the water, but the area where the water comes from. Similarly, the catchment area of a school or health centre is the area where the students or patients come from. We found that it is not easy to translate the term 'catchment area' into Arabic in non-academic language. Because of that, we have started talking about the area belonging to a khor or wadi. Interestingly, it is our experience that people living in an area often understand perfectly well what the boundaries of their catchment area (khor, wadi) are, while outsiders (including NGO, UN and government staff) often find this a lot more complicated.

Water resources can only be managed within catchment areas. This is because water cannot be moved between catchment areas without expensive interventions (pipelines, pumps, tunnels). It means that a form of governance is needed at catchment area level. However, catchment level governance does not currently exist in Sudan. Sometimes, catchment areas cover part of one locality (it is possible that there are several catchment areas within the same locality). In that case, only a single locality needs to be involved in the management of water resources. Other times, catchment areas cover (parts of) several localities. This means these localities need to coordinate. In a third instance, catchment areas are located in more than one state. And there are also cases in which catchment areas are located in more than one country. The more administrative boundaries there are in a catchment area, the more complicated IWRM planning becomes.

Because of this difficulty, the Aqua4Sudan partners began working in catchment areas within one locality. The rationale behind this choice is that once IWRM planning works in one locality, it will be easier to involve several localities in IWRM planning for larger catchment areas. And if people are convinced that IWRM planning can work between localities, it may be possible to tackle catchment areas that cross a state border or even an international border.

Stakeholders

For catchment-level IWRM planning, stakeholders are (groups of) people who have an interest in managing the water resources. The Aqua4Sudan consortium distinguishes two groups: primary and secondary stakeholders.

Primary stakeholders include the local government (mostly at locality level) and the different categories of water users. It is essential to include the local government in IWRM planning, because it is responsible for physical water planning. Likewise, it is of the utmost importance to include all water users. Water users are individuals who live in the catchment area and need water for domestic use, farmers who need water for their crops, pastoralists who need water for their livestock and for the grazing areas, and other people who use water. Farmers, pastoralists and other users can live in a catchment area, or they can live somewhere else and only spend part of the year in the catchment area. It is very important that not only the villages in the catchment area are included in IWRM plans, but also other water users who live outside the catchment area.

Secondary stakeholders are those who have an interest in water and IWRM, but who do not use the water themselves. Secondary stakeholders include technical departments at the state level (State Water Corporation, Groundwater and Wadis Department, State Ministry of Agriculture, etc.), and the private sector (traders, construction companies, etc.).

Water resources management committees

Water resources need to be managed. Because catchment boundaries are not the same as locality boundaries, a separate management body is needed. The Aqua4Sudan Partnership calls these bodies Water Resources Management Committees (WRMCs). WRMC members are representatives of the primary stakeholders in the catchment area.

Water resources management plans

In order to manage water resources, the stakeholders need to agree on a water resources management plan. This plan gives an overview of how much water is available, what the existing water supply is, how much water is needed, and what needs to be done to balance water availability, supply and demand in a sustainable manner.

STAGE 1 OF IWRM: PREPARATION

This chapter describes the preparations that need to be taken before starting an IWRM planning process for a catchment area. This stage of the process is about getting to know the catchment area and the different stakeholders, and explaining the relevance of catchment-level IWRM to the stakeholders.

Understanding the catchment area

After a catchment area has been selected, it is important to understand it. There are several questions that need to be answered. It helps to plot the answers to these questions on an overview map of the area that also includes villages and towns, rivers, grazing areas, cultivation areas, mining areas, forests, lakes, hills/mountains, etc.

1. What are the boundaries of the catchment area?

This is a very basic question, but it is easy to make mistakes. Because water resources must be managed in a hydrological unit (we cannot move water from one catchment area to another without high expenses), and because the boundaries of hydrological units are not the same as state, locality or administrative boundaries, there is often confusion about "what is in, and what is out."

2. What are main water demands in the catchment area?

In Sudan, this often is a combination of:

- Water for domestic use
- Water for livestock
- Water for crops: irrigating vegetables from wells (in winter, sometimes in a second season), spreading floods for irrigation of main crops, harvesting water on fields (terraces), and sometimes irrigating crops from rivers or dams.
- Water for grazing areas in floodplains. This is often forgotten, but if water is used for other things, the grazing areas in the floodplains will dry up.
- Water for the private sector, especially the mining sector. In some areas, this is a very important water use because of the quantity that is used, and the risk of pollution.

In case studies 2 and 5 the importance of understanding the significance of livestock demands on water use is highlighted. In case studies 3 and 4, the issues of groundwater recharge and of flooding were prioritised. The Aqua4Sudan partners found that slowing the flow of water in the upper catchment addresses both challenges.

3. Where do people get their water from at the moment?

What water infrastructure is there (wells, boreholes, dams, sand dams, hafirs, etc.)? In which locations do people get water from scoop holes (masheesh)? It is advisable to conduct this analysis separately for each different type of water use (household, livestock, grazing area, crop, industry, etc.).

4. How much water is available, and where?

This question needs to be answered in stages.

The first set of questions can be answered by visiting the catchment area and discussing with the water users:

- In which locations is there enough water throughout the year?
- In which locations do the wells dry up in the dry season?
- Which areas are flooded?
- Which areas have water quality issues?

The next set of questions need expert input, which is often available within the state:

- What is the geology of the area (use the geological map of Sudan, and hydrogeological maps if possible)?
- Where can we expect deep groundwater, and where can we expect shallow groundwater? In which areas can we expect the aquifer to be fairly stable? In which areas is groundwater availability less during the dry season? In which areas is the groundwater availability affected in a dry year?

- Where does the recharge of the aquifer(s) come from at the moment?
- Where is the soil (inside or outside the riverbed) coarse, and suitable for recharge?
- Where is the soil clayey, and suitable for storage reservoirs?

The last set of questions need hydrological modelling. Because there is very little data on rainfall and runoff available in Sudan, the modelling will need to be based on a mix of satellite data, available maps (geology, hydrogeology, soil, land use, etc.), and visits to the catchment area to check if the interpretation of the available information is correct. Additionally, because rainfall varies significantly from year to year, an analysis is needed for average years, but also for dry years (once in 5 years [moderate drought], and once in 25 years [severe drought]) and wet years (once in 5 years [moderately wet], and once in 25 years [extremely wet]). Answers need to be found to the questions below per sub-catchment area.

- How much rain is there in a year, and how is it distributed from month to month?
- How much of the rain becomes runoff? This is critical, because it is only the runoff that can be used for water spreading, or for increasing groundwater recharge.
- Which areas generate the highest runoff? (These areas have the highest potential for water harvesting).
- How much water flows out of the catchment area?
- How much of the rain recharges the groundwater?
- How much is lost to evapotranspiration (water that does not become runoff or recharge)?
- How much is the water shortage for crops if there is no water harvesting or irrigation? (Calculate this for the rainy season, winter season and hot season. Rule of thumb numbers (m3/feddan/season) are good enough[5] (see Annex 2).
- How much is the water shortage for grazing areas in the floodplains if there is no water harvesting or irrigation?

Understanding the social and political context

In each catchment area, there are many different stakeholders. It is important to find out who all the stakeholders are, and what their interests are. Document the primary and secondary stakeholders in a list, so that you can verify later on if all relevant stakeholders are included, especially women and (semi-) nomadic pastoralists. In Sudan, women are not always involved in decision making processes, but they are key water users. Because men and women have different social roles and responsibilities, they often have different priorities and preferences when it comes to water and water infrastructure.
As to pastoralists, the majority in Sudan move around with their livestock because water and fodder are available in different areas in different parts of the year. There may be a great number of livestock only needing water and fodder from the targeted catchment area for a few months each year. It is also possible that the people who own and herd the animals do not live in the catchment area. However, because shortages of water and fodder for livestock are a main contributor to conflict in rural Sudan, reducing the water and fodder problems of the (semi-) pastoralists may reduce problems for the resident population as well.

It is vital to understand the local political and economic interests. One way that IWRM programmes can fail is that powerful interest groups will obtain disproportionate control over the programme. This may be an economic group – such as a selection of cash crop growers – or locally dominant political groups. It is also important to establish relationships with government bodies that are responsible for the area (one or more localities, and departments at state level), and with traditional leaders who have a say in the area. There is no real alternative to seeking trusted local advice and analysing the risks carefully before starting an IWRM planning process.

There must be plenty of time and resources to conduct a thorough stakeholder analysis at the beginning of the project. If the situation is complex, then building relations and conducting a stakeholder analysis may take longer than expected. The Aqua4Sudan Partnership found that this step may take between two and six months. This is not wasted time. Having open relationships with all stakeholders will avoid conflict later on. As a matter of fact, IWRM only works if the stakeholders want to work together to find a solution. People do not need to agree with each other, but if there is no willingness to look for solutions together it is better to spend more time building relations before moving on to the stage of establishing a water resources management committee.

Raising awareness on the importance of IWRM

Before an organisation introduces IWRM in a catchment area, it is important that the different

[5] Most vegetables, but also sorghum need about 300-350 mm of water over an 100 day period. That is roughly 1,250 to 1,500 m3 per feddan. If rainfall is 250 mm, the gap is 50-100 mm (210-420 m3/feddan).

stakeholders understand how IWRM can make a positive difference in their lives and livelihoods. This means that the organisation needs to have an idea of what the water problems are (now and, with growing demand, in the coming years) and of some ways in which these problems can be addressed. A mere theoretical explanation of IWRM will in most localities be insufficient and unsuccessful. There are a number of examples of how IWRM can work in practice. If there are existing water resources management committees in the area, it might be useful to invite one of its members to introduce IWRM in a new locality/catchment area and explain how it has made a difference. A combination of public meetings in communities and smaller meetings with opinion leaders was found to be the most effective way of introducing IWRM in a new area.

The structure of the WRMC is flexible. The only thing that matters is that all primary stakeholders are represented in a way that is locally accepted, and that gives a meaningful voice to all stakeholders. The membership of the WRMC is made up of government representatives of the locality (or localities) in which the catchment area is located, and the different categories of water users that have been identified in the stakeholder analysis.
Technical experts (often from state level departments of water, agriculture, livestock, etc.) have an important role to play in giving technical advice, but they are not water users, and do not have a direct interest in the water resources in the targeted catchment area. Because of that, it is better if the experts have a role as advisors, but not as members.

If the catchment area is large, or if there are many stakeholders who need to be represented, it is possible to work with subcommittees for sub-catchments, who then select members for the main committee. Often, a committee works best if it does not have more than 15-20 members. If there is a structure with subcommittees, it is important that the subcommittees gather for some of the main discussions at the very least. One of the main discussions should be about the problem analysis, another about possible solutions and a third about the final draft plan before it is sent to the locality for approval.

The involvement of traditional leaders (men as well as women) needs to be optimised to the situation. In some areas, traditional leadership structures are well established and respected. In that case, it can be advisable to include traditional leaders in the committee.

In other areas, it is better to exclude traditional leaders from committee membership, for example if they do not live in the area themselves, or if their leadership is contested. In that case, they could still act as a sounding board for the committee.

The one chosen as chair of the committee should also depend on the local context. In some cases, it works best if a representative of the locality office chairs the committee. It is, after all, the locality that is responsible for physical planning in its territory. However, locality offices often have quite a high staff turnover, and staff are not always from the area itself. In that case, it may be better to have someone else chair the committee.

If an organisation establishes a catchment committee, it is important to draw on the experience of those working on similar fields in the area.[6] Committees to look for are village development committees, health committees, community based natural resources management committees, etc. Questions that need to be taken into account are: What are the challenges? What are the success stories? How does one ensure the committee is genuinely representative and gives voice to marginalised groups?

If there are more committees in an area, it may be useful to put them in touch with each other (through WhatsApp groups for example). This will help committees to exchange experiences and learn from each other, independent of the organisation that implements the IWRM programme.

[6] See also the case studies in this document.

STAGE 2 OF IWRM: CREATING A WATER RESOURCE MANAGEMENT COMMITTEE

The next stage of the IWRM approach is the establishment of a Water Resource Management Committee (WRMC). This is also sometimes known as a catchment management committee.

The structure of a WRMC is flexible. The only thing that matters is that all primary stakeholders are represented in a way that is locally accepted, and that gives a meaningful voice to all stakeholders. The WRMC members are representatives of the various water users identified in the stakeholder analysis, and government representatives from the locality (or localities) in which the catchment area is located. Technical experts (often from state level departments of water, agriculture, livestock, etc.) have an important role to play in giving technical advice, but they are not water users, and do not have a direct interest in the water resources in the targeted catchment area. Because of that, it is better if the experts have a role as advisors, but not as members.

If the catchment area is large, or if there are many stakeholders who need to be represented, it is possible to work with sub-committees for sub-catchments. These sub-committees then select members for the main committee. Often, a committee works best if it has not more than 15-20 members. If there is a structure with sub-committees, it is important that these participate in all main discussions. This includes a meeting in which the problem analysis is unified, one in which solutions are discussed, and one in which the final draft plan is evaluated before it is sent to the locality for approval.

The involvement of traditional leaders (men as well as women) needs to reflect the context. In some areas, traditional leadership structures are well established and respected. In that case, it is helpful to include traditional leaders in the committee. In other areas, it is better to exclude the traditional leaders from committee membership, for example if they do not live in the area themselves, or if their leadership is contested. In that case, they could still act as advisors to the committee.

The person selected for the chair of the committee also depends on the local context. In some cases, it works best if a representative of the locality office chairs the committee. It is, after all, the locality that is responsible for physical planning in its territory. However, locality offices often have quite a high staff turnover, and staff are not always from the area itself. In that case, it may be better to have someone else chair the committee.

Formation of the committee and the nine steps to produce the catchment plan is illustrated in different ways throughout the case studies. A broad overview is given in case study 4. Case study 2 involves a pre-existing committee. The case studies highlight the roles traditional leadership can play in different contexts. Case studies 1 and 3 shows the importance of amplifying the voice of women on the committee. Case study 1 highlights how both the government and the NGO have empowered the committee as the contact point on water problems for people within the catchment. This approach gives a strong sense of local ownership of water management.

When an organisation establishes a committee, it should draw on the experience of different bodies working on similar fields in the area. Examples of such bodies include village development committees, health committees, community based natural resource management committees, etc. It should take the following questions into consideration: What are the challenges? What are the success stories? How do you ensure that the committee is genuinely representative and gives voice to marginalised groups? If there are more committees in an area, it may be useful to put them in touch with each other. This will help committees to exchange experiences and learn from each other, independent from the organisation that implements the IWRM programme.

STAGE 3 OF IWRM: DEVELOPING A WATER RESOURCES MANAGEMENT PLAN

Once the Water Resources Management Committee has been established, a plan needs to be developed for the development and management of the water resources in the targeted catchment

The steps described below are the steps that the catchment committee needs to take before arriving at the final catchment plan. During the process, relevant technical expertise (especially the hydrological analysis) can feed into the discussions. It is however important that the planning process stays in the hands of the committee, and is not taken over by a few outside experts.

Gaining a detailed overview

In order to help the committee to focus on the issues in the catchment area, the committee can make a map of the catchment area and discuss it. New maps can be drawn on flipcharts or can be printed in a large size from Google Earth images or other digital tools. The committees should especially discuss and mark the following things on the map:

- Khors
- Villages/settlements
- Locations of water points (the water infrastructure assessment can be used to plot the infrastructure with coordinates on the map. Any details that might be forgotten can be added during the infrastructure assessment)
- Different land use areas (cultivation land, grazing area, corridor, floodplain, etc.)

After making this basic map ready, the following information should be added:

- Areas (or water points) where the water is salty
- Areas (or water points) with other quality problems
- Areas where there is not enough water to meet the different demands in the entire year
- Areas where there is not enough water to meet the different demands in part of the year
- Areas where the distance between people's houses and the water point is too far
- Areas (or water points) where there are problems with operation and maintenance
- Areas (or water points) where there is conflict over water between different stakeholders
- Areas affected by floods
- Areas in which garbage or other sources of pollution are collected, which could affect the quality of the water

It is possible to mark all of these details on one map. It is also possible to draw up one map per topic, and to put them next to each other on a big wall. After the map(s) are complete, discuss with the committee and government experts what the situation is, and document this analysis of the overall situation.

The preparation of the map(s) will take time. It can be spread over a few meetings if necessary. Taking time for this helps the committee members to discuss more, and to build consensus about the situation. Also, it may be an option to have separate discussions between men and women. Oftentimes women do not feel free to speak in the presence of men. If this is the case, the two groups can present their findings to each other.

On site follow up and collective problem analysis

The next step is to let the entire committee (and, if relevant, key people from the government technical departments) visit key problem areas and discuss the situation on-site. Many stakeholders only know a part of the catchment area, or only feel a responsibility for part of the catchment area. By taking the committee around the catchment area, the different stakeholders will understand each other better. For practical reasons (temperature, accessibility), it is probably easiest to do this between October and March.

During the site visits, it is key to let the committee members discuss problems and possible solutions with people living in the area. The Aqua4Sudan partners learnt that this step is often a turning point for committee members who previously focused on

competing water problems only. During site visits they begin to see the problems of the water catchment as a whole. This transition from competing individual perspectives to a collective perspective is the heart of the IWRM process.[7]

Joint identification and assessment of possible solutions

After the committee has gained a good understanding of the status quo, it is necessary to look at possible solutions. The risk here is that people tend to focus on one solution only, while often there are different possible solutions that can be considered. It is important here to facilitate the discussion carefully, so that people look at the entire catchment area, not only at individual solutions.[8]

Creativity is important in finding the right solutions. Sometimes there are alternative methods that people do not immediately think about. For example, if the available wells do not provide enough water, often the solution that people think of is to drill or dig more wells. However, it could also be possible to increase groundwater recharge, so that there will be more water in the existing wells. Also, not all solutions are in the form of infrastructure. Sometimes, managing land use in parts of the catchment area can have a great impact. For example, keeping livestock out of an area can help to re-establish grass and trees, and thus reduce flash floods and sometimes increase groundwater recharge. These examples show that there are several solutions possible for a problem.

While identifying solutions, it is useful to involve a range of experts in this discussion. Yet the outside experts should limit their role to giving suggestions. They should not dictate the final decision on the intervention.

After the different possible solutions have been listed, the advantages and disadvantages should be discussed. Different scenarios and their impacts on different water user groups should be considered. Topics that should be taken into consideration are livelihood, domestic, cultural and conflict impacts. A list of questions that can be used as guidance is given in Annex 3.

Prioritise, budget and plan

Next, the different options need to be weighed. Here it is important to go back to the analysis of water problems, and then see which combination of measures can best address the different problems without causing new ones. At this stage, committee members may fall back to their standard preferences (water yards for example). Therefore, they should be encouraged to look beyond these preferences to those solutions that are beneficial to everyone, and that are in line with the water balance analysis. Suggested solutions should be ranked according to importance and budget. Here it is important to agree on how the cost of operation and maintenance will be recovered, and how any infrastructure will be managed. An overview of the situation in the catchment area (supply, demand and availability of water, problems and opportunities), the priorities for intervention forms (including costs, timeline and future management and cost recovery) form the Water Resources Management Plan (WRMP).

Feedback from stakeholder communities

The draft plan is taken to different groups of stakeholders and reviewed. This is an important stage to ensure fairness to all users and collective acceptance of the WRMP. If suggestions for improvement are made, it may be necessary to adjust the WRMP.

Approval of the plan

After the WRMP has been finalised, it must be formally approved by the locality authorities. This is essential, because the locality authorities are responsible for physical planning in their territory. If the locality takes ownership of the WRMP, it becomes part of the strategy of the locality, and the locality authorities can also involve other actors in the implementation of the plan.

It is useful if the plan is also endorsed by other actors. These include key departments at state level (State Water Corporation, Agriculture, Livestock, etc.), and the state-level Water Resources Council. At the same time, endorsement by traditional leaders could give the plan more weight among local stakeholders. The more actors can endorse the WRMP without issues, the better.

[7] Case study 4 shows how problems can be interrelated. All the case studies are built on the fact that the committee has adopted a collective, catchment wide perspective.

[8] Case studies four and five show longer lists of project interventions.

STAGE 4 OF IWRM: ONGOING MANAGEMENT

After the plan has been finalised and approved, it needs to be implemented and updated on a regular basis to make sure that any changes in the situation are included.

Implementation

After the plan has been approved, the WRMC has a key role in implementing it. In most cases, the organisation that establishes the committee and facilitates the planning process also has budget for implementing (part of) the plan. It is also important to link the committee to other programmes (for example the 'Zero Thirst' programme of the government, and any infrastructure planned by the Dams Implementation Unit).

Some parts of the WRMP do not cost money to implement, but they do cost time. Examples are measures to manage vegetation, to establish small check dams (which can be made with local labour and locally available material), and to improve the operation and maintenance of water points. It is important that the committee takes a lead role in these elements of the plan. Its conduct on this matter will establish its reputation.

Communication

The committee needs to maintain some form of ongoing communication with water users and with the relevant authorities. For this reason, it is important that any IWRM programme encourages the WRMCs to interact directly with the relevant primary and secondary stakeholders. If implementing organisations take this role, there is no need for others to take the WRMC seriously. In case study 1, the decision by the implementing NGO to let all communities communicate their requests through the WRMC increased the status of the committee.

Public awareness with posters and signboards is part of a good communication strategy. The posters and signboards should include clear pictures, and make sure that the IWRM message is explained. Signboards that only state who built which infrastructure do not help much in creating awareness on IWRM.

Follow-up, monitoring and evaluation

IWRM is a process, not a destination. This means that the committee needs to monitor the implementation of the WRMP, and that the plan must be reviewed and, if necessary, updated on a regular basis (once a year is a good start). Case study 5 shows an example of how problem analysis and interventions progressed over the course of time. It demonstrates that the WRMP needs to be a "living" document.

Building the capacity of the WRMC for the long term

It is the experience of the Aqua4Sudan Partnership that organisations need to work closely with WRMCs for at least two to three years before these committees take real ownership over the management of water resources in their catchment area, and before they establish their own relationships with the locality and other key stakeholders. During this time, the nature of the committee changes. In the beginning, the main task of the committee is to develop the plan. After the plan has been finalised, the committee needs to think about how the plan can be updated, and what structure is needed to make sure that water resources are managed well in the future. It is important that the committee is taken seriously by the locality and by other key actors, so that whenever a new water project comes into an area, the project is first sent to discuss its plans with the WRMC. For that, official recognition of the WRMC is needed.

The long-term structure of WRMCs can differ from area to area, depending on the local conditions. If the catchment area is large, or if there is a lot of effort needed to manage the water resources, the WRMC can become a permanent organisation with specific tasks given to it by the locality. If the catchment area is small, or if managing the water resources is not much work once the plan has been implemented, the WRMC can be an advisory body to the locality, which

is called for a meeting between one and four times a year.

Two possible important roles for the WRMCs are:
- Finding solutions to conflicts over water (re)sources.
- Arranging for pre-emptive maintenance (servicing) of water infrastructure.

A good WRMC must have capacity on the following topics:
- Understanding (and explaining) how IWRM can make a difference for people in the catchment area
- Basic management skills (organising meetings, participatory decision making, taking minutes, etc.)
- Bookkeeping skills
- Conflict resolution
- Gender and inclusion
- Accountability

8 RISKS IN IWRM

This section describes some of the key risks that can affect IWRM programmes, together with ways of mitigating and managing these risks.

Risk of project capture by powerful actors

If a group of strong actors – perhaps a group of cash-crop cultivators or a group of traditional or local authority strong-men – takes control of a committee then the benefits of collective decision making will be lost. It is important to address this risk very carefully before forming the committee. Advice from people who know the communities and the local politics is essential.

Risk of failing water resources

Some IWRM plans fail because more water is allowed to be used than is available. If this happens, the water points will run dry. A qualified hydrologist is needed to assess the water resource potential of the targeted area, and to identify the limits of water availability.

Risk of failing interventions

A recurring problem with water resource programmes is that technical interventions fail due to poor design and implementation. This risk can be reduced by making sure that genuine technical expertise is obtained to design and implement the project. Engineers and site supervisors are roles that cannot be substituted by non-specialists.

Risk of poor local ownership

Many water activities implemented by humanitarian and development projects are not maintained properly because local committees do not have a genuine sense of ownership of the projects undertaken. If an NGO or UN organisation provides the infrastructure it is often seen as the organisation's responsibility to maintain it. Empowering the WRMC to be the decision maker has potential to provide real ownership of local assets, which brings a new perspective on responsibilities for maintenance – as some of the case studies have shown.

CASE STUDIES

The following pages describe catchment case studies. Information on the catchments is shown below.

Name and size	Landscape, climate	Inhabitants & Settlements	Points of interest
Khor Arab, Red Sea 12,500 km^2	Hilly, rocky upstream, sandy plains, alluvial floodplain, about 100 mm rain per year	+/- 60,000 70 settlements	Committee establishment, locality ownership
Odoud, Red Sea 10 km^2	Hilly, rocky with a sandy valley, about 100 mm rain per year	+/- 7,000 plus migrating pastoralists 1 village	Building on local initiatives
Mahala, Gedaref 120 km^2	Gently undulating, shallow to deep heavy clay soils, about 900 mm rain per year	+/- 18,000 plus migrating pastoralists 5 villages	Committee composition, landscape management
Endur, South Darfur 330 km^2	Gently undulating, mostly shallow soils, about 400 mm rain per year	+/- 12,000 plus about 80,000 IDPs in the catchment area and 150,000 IDPs downstream 8 settlements	Farmer-pastoralist conflict resolution. Numerous challenges addressed
Qala en Nahal, Gedaref 1,500 km^2	Gently undulating, shallow to deep heavy clay soils, about 600 mm rain per year	+/- 120,000 24 villages	Separating livestock from domestic water

Case study 1

Khor Arab, Red Sea State – Strong local ownership of the catchment committee

Description

Khor Arab is a large catchment area that begins in the Red Sea Hills and flows inland into wide open plains. The upstream sub-catchments comprise rocky grazing areas with some cultivation along the wadis and khors. The middle reach uses traditional water spreading systems for flood-based farming. The diversion structures are designed to direct enough water from the main channel to fields for cultivation but to be washed out in the event of a big flood to prevent excessive flooding of the fields and damage to infrastructure. The downstream part of the catchment area is an important grazing area that flourishes when the land is flooded at the tail end of the wadi. It is the best grazing for camels, goats and sheep in this part of the Red Sea state. Overall the catchment is characterised by water scarcity with occasional flash floods – as is common in dryland catchments.

The implementing NGO has worked in the area for many years, which has made it easier to establish a water resources management committee. For practical reasons, the catchment area has been subdivided into four sub-catchments. The project team visited all areas and discussed the concept of the project inviting nominations for the catchment committee. In this area the role of customary leaders is important and they are well represented in the committee. There is a representative of pastoralist groups on the committee who speaks for their interests in this project and more broadly as they interact with the state government.

Once the committee was established, a WRMP was developed following the process described in this document. The plan focused on groundwater recharge, improved operation and maintenance of water points, and water spreading for crops and grazing areas. Measures to reduce damaging flash floods have been considered.

Hearing from female water users

There was extensive discussion over the gender balance of the committee because traditionally in this part of Sudan there is a strict gender segregation. Many other local committees such as health committees are gender segregated. At the start of the project women only worked on the all-female sanitation and hygiene committee. In this case however it was agreed that women should be part of the main, mixed committee. This is a significant and welcome step in gender relations in rural eastern Sudan. There are 4 women out of the 22 members of the committee: 3 representing their respective villages and 1 representing the locality hygiene and sanitation office. There are a number of women's economic and livelihood initiatives that have emerged from this project.

Other success factors

A joint tour by the committee to all areas of the catchment was a turning point in the development of the WRMP. In this tour participants shifted their perspective from their own competing water problems to a collective striving to maintain water resources. Afterwards they made an effort to address the collective water challenges across the whole of the catchment area.

A notable feature of this WRMC is how it has become the first point of contact on water problems in the catchment. It has been well supported by the locality, which has provided an office for the committee. Both the locality and the project team refer people to the committee so that they have the key coordinating role prioritising work on water issues across the catchment.

Case study 2

Odoud, Red Sea state – pledges support to shared initiative

Description

Odoud is one of the upper sub-catchments in the Khor Arab catchment area (case study 1). The settlement has a single solar-powered borehole and a single handpump, which are the only water points in a 15km radius. The two water points serve a settled community and an important livestock migration corridor. Therefore, managing the interaction between the two types of use is a key challenge.

In the 1990s the community of Odoud decided to establish their own committee to manage the water points. By showing initiative, the committee has managed to attract some external support. The borehole was drilled by a mining company, and the locality provided a pump. A few years ago, the committee had collected enough money to buy solar panels. The committee is highly competent and well organised in taking care of maintenance, procurement and storage of spare parts on a pre-emptive basis. It has tools and mechanics. Allocation of water is on a time-share basis with all herds having particular time slots during the week. There are slots available for migrating herds which are allocated to the visitors by the committee.

As part of the planning process, the committee has identified the need for increasing groundwater recharge and for proper watering troughs. Three sand dams have been planned, of which two have already been completed. The watering troughs for livestock will make watering the animals more efficient.

Success factors

The water point committee in Odoud is interesting because of the strength and the self-reliance of the community.

The people in this area hold strongly to the idea that water is for all and no cash payments should be made for it. There is also a strong culture of providing water for visitors without demanding payment. The fund raising from the community is based on a pledge-based system. The committee records how much each family is willing to contribute to support the project. Pledges are made in non-financial capital such as livestock and labour. The pledges may not be collected immediately, but a record is kept and pledges are called in when the need for funds arise – such as when a water-yard requires repair. The system works because of the trust of the community in the committee and because of the careful oversight by the customary leaders. Nomads and poorer households are not required to contribute. Any visiting nomad meets the traditional leaders and gives assurances of the size and health of his herd, and they are then allocated a slot in the rotation of livestock watering.

Case study 3

Mahala, Gedaref state – A large inclusive committee addressing water resource and sanitation challenges

Description

Mahala is a catchment area with both settled communities and migratory pastoralists. The area experienced a significant population growth as a result of in-migration, in some cases by communities fleeing the severe droughts in Darfur during the 1980s. One of the villages has a name that reflects the comparative abundance of water that these drought refugees found: Um Sineibra translates as "the mother of taps". However, over time, the area has begun to experience increasing problems of wells running dry. There are several factors causing the lack of water: the increased demand for water and the reduction in recharge associated with the deforestation of the area. Then there are problems related to excess water. The main market in Mahala town was washed away in 2016 because of flash flooding. Another significant water related challenge is a recurring high level of Acute Watery Diarrhoea (AWD).

Setting up the committee

A decision was made to form a large committee so that the more marginal voices were clearly reflected. Leaders, women, youth, farmers, and pastoralists are all represented on the committee. In this traditional patriarchal context a specific effort was deemed appropriate to reinforce the voices of women and youth to enable an inclusive dialogue. There are 6 women on the catchment committee out of 30 members, who represent a diverse range of water users and ethnic groups. Since the pastoralists in the area are semi-settled, they are represented according to the villages where they are based.

Original and ongoing problem analysis

The WRMP for Mahala has undergone changes since the first draft was developed. In the beginning, the committee focused on drinking water, and mostly wanted more boreholes. This is however not feasible in part of the catchment area due to salinity, and many people depend on shallow hand dug wells. In 2016, there was an outbreak of AWD that badly affected the area. This highlighted the need for good water quality, and the need for properly protecting the hand dug wells. In the upstream parts of the catchment area these wells dry up. When the committee realised that the reduction in water availability was caused by a reduction in recharge due to deforestation, an experiment was agreed upon and three gabion check dams were constructed. The dams had a visible effect on the water level in two wells. In 2018, twelve additional check dams were constructed in the area under the leadership of the committee.

Over time the focus of the work has moved towards a broader landscape-based approach. Restoration of vegetation is now a priority because of the following benefits:

- Increased groundwater recharge
- Improved fodder supply for livestock
- Available firewood for domestic energy
- Reduced flood risks downstream

The collective learning and evolution of activities illustrates that IWRM is an evolving process rather than a destination. Making the WRMP is part of the process but the plan needs to develop as the collective understanding grows and the situation in the catchment changes.

Case study 4

Wadi Endur, Nyala catchment, South Darfur – four challenges in a mixed catchment

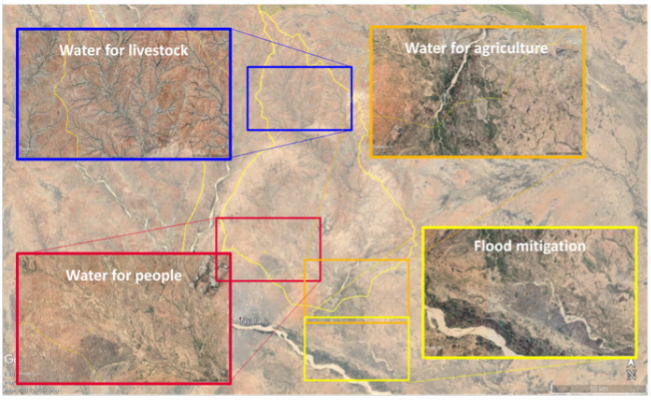


Figure 2 Categories of water problem and solution in Wadi Endur

Description

Wadi Endur is a small catchment area, flowing from the North to the West of Nyala. The wadi flows through an area with diverse communities that have experienced tension. There are several water problems in the catchment, which have been addressed in the following ways:

- Water for people: on the north side of Nyala two IDP camps and the surrounding area have experienced severe groundwater depletion. In order to increase the recharge of the aquifers that serve this area check dams have been built to slow the wadi flow and increase the infiltration to the aquifers.
- Water for livestock: in the rangeland to the north of Nyala a shortage of water caused herders to take their livestock to the wadi at the points where there is deeper alluvial deposits. The deeper alluvial deposits mean that the area is water rich and also good for cultivation (millet is grown in the area). To prevent problems of cattle encroaching on the millet growing area, the catchment plan is to build a combination of check dams and sand dams in areas that are not cultivated so livestock watering can be done there.
- Water for agriculture: Deforestation and disruption to agriculture in the crisis have changed the conditions for soil and water in the catchment. Floods have increased, as have erosion and sediment transport. This has led to changes in the routes of the wadi. In some cases farmland can no longer be used because water no longer flows through agricultural land. A weir has been proposed to raise the wadi bed level and to redistribute flows to the agricultural area. The upstream constructions, which slow the flows, will reduce some of the erosive power of the wadi in the agricultural area.
- Flooding is a problem at Kalma IDP camp. The attenuation of flood flows in the check dams and sand dams upstream is intended to reduce the flood risk in Kalma.

Development of the Water Resources Management Plan

The actions taken to draw up the WRMP have been as follows:

- The project team visited every community to consult them and explain the potential of a collective effort in identifying and addressing the water problems. The team spoke with community representatives, traditional leaders and government officials.
- All communities were invited to nominate representatives for the catchment committee. A decision was made in this case not to include traditional leaders on the catchment committee as they have their own network for communication. Representatives of the locality government are on the committee. The committee was established.
- The committee made a tour of the catchment, which enabled the representatives to understand the problems from another perspective. The committee then worked on a collective approach to the problems across the catchment, rather than merely focusing on their own needs.
- Meanwhile a technical analysis of the catchment was undertaken using remote sensing data and a hydraulic analysis to determine the water balance in the catchment. This was used to identify potential interventions. The water balance was explained to communities across the catchment.

- The committee combined the insights from the communities and the technical analysis and made a list of potential interventions in the catchment.
- The committee made another tour of the catchment in order to consult the communities about the proposed interventions.
- The WRMP was then drawn up. It is a live document and the discussion is ongoing.

Specific challenges

This catchment area is located in a conflict-affected area, so particular attention has been given to the interaction of the project stakeholders. The Nyala-El Fasher road runs through the catchment and acts as a boundary with pastoralists on one side and farmers on the other. For many years neither community had crossed the road to visit the other. The work on the catchment saw community members cross this road and visit each other again.

After the WRMP was developed, there was a dispute over the location of one of the proposed sand dams. There were some powerful local interest groups trying to change the original plan. As Darfur seeks to resolve land disputes arising from displacement and potential return, managing the location dispute called for careful diplomacy, negotiation and consideration of a range of possible solutions. Therefore, the Aqua4Sudan member organisation working in this area decided to postpone any work on the disputed sand dam, and instead focus on other parts of the plan for the first construction season. During the subsequent rainy season, the positive effects of the other infrastructure became visible. As a consequence, those opposed to the disputed sand dam changed their minds and asked for the sand dam to be constructed after all.

Case study 5

Qala en-Nahal, Gadaref – water quality, piped systems and mixed use

Description

Qala en-Nahal is a locality with 24 farming villages in the southwest of Gedaref state. Water resources in this area are limited because there are no significant wadi channels and very limited groundwater. There is, however, a remarkable piped supply of the Hawata project that is operated by a strong technical committee with oversight of the water users.

The Hawata project in the Qala en-Nahal locality was set up as a response to a refugee crisis in the 1980s. Since then it has been transformed into a successful long term water supply programme. The project uses a high level of technology and engineering. It does not cover all its costs, but a significant amount of the costs are covered by its tariff system. Also, the project is overseen by water users. This ensures user accountability.

Water problems

Over time, the population in the area has grown and water demands have increased. People and livestock both use good quality water in the head end and middle of the scheme, but this means there is not enough good water left for the villages at the tail end of the pipe network. So where animals drink people-quality water at the head end of the scheme, people drink animal-quality water at the tail end of the scheme. The IWRM challenge here is to find alternative sources of water for livestock, so as to relieve the pressure on the piped system and increase the availability of safe water for drinking.

A large committee to enable marginalised groups to be heard

With support of the Aqua4Sudan Partnership, representatives from all 24 villages that depend on the Hawata piped scheme, representatives of the Hawata scheme and locality officials were gathered to analyse the water problems they face and to suggest solutions. 9 out of 30 committee members are women, of whom 3 represent their village. The group is ethnically diverse and includes descendants of the original Ethiopian refugees and others who have arrived from Darfur. Pastoralists are semi-settled here and are represented as well. The process this group has undertaken to develop a committee and a plan are a close reflection of the standard process described in this document.

Work ongoing

The catchment plan includes the following interventions:

- Rehabilitation and construction of 9 hafirs to provide water for livestock.
- A hand-dug well has been upgraded to a water yard on the edge of Qala en-Nahal town. This has created a backup source of safe water for the piped system. Water availability will be further increased by the construction of a recharge dam and a series of small check dams further upstream.
- One of the hafirs is being built on a livestock migration corridor, which means that transhumant herds do not need to leave the corridor to take water from the local communities. The corridor has been demarcated as part of this project.
- The WRMC is working in conjunction with the locality authorities on local regulations for the operation and maintenance of the newly developed water infrastructure.

ANNEX 1: EXAMPLE THEORY OF CHANGE AND PROJECT LOGIC

When developing a project, it is important to formulate a theory of change and to identify potential outcomes and impacts. This annex gives an example of a theory of change that was developed for the Sustain Darfur project, which is implemented by the Aqua4Sudan Partnership.

Theory of change

- The partnership will collaborate with communities in the targeted areas to facilitate discussions on their needs and priorities for water and the problems and tensions over lack of water. Their needs will be compared with the overall availability of water, defined by a technical assessment.
- The process will bring together resident and nomadic communities, local authorities and other relevant stakeholders to gain a better understanding of water resources, competing uses, and water management so that all users gain access. The informal gathering of water users may be formalised over time if the participants consider it appropriate, without duplicating any existing formal structures. The process will result in a plan for increasing the availability of water based on construction of low or no maintenance infrastructure such as sand or sub-surface dams.
- The plan will be implemented with ownership and participation by communities. Construction of specific infrastructure such as sand dams will improve the reliability and availability of water resources in dry seasons and dry years. More water will be available for drinking, agriculture and livestock. This will reduce water shortages, building the resilience of communities to climate variability and shocks.
- Competition for water and pasture will be reduced, and hence water-related conflict will be reduced (including conflict between pastoralists and farmers over early livestock migration through cultivated areas, induced by the exhaustion of water resources in northern grazing areas).
- This will contribute to more stable livelihoods. Together with improved access to sanitation and hygiene, the general health and well-being of the targeted population will be improved. This in turn may contribute to the long-term viability of livelihoods for rural households, the reduction of poverty and the possibility of continuing to live in rural areas rather than seeking livelihoods and employment by migrating.
- By documenting and sharing lessons learnt, the programme will refine its approaches, contribute to the understanding of the factors that influence migration, and contribute to the development of conflict reducing and climate resilient best practice for service delivery in Darfur. This will build the evidence base for replication as well as informing policy and institutional reforms.

Project logic

The intended impact of the proposed project is 'Improved well-being and health of people in the targeted localities'.

The intended outcome of the proposed project is 'Increased availability of water for drinking and livelihoods, and improved sanitation and hygiene behavior for communities in rural areas of Darfur.'

The project has five outputs:

- Output 1 Inclusive mechanisms for Integrated Water Resources Management (IWRM) are in place in targeted catchment areas

Better management of water resources begins with governance: understanding how much surface flow and groundwater is available, having a plan of how to allocate the available water to different uses (household, livestock, crop, grazing land, and other uses), managing the future development of water resources, and managing access to water for different groups of users. Water must be governed at the level of catchment areas, as all upstream interventions have effects further downstream – especially because most of Darfur sits on top of shallow basement rock and has little or no access to deep groundwater.

Governance of water resources depends on active involvement of local government and technical departments, and on involvement of all stakeholders

(explicitly including women and nomadic pastoralists).

• Output 2 Sustainable access to safe drinking water.
Once well-grounded Water Resources Management Plans (WRMPs) are in place, activities will be implemented to structurally increase access to water in line with these plans. This includes the construction and renovation of groundwater recharge infrastructure and water points; the promotion of locally appropriate methods for household-level water treatment; the training on operation and maintenance for committees that manage the water infrastructure; and the improvement to spare parts supply chains (where relevant and feasible). Sustainability of arrangements for operation and maintenance is critical for the success of this output and will receive extra attention.

• Output 3 Behaviour change for improved sanitation, hygiene and nutrition practices.
Improved access to drinking water and improved agricultural productivity alone are not enough to improve the health and well-being of communities. Provision of drinking water must be combined with the promotion of good sanitation and hygiene practices, just as the improvement of productivity of animals and crops need to be combined with the awareness about balanced diets. Community-level approaches will be used, with messages that are customised to the specific constraints and opportunities that communities face.

• Output 4 Sustainable access to water and improved production methods for crops and livestock.
Improved availability and reliability of water also means that the risk of crop failure, grazing land degradation and livestock water point failure is reduced. This makes it less risky for farmers and pastoralists to invest in increasing the productivity of their livelihoods. Where relevant opportunities are identified, trainings will be organised to construct or upgrade small-scale infrastructure. Where relevant and feasible, the (re)planting of trees will be promoted to compensate somewhat for years of deforestation. The improvement of pastures and increased crop production need to go hand in hand with sustainable soil fertility management to ensure that soil depletion will not take place.

• Output 5 Action learning to promote replication of IWRM.
Integrated water resources management is fairly new in Sudan, and very new in the humanitarian community. Because of this, the project has a strong emphasis on documenting and sharing lessons learnt and encouraging other stakeholders to move from providing more water points to managing water resources in an integrated manner.

ANNEX 2: EXAMPLES OF BASIC WATER DEMAND CALCULATIONS

In this annex, examples are given for basic water demand calculations with Wadi Bargo catchment area in Kebkabiya locality, North Darfur State as a case study. Other catchment areas have a different water availability, and different gaps will be identified.

For the Wadi Bargo catchment area, the estimated values for rainfall (in mm/yr), groundwater recharge (in million m3/yr) and runoff + outflow (the water that can be used for different uses or for extra recharge, in million m3/yr) are as follows:

	Very dry (once in 25 years)	Dry (once in 5 years)	Average	Wet (once in 10 years)	Very wet (once in 25 years)
Rainfall (mm)	157.5	233.2	303.5	427.1	447.0
Recharge (million m3/yr)	0.4	3.2	19	170	190.6
Runoff + Outflow (million m3/yr)	1	7	25.8	110.5	153.1

It is clearly visible that the volume of groundwater recharge and surface water (runoff + outflow) is very high during wet years, but very low during dry and very dry years.

Domestic water demand

For domestic water demand in rural areas, a standard of 20 litres per person per day needs to be used. This is about 7.3 m3 per person per year.

Livestock water demand

For livestock, the following water requirements can be used:

Camel: 55 litres per animal per day (= 20.1 m3 per animal per year)

Cattle and donkeys: 30 litres per animal per day (= 11.0 m3 per animal per year)

Sheep and goats: 5 litres per animal per day (= 1.8 m3 per animal per year)

Water demand for rainy season sorghum

Rainy season sorghum needs about 350 mm of rain to give a basic harvest. This is almost 1,500 m3 water per feddan. More water will give better yields. The table below shows the water gap (= volume of water that needs to come from water harvesting) for the Wadi Bargo catchment area. In the last row, the maximum area is given that can be cultivated if all the surface water in the Wadi Bargo catchment area is used for sorghum (this means that no surface water is left for other uses!). As can be seen, this area is very small in dry and very dry years.

	Very dry (once in 25 years)	Dry (once in 5 years)	Average	Wet (once in 10 years)	Very wet (once in 25 years)
Rainfall (mm)	157.5	233.2	303.5	427.1	447.0
Water gap (mm)	192.5	116.8	46.5	No gap	No gap
Water harvesting requirement (m3/feddan)	808.5	490.6	195.3	0	0
Maximum cultivated sorghum area feddan)	1,240	14,270	132,100	Water is no limit	Water is no limit

Water demand for winter season vegetables

There is no rainfall in winter, and none of the rivers in the areas targeted by the Aqua4Sudan Partnership carry any water. This means that all the water must come from well irrigation. Because of the cost of pumping deeper groundwater and because of the limited suction head of common irrigation pumps (about 7 metres), vegetable irrigation is generally limited to areas near khors and wadis where groundwater is shallow.

Vegetables need about 300 mm of water. This is about 1,260 m3/feddan, spread out over about 100 days (so almost 12.6 m3 per feddan per day). The pump capacity limits how much can be irrigated from a single pump. For example, if a pump has a capacity of 50 m3/day, it can irrigate a maximum of 4 feddan.
In the table below an overview of the acreage that can be irrigated is given, if all the recharge is used for winter irrigation:

	Very dry (once in 25 years)	Dry (once in 5 years)	Average	Wet (once in 10 years)	Very wet (once in 25 years)
Recharge (million m3/yr)	0.4	3.2	19	170	190.6
Water requirement (m3/feddan)	1,260	1,260	1,260	1,260	1,260
Maximum cultivated winter vegetable area (feddan)	320	2,540	15,080	134,920	151,270

Water demand for hot season vegetables

In the hot season, the situation is the same as in winter: there is almost no rain, and all the water needs to come from well irrigation.
Because of the heat, evapotranspiration is higher. This means that the water requirement will be in the range of 500 mm. This is about 2,100 m3/feddan. Because more water is needed, a pump can irrigate only 60% of the area that it could have supplied with irrigation in the winter.
The table below gives an overview of the maximum area that can be irrigated in the hot season if all the available recharge is used:

	Very dry (once in 25 years)	Dry (once in 5 years)	Average	Wet (once in 10 years)	Very wet (once in 25 years)
Recharge (million m3/yr)	0.4	3.2	19	170	190.6
Water requirement (m3/feddan)	2,100	2,100	2,100	2,100	2,100
Maximum cultivated winter vegetable area (feddan)	190	1,520	9,050	80,950	90,760

Water demand for grazing areas

Rainy season grazing areas in Sudan can often manage with about 250 mm of rain. If the same example of the Wadi Bargo catchment area is used, this means the water gaps and water harvesting requirements are as indicated in the table below. The last row indicates the area of pasture that can be protected if all the surface water is used for spreading on grazing areas:

	Very dry (once in 25 years)	Dry (once in 5 years)	Average	Wet (once in 10 years)	Very wet (once in 25 years)
Rainfall (mm)	157.5	233.2	303.5	427.1	447
Water gap (mm)	92.5	16.8	No gap	No gap	No gap
Water harvesting requirement (m3/feddan)	388.5	70.6	0	0	0
Maximum grazing area that can be protected (feddan)	2,570	99,150	Water not an issue	Water not an issue	Water not an issue

Balancing different water demands

The calculations above show that there are limitations to the areas that can be cultivated and grazing areas that can be protected, and to the number of people and animals that can depend on a catchment area. The next step is to make a balance between the different demands and the available water, so that the total demand for water for crops, grazing area and livestock in a dry year (once in five years) is not larger than its availability, and the total demand for water for people is not larger than its availability in a very dry year. This exercise also highlights the importance of increasing groundwater recharge. If in average and wet years surface water can be turned into extra groundwater recharge, more groundwater will be available in dry years.

ANNEX 3: QUESTIONS THAT CAN BE USED FOR ASSESSING THE SUITABILITY OF WATER INTERVENTIONS

When different options have been identified for water interventions in a catchment area, it is important to compare the options to see which ones are suitable, and which ones are not.

A list of questions that can be asked is given below. It is important that enough time is taken to carefully assess the suitability of different options in a structured manner. Even though this requires extensive work, it will be worthwhile to avoid problems later on.

- What effect will this measure have on water availability for people in the rainy season?
- What effect will this measure have on water availability for livestock in the rainy season?
- What effect will this measure have on water availability for cultivation in the rainy season?
- What effect will this measure have on water availability for people in the winter season?
- What effect will this measure have on water availability for livestock in the winter season?
- What effect will this measure have on water availability for cultivation in the winter season?
- What effect will this measure have on water availability for people in the summer season?
- What effect will this measure have on water availability for livestock in the summer season?
- What effect will this measure have on water availability for cultivation in the summer season?
- What effect will this measure have on water availability downstream (drinking water for people and livestock, water for agriculture, flooding of grazing lands) in a normal year?
- What effect will this measure have on water availability downstream in a dry year?
- What effect will this measure have on water availability downstream in a wet year?
- Does this measure reduce the risk of flood damage to villages/towns in any way?
- What effect will this measure have on possible conflict between different water users at the water point?
- What effect will this measure have on possible conflict between different water users within the catchment area?
- What effect will this measure have on the water quality at the water point?
- What effect will this measure have on water quality downstream (think especially about salinity)?
- What effect will changing patterns in water use caused by this water point have on the wider environment? (concentration of livestock, local grazing, etc.)
- What effect will this measure have on the cost of water? (especially important if people were not paying for water so far, and if people may not have money to pay for water)
- What effect will this measure have on the operation and maintenance burden for the users (management requirements, availability of spare parts, labour needed to maintain the infrastructure, etc.)? And how can this be addressed?
- Are there any other possible effects that this measure will have, positive or negative?
- If there are any negative effects, how can they be mitigated?
- If there are any potential conflicts, how can they be addressed and who needs to be involved in this?
- What information is needed to be able to answer these questions properly?

ANNEX 4: RESOURCES AND INFORMATION

IWRM in Sudan

"Water Resources of the Sudan." University of Khartoum Water Research Centre, 2017.
"Community watershed management guidelines" Eastern Nile Watershed Management Project 2015

IWRM in Non-Nile Sudan

"Darfur: Water Supply in a Vulnerable Environment" Tearfund 2007
https://postconflict.unep.ch/publications/UNEP_Sudan_Darfur_Water_Resources_Summary_TF.pdf

"IWRM Good Practices in Sudan" UNEP 2018
Integrated Water Resources Management Good Practices in Sudan | UNEP - UN Environment Programme

"Some, For All, Forever: Emerging Development of Integrated Water Resources Management in Non-Nile Sudan." UNEP 2016
http://wedocs.unep.org/bitstream/handle/20.500.11822/22505/UNEP%20Sudan_IWRM_Some_for_all_forever_2016.pdf?sequence=1&isAllowed=y

"The case for drought preparedness" UNEP 2008
https://postconflict.unep.ch/publications/darfur_drought.pdf

"Towards Integrated Water Resources Management" UNESCO-IHE 2014
https://postconflict.unep.ch/publications/sudan/Sudan_WRM_2014.pdf

"Wadi Partners" UNEP 2016
https://postconflict.unep.ch/publications/Eco-DRR/EcoDRR_casestudy_Sudan_Wadipartners.pdf

Partner websites

ZOA
Home - ZOA (zoa-international.com)
International Aid Services
IAS-Intl.org (google.com)
Islamic Relief Worldwide
Islamic Relief Worldwide - Faith inspired action (islamic-relief.org)
Practical Action
Homepage - Practical Action
Plan Sudan
Sudan | Plan International (plan-international.org)
SOS Sahel Sudan
SOS Sahel Sudan – SOS Sahel International UK
World Relief
Christian Humanitarian Organization | Join Us | World Relief
DFID Sudan
DFID Sudan - GOV.UK (www.gov.uk)
Acacia
Rain foundation
Rainwater harvesting: powerful projects and tools (rainfoundation.org)

ACRONYMS

AWD	Acute Watery Diarrhoea
DWSU	Drinking Water and Sanitation Unit of the Federal Ministry of Water Resources and Irrigation
GWWU	Groundwater and Wadis Unit
IWRM	Integrated Water Resources Management
SWC/WES	State Water Corporation / Water and Environmental Sanitation project
WRMP	Water Resources Management Plan

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