Kenya Arid Lands Disaster Risk Reduction (KALDRR-WASH) program

Towards a better balance between water demand and supply

The Local Water Resource and Service Management approach applied to the pilot area Leheley, Kulaaley, Eyrib in Wajir

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1 General introduction

For the ASAL (Arid and Semi-Arid Land) areas in Kenya there are a number of challenges for water supply and governance. This leads to an increasing need for an integrated approach to assess the demand on the one hand, and the sustainable use of the water sources on the other hand. Essential challenges which are faced in the Horn of Africa include:

Current water supply is insufficient to cover the demand in dry years: in many areas in the Horn of Africa recurrent drought periods case problems in the water supply. A goal in the area is to increase the resilience to drought.

Increasing demand leading to water scarcity: population growth, economic development and societal change are leading to an increasing demand for water in the ASAL areas. As a result water scarcity is increasing, which makes good water governance in the region more urgent with the day.

Increasing complexity of water systems: the more water resources are developed, using different types of infrastructure and involvement of more stakeholders the complexity of relations and dynamics between different water users and uses is increasing. This also increases the challenges put to water governance. Clear illustrations of this are the frequent conflicts over water use and grazing lands between different communities in the ASAL areas. This complexity asks for more dialogue and negotiation between water users. An additional factor is ownership. Ownership of, or the right to use, a water resource or water supply infrastructure often implies the right to exercise some control. Water governance requires clarity around roles and responsibilities and the definition of property rights and who benefits from these rights. Also clarity is required how the rights are enforced.

Increasing uncertainty linked to climate change: the ASAL areas are increasingly suffering under repetitive and prolonged droughts, resulting in starvation of people and their livestock. Climate change is impacting on water resources primarily through more frequent extreme events (e.g. floods and droughts) and temporal and spatial shifts in rainfall patterns. The overall effect is that it increases risk and vulnerability, threatening the livelihoods, health and security of the population of the entire ASAL area. The population and its governance structures need to build resilience against these natural events of which better water governance is a crucial element.

Equity in access to water services and resources: in the ASAL area it is in general recognised that reducing poverty is linked to access to (safe) water for the different uses. For people who are able to pay or belong to elite social groups, water is rarely scarce. However, the poorer and more marginalised groups of society disproportionately lack access. In the ASAL areas the pastoralist culture often still prioritises water for livestock above water for women and children. In other words, lack of access to suitable and sustainable water services is at the same time a cause, a result and an indicator of poverty and inequity.

The KALDRR program

The Millennium Water Alliance (MWA)[1] program Kenya Arid Lands Disaster Risk Reduction (KALDRR-WASH) is implemented by the MWA members CARE, Catholic Relief Services (CRS), Food for the Hungry (FH) and World Vision (WV) – to improve access to water, sanitation and hygiene (WASH) and build resilience to climate change for at least 160,000 people in the arid lands of Kenya. The program will be implemented over the period of two years with a total budget of $9.83 million – $8 million in grant funds from USAID and OFDA and approximately $1.85 million in match funding from MWA and its partners. The KALDRR program has a partnership between MWA and a Dutch consortium, consisting of the organisations Aqua for All, Acacia Water and the IRC, International Water and Sanitation Centre.

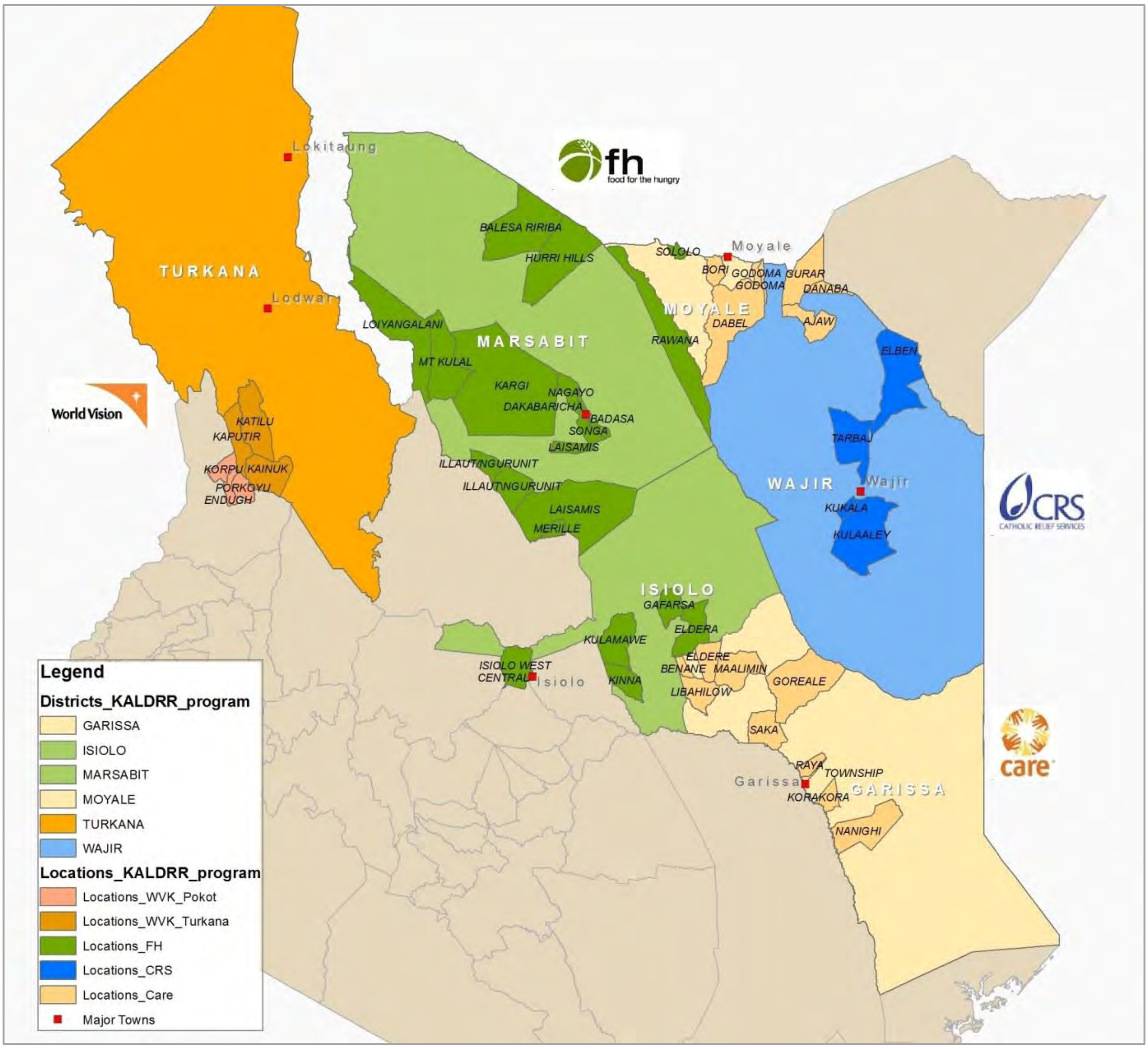


Figure 1-1: KALDRR project areas

This partnership has the goal to pilot an innovative approach to address the water governance challenges by using an integrated approach for local water resource and service management. In this approach the

[1] For more on MWA, see: http://mwawater.org/

methodologies: for maximizing the potential of water storage (3R – Retention, Recharge and Reuse[2]); for integrating *all* water uses taking into account *all* water sources (MUS – Multiple Use Services)[3]); and for a sustainable long-term financing of services (LCCA – Life Cycle Cost Approach)[4] are applied. Central in this approach is the assessment of the potential of different small scale water buffering interventions, based on the characteristics of the landscape (3R) and the demand and potential for multiple use (MUS).

The 3R analysis consist of a general analysis for the full KALDRR program area, which covers large parts of Northern Kenya, and zooms in to a local specific analysis in four target areas, one with each of the local MWA implementing partners. The results of the general 3R analysis for the full KALDRR program area are provided in a separate report: "General Physical Landscape Quickscan", which provides technical details behind the 3R analysis and development of the 3R potential map. Additionally a synthesis report is developed which provides an overview of the general characteristics and buffering potential of the full KALLDRR program area, based on the general physical landscape quickscan and the local inventory in the four target areas.

This report describes the result for the evaluation of the pilot area in the target area of CRS. The area is located in Wajir County. After the conceptual framework in chapter 2, chapter 3 presents the general methodology used throughout the 3R/MUS study. In chapter 4, the selected pilot area is further introduced. Chapter 5 and 6 give the area specific results of the so-called RIDA approach. Chapter 7 discusses in detail the potential for 3R interventions in the pilot area and chapter 8 provides the process and content for developing solution strategies for the pilot area by the stakeholders.

[2] For more on 3R, see: http://www.bebuffered.com/
[3] For more on MUS, see: http://www.musgroup.net/
[4] For more on LCCA, see: http://www.washcost.info/

2 Conceptual framework

2.1 Service Delivery Approach – long-term and area-based

A service delivery approach focuses on the long-term provision of water services at scale as opposed to the implementation of discrete, one-off projects at the community level. The approach thus includes both the physical infrastructure required to provide water *and* the management systems and capacities required at multiple levels to keep dependable and sufficient quantities of safe water coming out of the tap over the long-term.

Two important elements that are applied for the pilot area interventions are *area-based* and *long-term*. The *long-term* is needed because good water governance implies taking decisions about what water will be allocated for what use and where. Such decisions are not taken for a short period and often determine the location of settlements, the grazing land areas or land available for irrigation. Time spans for rural domestic water design usually cover a minimum design period of 10 years, but for larger infrastructure longer periods are no exception. Good water governance implies that the strategies take into account uncertainties of the future. For example uncertainties that occur around population growth and diversification of the livelihood pattern, but also economic development and climate change effects.

The traditional intervention method is often community focussed and has a project implementation character. The limitation of this approach is that it doesn't address problems that take place beyond the scope of the community. Examples of this are the capacity of providing support by the District Water Office or the risk that the new water infrastructure attracts new herds and people from the surrounding areas. The *area-based* element is important because it allows taking into account the different potential water uses as well as the potential of all water sources in the area. The area-based approach brings together the different stakeholders that have a water interest related to the area.

From Project Implementation	To Service Delivery
Focus on community level	Planning for services at scale (district or region)
Planning for project cycle time frame	Planning for indefinite service provision
Creates temporary institutions and staffing	Supports permanent capacity development
Financing focuses on initial construction	Financing takes into account full life-cycle expenditures
Different programmes adopt differing approaches and policies	Coordinates actors under one policy framework with agreed models for different service levels

2.2 Analysing the resources, infrastructure, demand and access (RIDA)

A key concept and framework for the KALDRR project is the RIDA (resources, infrastructure, demand and access) analysis. The concept of RIDA is simple. Users have a demand for water, and to meet this they usually rely on a provider (who manages infrastructure, like pipes and reservoirs), while both user and provider rely on natural water resources (rivers, lakes or underground resources) which must be managed and kept clean. These users, water service providers and water resource managers have separate approaches and institutions, and may lack a common meeting point. Note that infrastructure comprises not only physical structures but also includes the organizational structures that keep them working. See also figure 2.1.

Water users think in terms of households, villages, grazing lands managed by their water committee and organised in water user associations. Water service providers think in terms of boreholes, irrigation schemes and water pans. Water resource managers think in terms of catchments and aquifers and the regional level bodies that look after them. Many of the most difficult problems of water resource management come from the fact that the boundaries of these three groups of people do not match, and the institutions involved are different.

The problems that a poor woman experiences in getting domestic water may be related to local issues with access within the village, or to poorly managed supply infrastructure, or to the fact that there is simply not enough water resource to meet everyone's needs. The most difficult and troublesome problems relate to all three.

Box 2.1: Seven principles for local water governance

The Empowers project formulated seven principles for Local Water Governance:

1. Local water governance should be based upon the integrated participation of all stakeholders and end-users at all levels
2. Local water governance requires that special efforts are made to include vulnerable groups
3. Locally appropriate solutions and tools should be developed through the use of participatory research and action
4. Capacities of stakeholders should be developed at different levels to enable them to participate in water resource planning and management
5. Water information should be considered as a public good, and access to information be enabled for all citizens
6. Awareness must be developed for informed participation in water governance
7. The efforts of all actors (government, partners in development, civil society) should be harmonised and contribute to agreed and locally owned visions and strategies

(Empowers, 2007)

RIDA is used to structure the collection of information in the assessing phase. However, it should also inform all analysis of water related problems and potential solutions – from initial problem tree analyses, through stakeholder identification and strategy development. The methodology for the KALDRR project is based on principles for local water governance (box 2.1).

The project integrates two methodologies for the situational analysis. For the analysis of the hydrological resources and infrastructure potential determination the 3R approach is applied (see section 2.2.1). For the management part of the resources analysis, and the demand and access analyses and optimization the MUS approach is applied (see section 2.2.2).

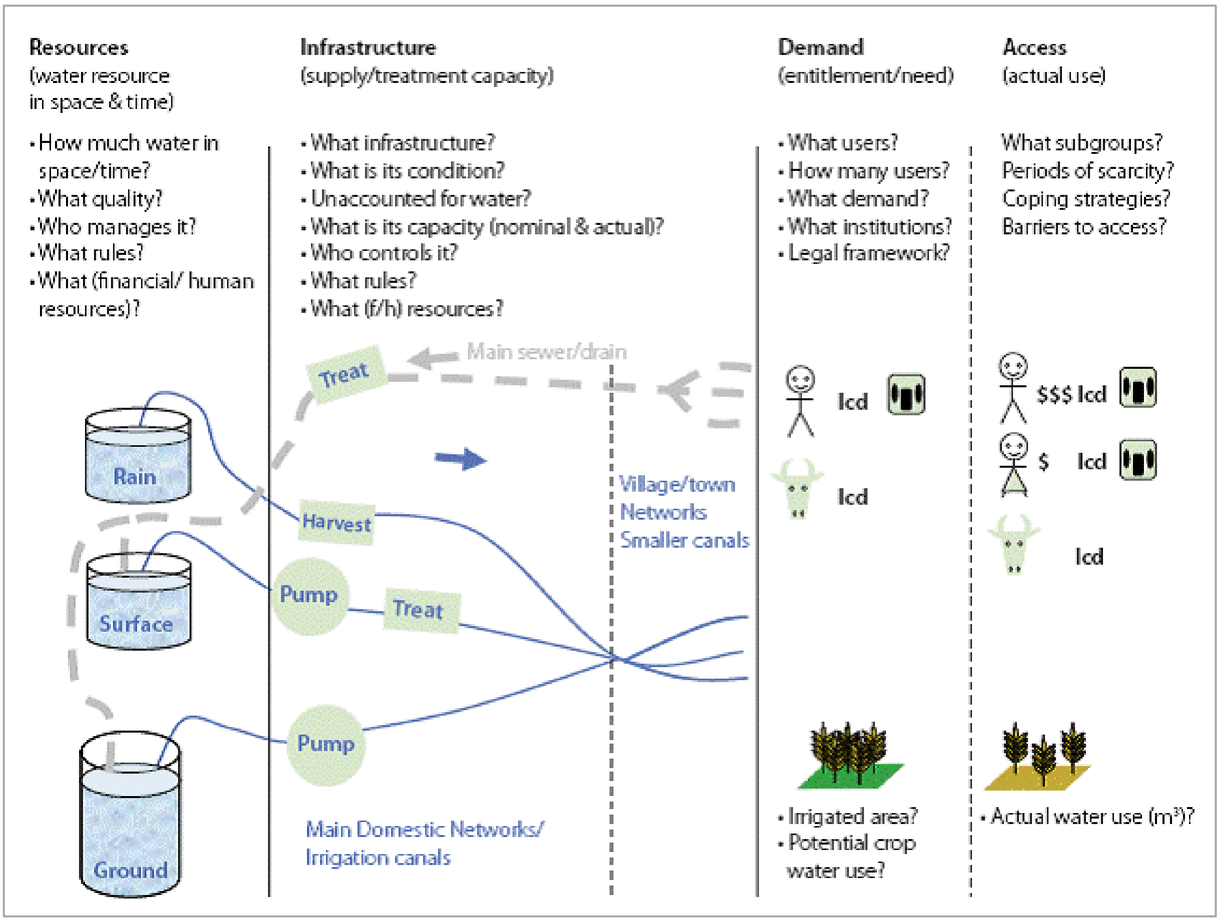


Figure 2-1: Example of RIDA (Empowers 2007)

2.2.1 Resources and Infrastructure: using the 3R approach

The following is based on the publication 'Profit from Storage, The costs and benefits of water buffering', Tuinhof et al., 2012.

The resource determines the amount of water that is potentially available, while the infrastructure makes it accessible. In many areas that currently suffer from droughts the resources are in total enough to fulfill the demand. However, the moments that water is naturally available are limited in time, and long periods of droughts may occur. Therefore, infrastructure is required to store the water and make it available when and where it is needed. The larger idea is thus that tackling a local water crisis is not so much about reallocating scarce water, but to store water when it is plentiful and to make it available for the dry periods – and also to extend the chain of uses. This is the central thought of the 3R approach, in which through Recharge, Retention and Reuse the amount of useful water is increased. The focus of the 3R approach is on increasing storage and availability of water. 3R interventions and techniques are already broadly used. Figure 2-2 provides an overview of different often well-known types of 3R interventions that exist. Many of these have the potential to be implemented in more places besides the regions where they are currently applied, creating the opportunity to increase the water storage, and thus creating resilience against dry periods. Four main categories of interventions can be distinguished:

- Storage in groundwater (either for domestic or agricultural water supply)
- Storage in soil moisture in the unsaturated zone (generally for agricultural purposes)
- Storage in closed tanks and cisterns (usually rainwater harvesting and of small scale)
- Storage in open reservoirs (usually medium to large scale)

Each type of buffer has its own strength and weakness. The time that water is retained and stored differs between the systems. In general the buffering capacity increases as one moves from small to large storage and from surface to soil/groundwater storage. Whereas small tanks and soil moisture will help to bridge for example a dry season, large surface storage and particularly groundwater storage can help bridge even an unusual dry year or series thereof. Usually different types of storage complement each other in water buffering at landscape and basin level.

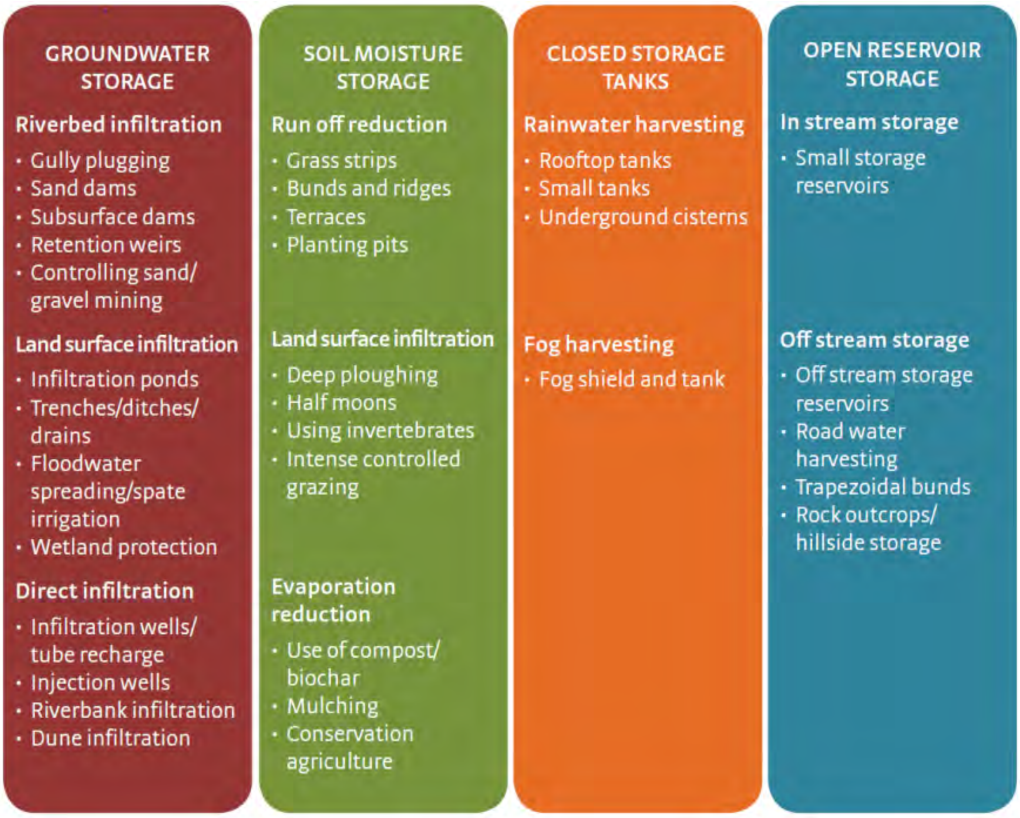


Figure 2-2: Overview of 3R techniques (replicated from tuinhof et al., 2013)

The selection of suitable 3R interventions depends on the intended use of the water. For drinking water, where high quality is desirable, closed storage in tanks or in groundwater storage are most suited. The demand for cattle or irrigation water may be suited with water from a lower quality, which broadens the range of possible 3R interventions with open water storage and soil moisture (the latter mainly for crops). The intended water use, that determines the quality of the water that is needed, is assessed in the MUS analysis (see section 2.2.2).

Additionally, for successful implementation the 3R interventions have to fit within the characteristics of the landscape. To locate the areas where different 3R interventions can be applied, a landscape analysis is therefore required. For example, storage of groundwater can be very beneficial, but it can only be applied where the ground is sufficient porous and where the water is not lost to too large depths. As an alternative, when the infiltration capacity is low, open water storage may become an option. Depending on the sediment in the rivers, reservoirs may fill up with sand, thus creating an excellent new location for groundwater storage in the form of sand dams. The application of the different options is thus dictated by the geo-hydrological characteristics of the landscape.

The 3R analysis focuses on this physical landscape analysis, in order to provide an advice about the best manner to store water in the wet period, and make it available for use in the dry periods. This also includes an advice on the kind of locations where interventions should be placed to accumulate sufficient water to recharge the reservoirs. Combined with the demand from the MUS analysis this provides an estimate of the size and the number of interventions required to make the area resilient for (long) drought periods. Hence, the kind of intervention that suit in the physical landscape, and the best areas for implementation are indicated by the 3R analysis.

Box 2.1: 3R = Recharge, Retention and Reuse

With 3R the water buffer, where water is stored during wet periods, is managed through recharge, retention and reuse. The idea is to create strong buffers and extend the chain of water uses.

Recharge

Recharge adds water to the buffer. Recharge can be natural, for example the infiltration of rain and run-off water in the landscape, or it can be managed (artificial recharge) through special structures or by the considerate planning of roads and paved surfaces. Recharge can also be the welcome by-product of for instance inefficient irrigation or leakage in existing water systems.

Retention

Retention means that water is stored to make it available in the dry periods. It creates wet buffers, so that it is easier to retrieve the water. Retention can also help to extend the chain of water uses. Additionally, retention may raise the groundwater table and may affect soil moisture and soil chemistry, which can have a large impact on agricultural productivity.

Reuse

Reuse comprises different elements. The simplest form is the use of the water in the dry period which was stored in the wet period. It can be further extended when the water is kept in active circulation. This can be achieved with the management of water quality, to make sure that water can move from one use to another, even as the water quality changes in the chain of uses. Further, reuse can be enhanced by reducing non beneficial evaporation to the atmosphere, and by capturing air moisture, such as dew, where possible.

2.2.2 Demand and Access: using the MUS approach

The following is based on the report 'Multiple Use Water Services in Ethiopia - Scoping Study'; Butterworth et al., 2011.

The demand and access are analysed using the Multiple-Use water Services (MUS) approach. This is a participatory approach that takes the multiple domestic and productive needs of water users who take water from multiple sources as the starting point of planning, designing and delivering water services. The MUS approach encompasses both new infrastructure development and rehabilitation of existing, as well as governance.

In terms of livelihood improvements, MUS concurrently improves health, food security, and income, and reduces women's and girls' drudgery, especially among the poor in rural and peri-urban areas where their multi-faceted, agriculture-based livelihoods depend in multiple ways on access to water. People in many rural communities have practiced their own forms of 'integrated water resource development and management', self-catering for their needs for many generations. In addition, MUS turns the problem of unplanned uses into an opportunity to leverage investments, avoid infrastructure damage from unplanned use, and generate broader livelihood returns.

In terms of environmental sustainability and water efficiency, MUS recognizes that people use and re-use conjunctive water sources in ways that optimize, for them, the efficient development and management of rain, surface water, soil moisture, wetlands, and groundwater, and other related natural resources within their local environment. Local knowledge and coping strategies for mitigating seasonal and annual climatic variability by combining multiple sources is at the heart of community resilience. Such efficiency and resilience will become ever more important as the impacts of climate change become more visible.

The MUS focus on the poor puts people and multiple uses at centre stage instead of casting allocation issues in terms of monolithic 'use sectors' that fail to differentiate between vested interests and multiple small-scale uses for basic livelihoods. Instead, MUS considers the distribution of water use by individuals, each with multiple water needs. Focusing on the poor, MUS especially safeguards poor people's rights to water, food and livelihoods and their fair share of the resource in quantitative terms, and exposes poor people's greater vulnerability to unsafe water in qualitative terms.

3 Methodology

3.1 Process cycle

Water governance is a continuing and cyclic process that includes the steps of analysis, planning, and problem solving. In principle a continuous monitoring of the situation and the activities, leads to regular adaptation of the plans. For the KALDRR project we combine the MUS guidelines (Adank 2012) and the 3R approach, which is based on the experiences with small scale water storage interventions in earlier projects. This provides an area integrated approach, with an analysis of the physical landscape to provide advice on the potential of different kinds of interventions. The emphasis in the current report is on the earliest phases of the project cycle:

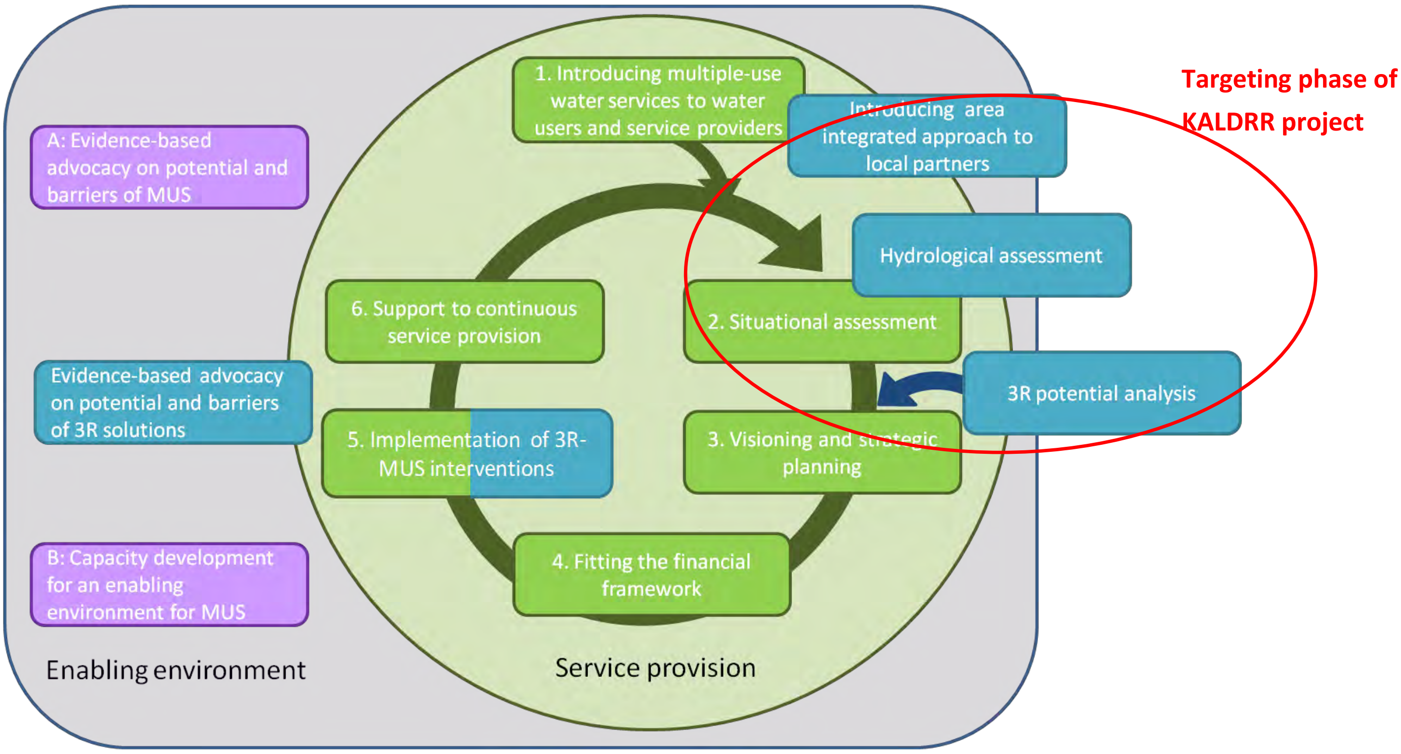


Figure 3-1: Process cycle, combining the MUS components (in green) with the 3R components (in blue)

The first phase (*1. Introducing MUS to water users and service providers*) aims at creating awareness for the integrated local water governance approach among the stakeholders in the pilot area.
The assessment phase (*2. Situational assessment*) includes an assessment of water resources, infrastructure, demand and access in the pilot areas. The result and discussion of these assessments are the main content of this report. During this phase the 3R approach is included, with a general and local geo-hydrological landscape analysis to establish the potential of different interventions to buffer water in the area.

The assessment phase is followed by visioning and planning phase (*3. Visioning and strategic planning*). The MUS Group recognizes that MUS interventions require a phase in which financial resources are matched with costs *(4. Fitting the financial framework)*, which leads to the development and adoption of a financial framework for the development and provision of multiple-use water services. The framework that we will use in the KALDRR project will be based on the Life-Cycle Costing Approach, developed by IRC' WASHCost project. The focus will be on knowing better the complete cost picture, including O&M, rehabilitation and support costs for the different interventions and agree on ways to finance these costs. This is not a one-off exercise and it is foreseen that joint research into the costing and financing of typical ASAL interventions will be required.

During the implementation phase (*5. Implementation of 3R/MUS interventions*), both the construction of new infrastructure and the rehabilitation of existing infrastructure is implemented The focus in the KALDRR project is on 3R type of techniques, but the overall water strategies for the area don't exclude for example the rehabilitation of a deep borehole. Next to the hardware interventions, the implementation phase also includes interventions to improve governance through better coordination and information sharing as well as capacity development of service providers (like water users committees). This phase includes the development of work- or action plans and is about the more pragmatic planning of concrete activities in order to achieve the vision.

Often project cycles tend to have a monitoring and evaluation phase that follows the implementation phase. For the KALDRR project the focus is on providing insight in the 3R interventions that fit within the characteristics of the physical and socio-economic landscape and on service provision with its on-going administration, management and O&M, including post construction support (*6. Support to continuous service provision)*. This is in line with the MUS guidelines and monitoring and evaluation are considered to be part of this on-going administration and management during all phases.

In this report the results of the assessment phase (*2. Situational assessment*) are provided, including the hydrological assessment and the 3R potential analysis. At the end of this report, in chapter 8, the first steps towards phase 3 are given.

3.2 Area selection

The situational assessment is performed for each IP for a selected target area within their focus region. Therefore, a limited geographical area suitable for piloting the local water governance approach was identified. The selection of this area is agreed upon with the IP's, based on the following criteria:

- For the pilot area a region with substantial 3R potential is selected. With the 3R hydro-geological desk study, using existing GIS databases and satellite imagery were analyzed. This resulted in a classification of areas that are likely to be suitable for 3R interventions (for details see the General Physical Landscape Quickscan; Acacia Water, 2013).
- The target areas are selected to represent the most important different physical landscapes in the various districts of the MWA project area. This is done to allow potential upscaling of the local results towards a broader area.
- The logistics and security should allow the 3R/MUS support team to carry out field visits effectively and efficiently.

- The existing MUS practices were assessed at a general level for the whole ASAL area of Kenya, based on the MUS scoping performed. From this it was concluded that the MUS analysis did not add further constrains of the area selection.

3.3 Field work

During the 3R/MUS field visits the focus has been on carrying out the situational assessment for the Local Integrated Water Resources and Service Management plan for the target area. In addition, the IP is supported with technical advice for some of their (already identified) hardware interventions. The methods applied can be summarized as:

- Agreement with IP on pilot area ,
- RIDA framework for overall guidance to the analysis of the area
- 3R ground truthing[5] of the desk study on the characteristics of the geo-hydrological situation
- Mapping of existing water infrastructure
- Identification of water resource potential, and the potential of interventions that increase water storage
- Participatory focus group discussions, including the seasonal calendar and wealth ranking-livelihood matrices to assess water use, access and demand
- Participatory water mapping of the pilot area with representatives of villagers, government and other partners to create a common understanding of the situation and to make a start with a long-term vision for the pilot area.

Below more detail is provided on point 2-5 is provided in section 3.3.1 and on point 6-7 in section 3.3.2.

3.3.1 Geo-hydrological situation (i.e. resources) & infrastructure

The geo-hydrological situation is assessed based on a general data analysis, extended with an area specific field analysis. For the results of the general data analysis we refer to the document 'MWA 3R potential analysis, General physical landscape quickscan' by Acacia Water. In the fieldwork the analysis of the physical landscape characteristics and the general potential for different 3R methods in the target area are verified and refined. In addition to the local assessment, this information will also be used to refine the up scaling to the whole KALDRR project area.

The local hydrological inventory consisted of two main strategies for the gathering of information and data. The local stakeholders, including the IP staff, Ministry of Water and Irrigation, Water Resources Management Authority, local NGO's, community leaders, water source management committees and operators, and local water users, were consulted to collect data and gather the existing information. Additionally field assessments were carried out including:

- High potential areas were identified from the maps and satellite images from the general landscape analysis, extended with information based on the experience of local informants. These areas were visited during the fieldwork.
- Evaluation of existing water resources and infrastructure based visual inspection of the infrastructure, on-site water quality testing (EC and pH) and evaluation of the soil, morphology and geology characteristics. Additionally, local water users were consulted on the water usage

[5] Ground truthing is the process of sending technicians to gather data in the field that either validates or complements airborne general and remote sensing data collected by aerial photography, satellite sides can radar, or infrared images.

types, ownership and O&M and management, functionality, dry season water availability, and any constrains that were experienced.

- Evaluation of identified physical landscapes characteristics and 3R classes, based on a geo-hydrological evaluation based observations of the geology, the morphology, the soil types, the vegetation characteristics and surface runoff patterns.
- At the selected locations specific site assessments were performed. The soil texture was determined and auger profiles were made where a detailed soil description is collected. Also, the infiltration capacity is determined at several locations in the area, based on tests with the double ring-infiltrometer. At locations where shallow groundwater could be expected test pits were dug and the water quality was tested. In riverbeds the steepness and distance between the riverbank was assessed in more detail than the general data could provide, and the sediment depth is determined by the probing of riverbeds. The results of the field tests are provided in Annex 7.

3.3.2 Water demand and water access

Water demand captures the ideal water use and often is set by the water 'entitlements' as defined in norms and guidelines. It defines the requirements for water by users at a certain time and place where users are considered both as individuals and groups. They may require water for irrigation, domestic, industrial or other uses. The environment is also considered a user, with specific needs of its own. For the areas in the KALDRR project also a demand for wildlife is included.

Water access is about the actual water use; unsatisfied demand; etc. Demand and entitlements are often constrained by legal, economic, and social barriers. Demand is also hugely variable across users and time, and importantly, the water use of any single user is impacted by the demands of other users.

For assessing the present water use practices and barriers to accessing water, the same tools as the one used for "Water demand" were used. During FDG with the communities in particular, tools such as the "calendar exercise" have been used, to understand how water duty can compete with other activities, and where period of water scarcity can impact the livelihood of the households.

For assessing the water demand and access for the target area, a number of tools have been used in the field, which included:

- Focus group discussions with communities and water user associations, to evaluate their water uses, economic conditions, domestic, agricultural and livestock water needs; given the particular pastoralist context of Northern Kenya, a specific emphasize was given on understanding movement of population and livestock and get an understanding of seasonality of water demand (see annex 4).
- Focus Group discussion with Water Committees (when existing), to understand ownership, O&M, financial management and challenges and constraints faced in managing the water point,
- Key Informant Interview with local stakeholders, including the IP staff, district representatives, irrigation scheme associations, water source management committees and operators, to collect additional information on water management and infrastructure maintenance and local water users, were consulted to collect data and gather the existing information, and
- Stakeholder meeting, during which data is collected through group work; exercise such as "participatory mapping" (annex 5) is conducted, where landscape, demographic, water resources and water use are summarised on one map by all participants.

Data collected were used to fill-in an Excel sheet, which sums-up all water demands (domestic, agriculture, and livestock) per season.

3.4 Participatory planning: methodology for matching RI and DA

The information collected during the desk study and in the field is used to provide the situational analysis based on the RIDA framework and is presented in chapters 5 and 6 of this report. Chapter 7 describes in detail the landscape analysis for assessing the potential of 3R interventions. This landscape analysis is part of step 6 of the methodology presented below. The methodology is explained using the example of the Logologo area in Marsabit (see annex 10). An important input for the visioning and strategic planning phase is to bring the RI and DA components together and make a first estimate about what type of 3R interventions will be needed to meet a certain water demand level in a point in the future. During a KALDRR workshop of 19-23 August 2013, the exercise was carried out by the project partners, which methodology is briefly explained in this section. During the visioning and strategic planning phase this exercise will be carried out by the stakeholders.

Methodology for first estimate of what resources and infrastructure are needed to meet the future demand for the different water uses.

<u>Step 1:</u> Agree with stakeholders on the year in the future that will be used for the planning. In the case of the KALDRR August 2013 workshop, either the year 2023 or 2033 were used.

<u>Step 2:</u> Agree with the stakeholders on the length of a typical dry period in months. This is important, because the 3R approach basically aims at bridging a dry period with sufficient volume of water stored. KALDRR August 2013 used a dry period of 10 months, a year with only one wet season.

<u>Step 3:</u> For each type of demand, calculate the water gap in the future year by deducting the projected demand with the present supply of the existing water supply infrastructure. The following points need to be taken into account:

- Five types of water demand have to be considered: (1) domestic, (2) livestock, (3) small scale agriculture and (4) migrating herds and (5) wildlife;
- For the existing infrastructure, the first assumption made is that the water point is operational, even though it may be presently out of order due to e.g. a broken generator;
- The second assumption made is that the capacity of the water point in the future will not decrease (as compared to the water point current capacity);
- In principle a distinction needs to be made between:
    - the water gap in terms of water resource, and
    - the water gap in terms of infrastructure needed to make the resource accessible.

  For example in Turkana, there is a high demand for irrigation scheme, linked to the presence of a perennial river. In that case, the irrigation infrastructure gap is big, while the water resource gap is low. Another example would be if a water point with very large capacity is located more than 1km distance of the users: in that case there is no water gap, but there is a gap in bringing this water to the settlement.

<u>Step 4:</u> For each type of water use, draw on a separate map where the gap(s) will occur in the area and put estimated volumes (see example in annex 10).

<u>Step 5:</u> Use the 3R map 'Potential for 3R interventions for the MWA program area in Northern Kenya' to zoom in on the pilot area and identify the possible 3R interventions. For the target area assessed in this report the 3R map is included in figure 7.2, for the map of the full MWA program area in Northern Kenya

we refer to the synthesis report ‘Potential for water buffering, a landscape based view’ (Acacia Water, 2013). It is important to note that the map only provides an indication of possible type of 3R interventions. **The feasibility of each and every intervention needs always to be verified by a visit on the ground** (see example in annex 10).

Step 6: With the table of annex 9, a rough estimate of the amount of water that can be stored within an intervention can be made. Note that in most interventions water losses occur. When estimating the amount of water that will be available for use from an intervention, it is therefore important to subtract the loss from the potential storage. Based on these numbers a rough estimate of the number of 3R interventions required for the different water demands can be made. The exact storage is location specific and should be further detailed in the field. Note also that some gaps cannot be filled with a 3R-type intervention. In some cases, for example a new borehole might be required.

4 Target area

4.1 Description of Wajir County

According to the Kenya Open Data6, Wajir County is located in North Eastern Kenya and covers an area of 56,685 km^2. It has a mean annual temperature of 28 °C with rainfall amounts ranging between 250 mm (annual average) and 700mm per annum in different parts of the County. The administrative headquarters of the County is Wajir Town.

Geographically, Wajir County borders Mandera County to the North and North East, the Republic of Somalia to the East, Garissa County to the South and South West, Isiolo and Marsabit counties to the West, and the Republic of Ethiopia to the North east. The County covers an area of 56,685 km2 while the population is 661,941 (Male – 55 %, Female –45 %) according to the 2009 National Housing and Population census. The population density is 12 people per km^2 with an annual growth rate estimated at 3.7%, compared to the national average of 2.7% and the Northeastern rate of 3.2%. The majority of the population in the County lives in rural area with the urban population being 14.6%, (96,855 people) compared to the national average of 32.3%. On the other hand, Wajir South Sub-County in which the pilot 3R/MUS will be implemented, has a population of 130,070 (2009 National Census) and covers an area of approximately 21,595 km^2.

The Kenya Open Data states that the main economic activity in Wajir County is pastoralism with some agro-pastoralism being practiced in the Northern part of the County. The large tracts of land in the County provide the grazing pastures for the large camel and cattle herds found in the county. According to FEWSNET, Wajir County lies in the Livelihood zone 9, with livestock production being the most significant source of income, contributing from 60-80% of the total household income. From Focused Group Discussions (FGDs) with the people of Eyrib, Sukela anf Boji South Sub-Location in Wajir South Sub-County, the average household (which make up approximately 75% of the population in these Sub-locations) keeps an average of 80 shoats; 10 cattle, 30camels7 and at least 2 donkeys. Both camels and donkeys are considered burden or transportation animals. According to FEWSNET, while goats' contribution to food and cash income is important, camel's contribution to household food is crucial as they provide milk throughout most of the year.

According to a report of the Social Analysis Study undertaken by the Arid Lands Resource Management Project in Kenya in 2004, migration in search of water and pasture is the first coping strategy among pastoralist communities in northern Kenya, including Wajir and in case of extreme drought conditions, the

[6] The Kenya Open Data initiative was launched on July 8, 2011, by the then President of Kenya, Mwai Kibaki, to make key government data freely available to the public through a single online portal.

[7] According to the people Eyrib Location, camel is the moving bank of the pastoralists in Wajir County since it can withstand drought situations much better than cattle. It is therefore the preferred animal for those who can afford it.

people turn to slaughtering their animals in order to preserve the meat and milk animals, especially goat, are lent out by the comparatively better off HHs to the poorer HHs to enable the latter have at least some milk for the family. Other important coping strategies according to FEWSNET include petty trading during period of stress, and when households come together at watering points. Formal waged labour and casual labour make minimal contributions to household income. Finally, FEWSNET states that constraints to livestock production that limit the contribution of livestock to food security include poor access to markets, low prices fetched for animals; high insecurity and risk of raids even along trading routes; frequent shortages of drinking water for livestock; shortages of pasture and browse; and the prevalence endemic livestock pests and diseases.

In general the communities in Wajir area use water basically for livestock and domestic consumption. Minor irrigation is carried out immediately south of the town. This water is not usually available in all the villages visited and during dry seasons water has to be trucked for long distances.

4.2 Area selection in Wajir

For the area analysis within the target area of CRS, an area is selected in the Wajir County. The selection is preliminary based on expected potential for different 3R/MUS interventions, the variability in the landscape and the accessibility of the area for the 3R-MUS support team.

The 3R target area is located south of Wajir town. The selected pilot area for the local inventory extends about 70 km to the South of Wajir town and comprises the Sub-Locations Leheley, Kulaaley and Eyrib. In this area the rivers Lagh Bor (in the north-middle of the target area) and Lagh Bogal (in the south of the target area) are examined in more detail, as well as the settlements in the south-east of Leheley and in the north of the target area. Addition also a short field visit is performed to Lafaley, the Sub-Location north of Wajir town. Besides areas of interest in Godoma Location East of Wajir were visited up to Bute, 50 km east of Wajir Town, for the MUS analysis.

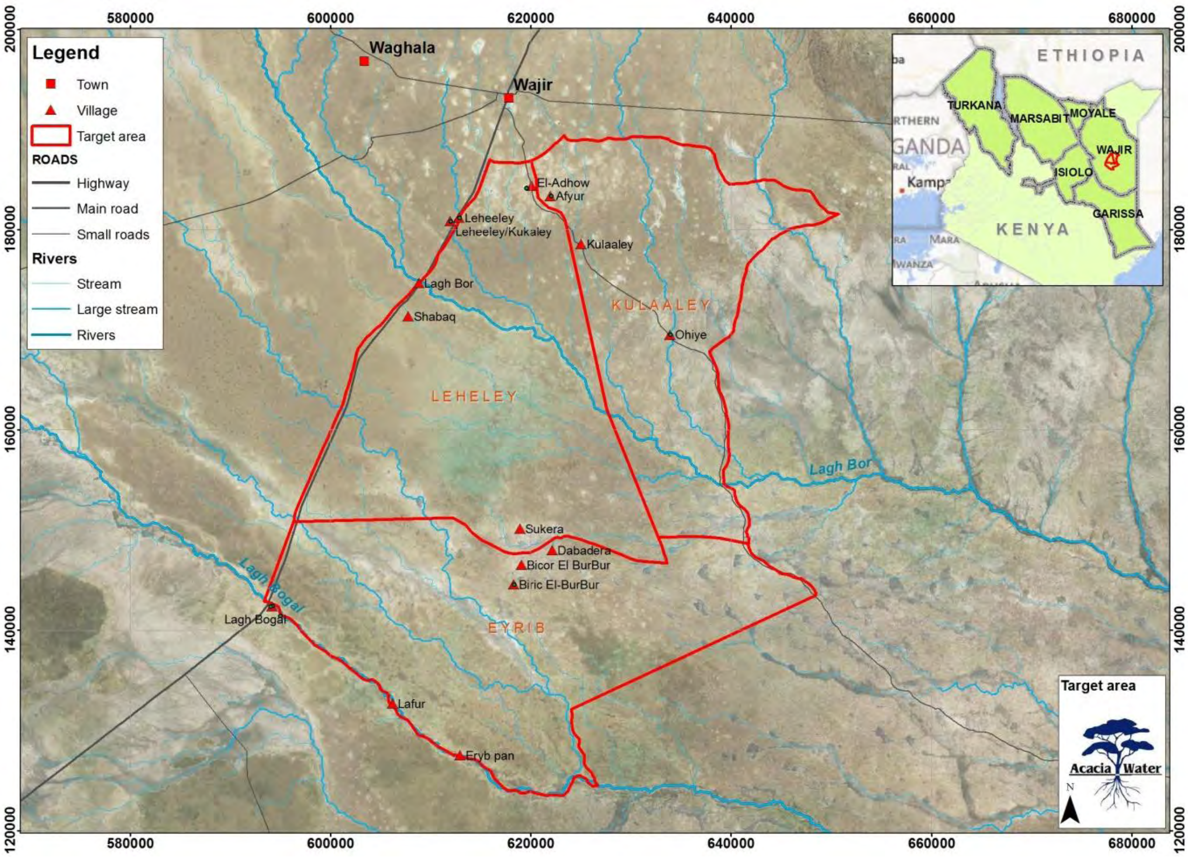
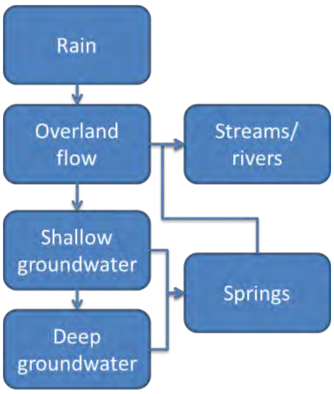


Figure 4-1: Selected target areas. In red the 3R target area where the resources and infrastructure are evaluated.

5 Available resources, current infrastructure and management



5.1 Available resources

The resources from which water can be harvested exist of rain -which can be directly harvested and stored-, overland flow, gully flow, seasonal rivers, groundwater and springs. These components their characteristics in relation to the different landscapes classes are described in this chapter.

Figure 5-1: Water resources and their relation

Rain

The area is described as very arid with an average annual rainfall of between 150-450mm, and an average annual potential evaporation of between 2,100-2,500mm. The rainfall pattern is bi-modal and apparently falls in the periods of March to May and September to November, corresponding to the change in the monsoons. It has been noted that rainfall over the greater part of the study area is irregular, infrequent and erratic. Occasional showers are experienced in the period between May and September. The period between July and August is generally dry. The driest period of the year occurs from December through March, and is caused by the northern monsoons. Data from two rainfall stations in the project area are tabulated in table 4-2.

Overland flow

In the target area the topography is gently inclined to flat, however few depressions are spotted. The upper north of the target area is characterized by shallow wells and there is no noted overland flow. Slightly more south in the northern part of the target area, along Lagh Bor, the topography is gently inclined. Overland flow accumulates into the lagga (stream) and it flows downstream in a NW-SE direction. It is not locally being utilized efficiently and runs-off.

In the middle of the of the target area (in the southeastern side of sub-county Leheley) the general area is observed to be a flood zone and the water do not percolate quickly after the rains, soil tests indicated low permeability at this location.

Streams and seasonal rivers

Flow in perennial streams is bimodal, mimicking rainfall with a lag time that rarely exceeds a month. Ephemeral flows occur when local rainfall exceeds field capacity: flow duration ranges from a few hours to periods of several weeks, depending antecedent conditions, rainfall intensity and duration. Most rivers flow from north-west to south-east. Ewaso Ngiro is the major drainage basin in the general area which pass at the periphery of the Boji Plain marshy area. Further north, the area is drained by Lagh Bogal, which is at the southern edge of our target area. More towards the north of the target area Lagh Bor is found.

Lagh Bogal

Originating from the Moyale District is the Lagh Bogal, which has the Lagh Walda and Rawana as its tributaries and drains to the south east. The river first forms the boundary between Marsabit and Wajir, then Isiolo and Wajir Districts, thence to Elgal and on to the border north of Liboi. The stream fades at this point, but in former moister periods probably joined the Laaq Bissiq east of the border. Within Somalia it joins the Lagh Dera north of Dobli.

Lagh Bor

It originates in western Wajir District flowing through Buna, Giriftu and south of Wajir Town, and onwards to the Kenya – Somalia border at Dif where it flows out the study area and into Somalia. The Lagh Bor probably recharges the shallow aquifer utilized by shallow wells at Giriftu.

The Lagh Bor Drainage System consists of two valleys, the Lagh Bor itself and the Lagh Katulo covering about 75,064 km2. The two rivers drain most of Wajir District, western and southwestern half of Mandera District. The Lagh Bor rises as two major tributaries, the Lagh Bor itself and Lagh Jara from the northern tip of Wajir District and southern extremity of Ethiopia respectively. The two tributaries flow in a southward direction and join just north of Buna Centre to become main Lagh Bor valley. This valley flows in a south-southeast direction turning to a southeast direction south of Wajir Town. It disappears into Somalia as Lagh Bisika near Dif. Lagh Bor forms the main drainage way for Wajir County.

Shallow groundwater

A major shallow aquifer is present at Wajir Town and surroundings. According to geophysical profiles conducted (Water and Sanitation Report, 2005) in the area, the aquifer stretches radically from Wajir Town covering an area of 238 km2. The aquifer comprises the Wajir well fields and it describes an eclipse which extends as follows:

- 5.7 km on the Wajir -Habaswein stretch
- 15.0 km on the Wajir-Wagalla-Griftu Stretch
- 4.3 km along Wajir-Lafaley-Tarbaj stretch
- 15.3 km along Wajir-Wajir Bor stretch

The Wajir shallow aquifer comprises two distinct fairly to moderately recharged hydrostratigraphic horizons in the range of 6.3 m to 10.8 m depth, and the lower one in the 29.3m to 36.5 m depth range. The former comprises a thin layer of loose, coarse grained sands with a thickness ranging between 0.5 and 1.0 meters below which exists an interface of jointed limestone and gypsiferous deposits of the sedimentary order. The upper aquifer contains about 90% of all groundwater in the aquifers underlying Wajir town, and has mostly been tapped by use of shallow wells. Hand dug wells depths range between 5m and 30m bgl in the Wajir aquifer. The groundwater chemistry of the Wajir town shallow aquifer is considered stable and no major deviations in chemical parameter concentrations over long periods of time.

Salinity in most parts of the rest of Wajir County is generally high. Some areas have such high salinity that even salt resistant animals (camels) do not drink the water. Boreholes drilled in such areas have therefore not been equipped hence the large areas of the district without permanent water supply.

The salinity increases from the Merti aquifer towards the north and northwest, changing to sodium chloride type (common salt). An increase in magnesium and calcium is also indicated as well as nitrates (assumed to come from nitrogen-rich fossil soils) to even dangerous levels. High nitrates of suspected palaeosol origin are restricted to the Wajir carbonate aquifers. Most operating boreholes have hard water.

Deep groundwater

The Wajir deep aquifer underlies the shallow aquifer dominantly of Quaternary sediments. The deep aquifer is encountered at depths greater than 100 m bgl within the Mandera Jurassic sediments. The aquifer terminates at the fringes of the Merti Beds. This has been ascertained by previous studies in the area which showed variant water quality characteristics and vertical and lateral extent of the aquifer. The area is characterized by different aquifer zones, the series covers an approximate area of 54,895 km2 of the areas of both Wajir and Mandera.

The sedimentary aquifers are most likely recharged indirectly via lateral groundwater flow. The Wajir deep aquifer has boreholes penetrating in the range of 100m - 300m with water struck levels varying from one borehole to another. Deeper aquifers in Wajir area have relatively low yield and the water is of poor quality. Boreholes drilled in Upper Jurassic Sediments at Wajir have poor groundwater potential and most of them are dry. Potential for deep aquifer is uncertain owing to the poor water quality and low yields of tested boreholes from deep aquifers.

5.1 Existing infrastructure

In the area under study a number of different water infrastructures exist. The difference between the kind of interventions is related to the landscape, and can also be regarded as indications of the 3R potential zones, as will be further elaborated in chapter 7. The existing infrastructure is further explained below.

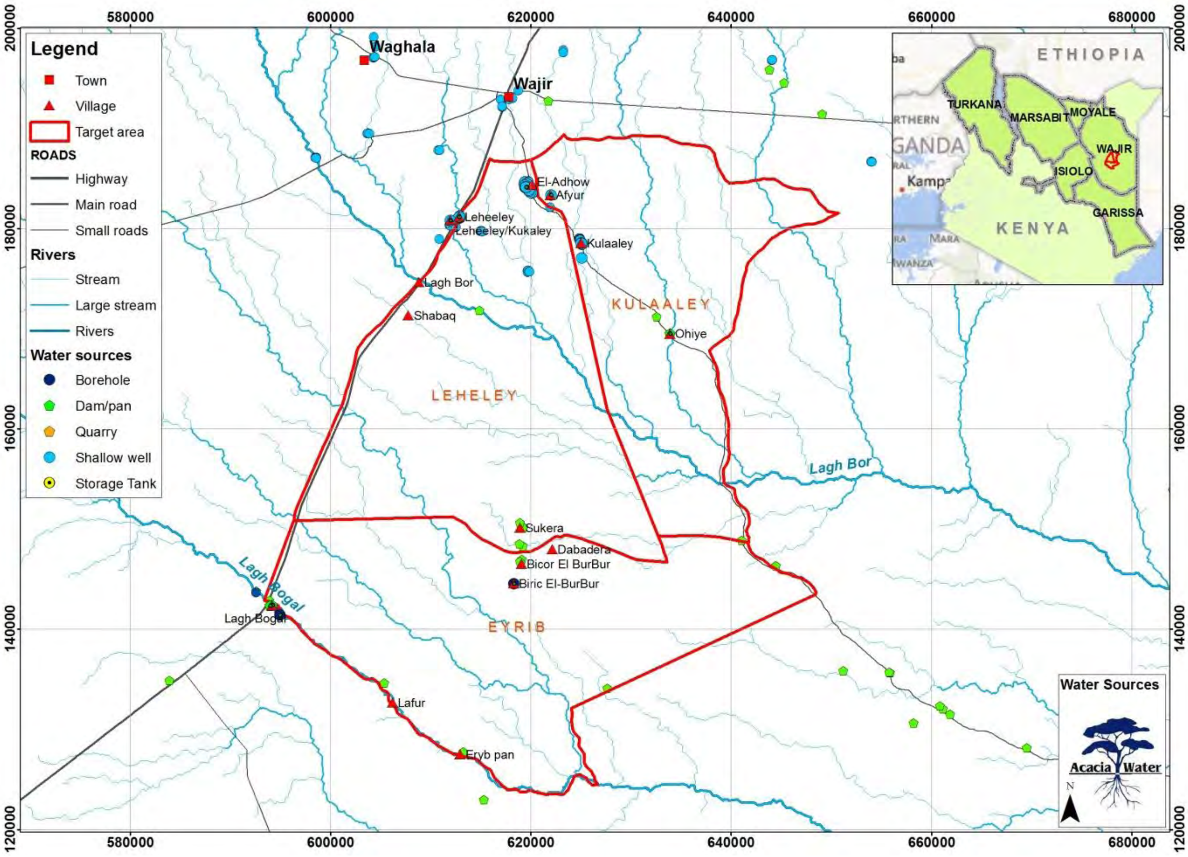


Figure 5-2: Existing water sources and rivers

Boreholes

In the study area only 6 boreholes were encountered and they are currently not working. Four boreholes are in Lafaley and one each in Lagh Bogal and Biric BurBur. They are not currently working due to technical problems and need to be rehabilitated. Borehole development is a major challenge considering that most of the boreholes which have been sunk in the area are either low yielding or are too saline to provide water for human consumption. It is therefore recommended that a comprehensive hydrogeological survey be carried out before a borehole is done to ensure viable production of quality water.

Shallow wells

In the area shallow wells are present at various locations in the north of the target area. Shallow wells are found in Leheeley/Kukaley, El-Adhow Village, and Kulaley Village. Also north of Wajir town, in Lafaley shallow wells are found. Most of the shallow wells are located along depressions.

Lafaley Site Shallow wells.Well preserved but not covered.

Leheeley/Kukaley

In Leheeley/Kukaley the site where shallow wells are found comprises a wide depression forming a natural pond where surface run-off collects during wet seasons and percolates into the ground. Wells are scattered all over the region at a radius of about 50-100m. The wells been dug in the area do not dry up and provide water the full year, while the natural pond dries up during the extended dry season.

The wells are observed to emanate from the calcareous aquifer. The area is overlain by sands, underlain by limestone formation which form a very good aquifer which does not dry up even during droughts. On the eastern side of Habaswein-Wajir road the water level is shallower compared to the adjacent side across the road. Generally, the water level is at ground level (artesian), with average water levels of the wells between 0 and 10m.

El-Adhow

In the village of El-Adhow shallow wells are also located near a depression. The depression has about 30 shallow wells. Additionally, 15 shallow wells are located in the village. The water quality of the well along the depression is better than in the village wells. Water in the shallow wells in the village is reportedly hard and saline and only used for livestock watering while the human consumption demand is met from the shallow wells along the depression. The wells located in the depression are fresh, with salinity increasing eastwards.

The site is situated in a depression dominated by carbonate rocks, the aquifer is weathered limestone. Some water flows into the depression during the rains, but the area also seems to have an underground aquifer which recharges the entire area. The wells are generally perennial and do not dry up even during extended drought though the water levels decline. Nonetheless, it is reported that water salinity is reduced during rainy season when the depression floods and gradually deteriorate as drought sets in.

Kulaley Village

Shallow wells form the main water sources in the village in the dry period. During rains the shallow wells are not used since the area is a lagga and water passes through it. The wells are seasonal and only have water during the wet season and 3-4 months afterwards. By August the wells dry up and people go to El-Adhow to collect water using donkeys.

The wells tap a confined to semi-confined aquifer which dry up during droughts. Total depth range is about 2-10m. The geology is basically carbonate rock types which contribute to the availability of water in the shallow aquifer in the general area. In Kulaaley the wells are aligned with the lagga (stream), the water presence can be attributed to the lagga which exposes the underlying water-bearing formation and on the other hand deposits water storage sediments, which is good for buffering the water back into the aquifer.

Lafaley

In the Lafaley village four shallow wells have been dug in the village. The general water level is at an average of 10m and high salinity is observed in the shallow wells. The existing shallow hand dug wells dry up during droughts. The wells were considered to have a low recharge rate and thus the yield cannot sustain the people during drought when demand is high.

Also the surface water sources (pans, seasonal run-off streams, ground tank, ponds and dams) dry up. The only source of water during extended drought is water trucking from Wajir.

Water pans and valley tanks

Several water pans were encountered out of which only a few were functional - Eryb and Lagh Bogal South. The rest of the pans are dry notably in Sukera, Dabader and Biric Bur Bur. Here first the well functioning pans are described, and then shortly the mal-functioning pans are noted. Details on the options to improve these pans are provide in chapter 7.

Eryb pan

Near the village Eryb (in the south of the target area) a dam is located along Lagh Bogal. It is the main source of water for the village and serves the 251 households in the village and the school (with 400 pupils) for domestic water and livestock consumption.

The water in the reservoir behind the dam lasts for about 90 days after the rains. Surface area is approximately 100*150*3m depth. After settlement started (1997), the dam was de-silted for use by the local population, the last rehabilitation was done in 2007. The water in the pan has a high turbidity. The dam is not fenced and camels/goats/sheep/cows access it.

Left:Eryb site,the only source of water is this pan.Right:Livestock and humans quee for water at the pan.

Figuur 5-1 Lagh Bogal pans at Elgal (source: Microsoft Virtual Earth) and Eryb (Source: Google Earth)

Lagh Bogal (Elgal) pan

In the same river as the Eryb pan, about 25 km upstream, a series of pans is found near the village Elgal. The dam is constructed by NGOs, and the upstream dam was dug by WASDA. An O&M team of 2 operators: Mr Dakane Sankas Mohamed and Abdi Wahab Sheikh Abdullahi has been selected from the community. They are paid from payments done by water users.

The peak flow of the river is about 1 month during rains. The water trapped in the pans does not last the full dry season, the pans dry up after the rains. After water dries up in the dam, water is tracked from Wajir.

Further along the river, good possibilities for more pans are found as the soil has a low permeability, for example near the village Lafur.

Pans with more potential

Ohiye

The area is very dry with no human settlement. A large newly constructed dam is the most conspicuous feature in the area, the dimensions of the reservoir are 100x100x2m. This reservoir is dry most of the year. It has no lining on the reservoir area, dark sandy clay soils exist on the surface. High seepage losses and high evapotranspiration losses are therefore expected. Additionally, the silt trap appeared to be not working properly due to siltation. A very high siltation from the dam/reservoir embankment was confirmed from the gullies.

Natural pans

Various natural depressions are found in the area, which serve as pans for a short period of several weeks after the raining period. They are not fully developed, and their potential could be further used (see chapter 7). Examples of such natural pans are found at Shabaq, Dabader, Sukera, and Bicor El BurBur.

Rain water harvesting tanks

Rain water harvesting tanks are present in the area, for example at schools where roofs with iron sheets are present. At the primary school in El-Adhow one tank is found, it was noted that this tank cannot store all the water. At the Lafaley Primary School two 10m^3 rainwater harvesting tank are found, and a 40 m^3

closed masonry tank. At Elado Primary School a $10m^3$ tank is found and guttering over a surface area of about 1000 m^2 is available, while guttering is not done on $600m^2$ of roofing surface area.

In Leheeley Hospital and in Kulaaley near the hospital underground tanks exists. Also in Lafaley an underground tank has been set up near the wells for storage of water. A ground tank constructed downstream of the water pan near the existing well is used to harvest surface run-off. The tank has a radius of 1.5m, a depth of 3m, and thus an approximate storage of 21 m^3.

5.1 Management and governance of water resources and water services

Introduction and participation in the assessment

Assessment of the water demand and access for Wajir County was carried out in three sub-locations – Eyrib, Boji South and Sukela – which together make up Eyrib Location of Wajir South District. The methodology used in conducting the assessment consisted of Focused Group Discussions (FGDs) with the Chief of Eyrib Location, the project staff (CRS/Caritas),the Public Health Officer, County Wildlife Officer, the District and the Livestock Production Officer; Community Meetings with men and women in the three sub-locations and the stakeholder workshop. Participants at the workshop included project staff, relevant line ministry officials (Agriculture, Livestock, public health, Kenya Wildlife Service), the Chief of the three sub-locations, NGOs (Save the Children, Wajir South Development Agency (WASDA), the District Pastoralist Association (DPA), APHIA Plus Imarisha) as well as male and female representatives of the three sub-locations.

The assessment was conducted from 16th to 20th September 2013, with the stakeholder workshop on September 19th.

Balancing people, livelihood, environment and water

In Wajir South District, pastoralism is the economic and livelihood mainstay of the people and this applies to the three sub-locations of study. This is unlike Wajir North District where agriculture is practiced in Gurar (which borders Moyale), Bute, Korindale and Buna areas, alongside pastoralism.

Being the main economic and livelihood activity, life in Eyrib, Boji South and Sukela sub-locations revolves around livestock. All segments of the community, including women, girls, boys and men are engaged in one aspect or the other that has to do with livestock. Activities include milking, watering, herding and taking care of the general welfare of livestock, in addition to the household chores for women.

Because life revolves around livestock and human welfare, the people of Eyrib, Boji South and Sukela sub-locations have to maintain a fragile balance between different interests, which are mostly centred on water availability. People in general are well aware of the importance of maintaining the balance between the use of water resources for livelihood on one hand and preserving the environment that provides for these resources.

The pastoralist population in Wajir South and indeed the entire North Eastern region of Kenya is divided into two categories – the nomadic pastoralists (*Rer Badia*) and the settled/sedentary pastoralists. Each household has two to three members who are *Rer Badia* – usually the elder wife of the household head and one to two youth who are enthusiastic about caring for livestock. The rest of the household members would be permanently settled in the village or living/working in towns such as Wajir. In some cases, a household may hire youth from poorer households to take care of their livestock in the *badia* (bush). The *Rer Badia* and the sedentary pastoralists rely on each other for food. For example, the *Rer Badia* usually accesses their food supplies such us flour, cooking oil and other condiments from their household members in the village while those in the village rely on the *Rer Badia* for milk and meat.

The *Rer Badia* pastoralist population moves with their herds of camels, cattle and shoats (sheep and goats) around in the area, using wet season grazing areas nearer to the villages during the rainy season and the dry season grazing lands located mostly in the areas nearer to the Leheley open wells during the dry season. As in many other areas, the burden of water fetching for domestic use and for watering young livestock is the responsibility of women, who have to walk (1) to get water for the household and (2) to move around goats and sheep (and cattle if no men in the household) to the different water and pasture points according to availability of water in the different seasons.

To be able to use the wet season grazing lands near the villages or the dry season grazing lands nearer to the Leheley open wells, there must also be a water source that can provide for drinking water for both the people and the herds. If not enough water is available at the grazing land, the grazing land cannot be used optimally and when there is abundant water available it may attract too many herds and overgrazing takes place. Water demand and water availability are two dynamic variables which interact with each other.

This delicate balance can easily be disturbed and lead to tensions between the different communities over the use of water and/or grazing lands. This means also that for the planning of the water sources, a careful assessment and consultation needs to take place. In accordance with the Do No Harm principles, assistance brought in conflict-prone areas shall not worsen conflict among groups which the project is helping. This call for conducting an in-depth analysis of the way water points are managed, and goes beyond the rules set by the authorities, to how they are managed traditionally.

Participants met in Eyrib, Boji South and Sukela sub-locations indicated that conflicts do occur at the dry season livestock watering points – be it the borehole in the neighbouring villages– Sukin which is located about 40 kms away from Eyrib sub-location – or the open shallow wells in Leheley (which is the district headquarters of Wajir South District). The borehole water at Surkin, which is used only by livestock because of high salinity levels, is paid for according to the type of livestock. On the other hand, water at the Leheley shallow wells is free. Nevertheless, at both the borehole and the shallow wells, conflicts arise when some pastoralists refuse to follow the set rules in order to gain undue advantage over others for their livestock.

At Eyrib sub-location, water from the Eyrib earth pan is used for both domestic and livestock watering during the wet season and between two to three months after the end of rains. The Chief of the location and the water committee are making attempts to preserve the water for only domestic use to enable it last longer (up to 3 months after the end of the rain) but this is not easy to enforce since the it is an open pan with no fencing around it. The study team witnessed cattle going right into the pan even as men, women and young men were busy fetching water for watering shoats and camels in makeshift watering troughs.

The massive influx of camels, cattle and shoats in the dry season for the North Eastern region represents a significant source of income for the borehole water point managers while at the same time being a source of management headache as some people ignore the set rules for water management, resulting in conflict. While the massive influx of livestock at the Leheley open wells is not a monetary issue, it nevertheless marks a busy time for the respective clan *Gudis* as members disregard set rules for livestock watering.

Water Service Provision

The delivery of water services in the three sub-locations is a local affair. The only real water source is the Eyrib earth pan which in a good rainy season can hold water for up to three months from the end of the rains, if the chief and the Gudi enforce the rule of preserving it only for domestic use. At Sukela and Boji South sub-locations, rain water is collected free of charge from natural depressions/ponds and road side drainage, and is used for both domestic and livestock watering purposes. In these sub-locations, rainy season water ends with the end of rains. In all three sub-locations, water trucking is the dry season mode of water provision. Mostly it is a local affair with private individuals (there were five in Sukela), groups of individuals (as was the case in Sukela) or community initiative in which money from the sale if water during the rainy season is used for water trucking (as was the case in Eyrib), acting as water service providers through trucking services. In extreme drought situations however, the government and nongovernmental actors step in to support the water trucking service.

Traditional water governance: Traditionally, there were no formal/legal institutions responsible for water use. Use of water and pasture in the dry season grazing areas was controlled by the traditional conflict resolution system known as the Gudi (Council of Elders). Each clan and its sub-clans had a Gudi that resolved intra clan/sub-clan conflicts. For inter-clan conflicts, the respective Gudid met and negotiated a resolution that was agreeable to both parties. In the case of access to water and pasture, the Gudi from the clan that claimed traditional ownership of the area in which the earth pan or pasture was located controlled the access. E.g. other clans coming to graze and water their livestock had to seek permission from the respective Gudi to be allowed access to the grazing area and to the water source. Nomadic pastoralism was practiced and once earth pans and natural ponds dried up, people moved away. The Gudi guided users and arbitrated any conflicts that arose over water or pasture. The dry season grazing areas around the present day Boji and Sukela sub-locations were zoned by the respective Gudis agreeing among themselves according to the sub-clans that brought their livestock to these areas for purposes of watering at the Leheley open wells.

For sustainability, there was no monetary payment for accessing water from the earth pans, shallow wells or scoop wells or ponds. However, the Gudi would ask livestock owners to disilt sections of the earth pan from which water had receded while in other cases, the Gudi would mobilize young men to undertake the disilting exercise. In this way, by the time the entire earth pan dried up, it would have been fully disilted in readiness for the subsequent rainy season.

At the Leheley dry season water area, the open wells are either individually owned or owned by a group of individuals from the same family or sub-clan. Access to water is family and sub-clan based. The nomadic pastoralists who come to the wells with their livestock during dry the season seek permission from their extended families or sub-clans for use of their wells, and access is always granted. Nevertheless, because of the large numbers of livestock from respective family/sub-clan members that flock the Leheley wells, the respective Gudi may prepare a timetable for livestock watering. For example, one may be required to water his livestock after every two days or on alternative days to allow all family/sub-clan members have access to the wells. This arrangement sometimes results in conflict as some individual seek to force their way into the well for the sake of the weaker species of livestock such as cattle and sheep which cannot go for long without water. Such conflicts are resolved by the Gudi.

Introduction of formal and structured management of water provision and access: Prior to the introduction of the SAPs in 1992, there was increased government intervention in the construction of boreholes, provision of diesel for running the boreholes as well as technicians and spare parts for the operation and maintenance of boreholes. In 1992, the World Bank led Structural Adjustment Programmes (SAPs) introduced issues of cost sharing and community management of community-level projects such as boreholes in the ASAL and other areas of Kenya. With SAPs came the establishment of community water/project management committees and the district level Pastoral Associations (PAs) to be in charge of operation and maintenance of water projects, especially boreholes, and range management respectively.

On their part, users at the project/borehole level were required to organize themselves into Water Users Associations (WUAs). Control and decision-making on water access at the boreholes became the responsibility of the water committees while O&M became the responsibility of the PAs in terms of provision of spare parts. Users were required to pay for access to water which for pastoralists was a tall order as payment was established according to the types of livestock – camels, cattle, donkeys and ruminants (goats/sheep). This was a difficult time for pastoralists in the ASAL areas as people were not used to this type of formal management of water (or grazing) which are the main preoccupations for pastoralists. With the coming of SAPs and the requirement to establish management committees, the sub-clan or community level Gudis in most cases transformed themselves into the required committee while also undertaking their traditional Gudi responsibilities.

The coming of SAPs also saw an upsurge of non-governmental actors in the ASAL areas and most of them stepped in to also provide water – both boreholes and earth pans, and generally intervened in repairs of boreholes, provision of spare parts to the district level PAs and training of water (usually boreholes) management committees. This was also the stage that saw the introduction of water trucking services which were initially provided by government but later became the responsibility of the communities.

The Water Act, 2002: Formalization of the SAPs initiated water governance system in Kenya:In 2002, a new water governing law was enacted – the Water Act, 2002 – both to rationalize the water service provision and water resources management in the country, and to entrench community participation in water management into the law. The institutions that were created by the Water Act, 2002, include the various water service boards (WSBs) operating at regional level, the Water Resources Management Authority (WRMA) with regional offices, Water Service Providers (WSPs), the Water Users Associations and the Water Service Trust Fund (WSTF). Thus, in Kenya today, according to the Water Act of 2002, water service provision is the mandate of Water Services Boards (WSBs) which are mandated by the Act to undertake water service provision through Water Service Providers (WSPs) which act as agents of the Boards. The WSPs should work in tandem with the Water Users Associations (WUAs) which should be the primary organization and mouth piece of the water users.

The WSB responsible for water services in Wajir and other northern Kenya counties is the Northern Water Service Boar (NWSB). In addition, the Water Services Trust Fund (WSTF) was created by the Act to finance pro-poor investments through the WSBs. The NWSB is in principle the agency that enters in a license agreement with the different WSPs via Water Service Provision Agreements. The communities can access funding via the WSTF by registering as a Community Based Organisation to form a Water User Association (WUA). All water users from a given area become de facto members, and together they establish the WSP that will be responsible for the actual water services. The WSBs contract Support Organisations (SO) that to support the WUA in the whole process of developing the water service and build the capacity of the WUA/WSP.

The Water Act, 2002, also created the Water Resources Management Authority (WRMA) with the mandate to manage and protect Kenya's water resources. The Catchment Area Advisory Committees (CAACs) support the WRMAs at the regional level and on paper Water Resource Users Associations (WRUAs) are established as a medium for cooperative management of water resources and conflict resolution at sub-catchment level.

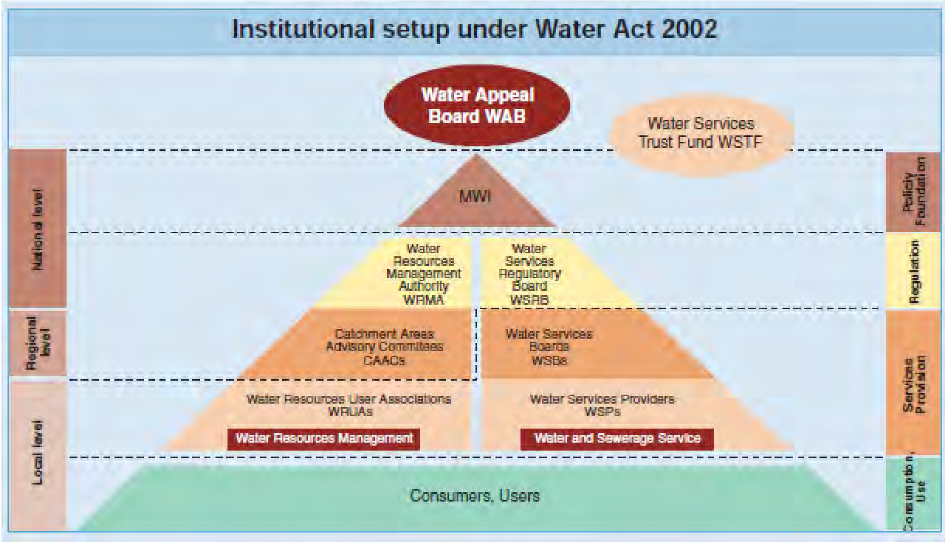


Figure 5-3: Institutional setup water sector Kenya (Source: Kisima, May 2008)

While the WSPs and WUAs are known and fairly active in areas of Wajir where there are boreholes constructed by the government or nongovernmental actors, they are virtually absent in Eyrib location (Eyrib, Sukela and Boji sub-locations) where the Eyrib earth pan is the only formal source of water.

Water governance today in the three sub-locations: The WUA/PA/Water Committee management system is associated with boreholes. Attempts to introduce this system to earth pan management have remained lukewarm while the Gudi has remained the main decision making system for earth pans, open shallow wells, scoop wells or ponds. For example, at Eyrib, the community reported that there is a management committee (only one person was at the meeting) assisted by the Gudi and the Chief. This means that management of water is both traditional and administrative. The role of the Chief in the Eyrib earth pan management is to enforce a ban on watering livestock at the pan to enable it provide domestic water for as long as possible.

The wet season earth pan at Eyrib: Currently the earth pan water is paid for. E.g. for the Eyrib earth pan, payment is pegged at Kshs 10/= for a camel, 4/= for cows, 3/= for donkeys and 1/= for goats/sheep. On the other hand, the earth pan water for domestic use is pegged at a flat rate of Kshs 300/month per household regardless of volumes or quantities required by a household. While a member of the 'water committee" collects the fees, it is normally handed over either to the Chief or selected Gudi members who are able to negotiate for government trucks during the dry season.

Wet season water sources at Sukela and Boji sub-locations: During the rainy season, the Sukela and Boji communities collect water free of charge from the natural ponds, depressions and roadside.

Dry season water trucking at Sukela, Boji and Eyrib: At Sukela, there were up to five (5) 15,000 litre flexible water storage tanks that are privately owned (by individuals) while at Boji, there was a 45,000 litre underground community tank with corrugated iron sheet roof but the committee of 2 women and one man that runs it could only afford to truck 15,000 litres every three days, i.e. if the truck brings water on day one, the next delivery would be on day four. There was also privately trucked water but people preferred to use water from the community tank which is comparatively cheaper. Water trucking is a lucrative business for private truckers in all three sub-locations. The cost of trucked water in each of the three sub-locations is presented in the table below.

Cost of trucked water in the three sub-locations

Sub-location	Cost of water trucked through community initiative	Cost of privately trucked water
Eyrib	Kshs 15/20lts	Kshs 30/20lts
Sukela	N/A (no community initiated trucking service at time of study)	Kshs 30/20lts
Boji South	Kshs 20/20lts	Kshs 30/20lts

From the above water tariffs, it is clear that the cost of water is a burden on most households, especially the poor as most of the household income is spent on water – up to Kshs 4500/=+ (about $ 50+) every month. This is money that could be leveraged to initiate other income generating activities such food kiosks and restaurants, sale of clothes and other small scale enterprises. At Boji, the people lamented that most of the household income leaves the village as it is spent on water trucking from Wajir town.

Water Resource and Service Authorities and support to service provision

As mentioned above, according to the Water Act, 2002, water service provision should be through the WSPs, licensed by the WSBs. In this structure there is no formal role anymore for the District Water Offices (DWOs), but they still exist directly under the Ministry of Water, Environment and Natural Resources (MEWNR) with their own budgets independent from the WSBs (for both new investments and operational costs). In addition to the DWOs, there are now County Water Officers (CWOs) responsible for the coordination of water activities at the county level (a county is composed of a number of districts) but with no clear relations to the water governance institutions established by the Water Act, 2002. The CWO/DWO and NWSB work in parallel and in fact there is no support from the NWSB to the CWO/DWO, or coordination in regards to money allocated for which projects.

Local coordination

In Wajir County, Water Environment and Sanitation Coordination (WESCOrd) is the body responsible for coordinating WASH activities including zoning of areas operation among the different actors in the sector.

On the ground, the main actors in the WASH sectors and strongest supporter to community water service are the CWO/DWO and the NGOs. Neither WRMA nor the WSB structures are on the ground in Wajir, especially, Eyrib, Sukela and Boji sub-locations.

The limited capacity and confusing roles of the water service and water resource authorities results in ad hoc support to water users, leaving the task to CWO[8]/DWO and NGOs. As monitoring of both the services provided as of the performance of the WSPs or WMCs is lacking, there is no clear picture on the current performance status, but field observations indicate that management in general is poor. Although the WESCord acts as a local coordinator, its impact is yet to be felt in areas like Eyrib, Sukela and Boji sub-locations and apart from zoning areas of operation to the various actors, there is no planning based on a longer term vision that can guide development in general and of water sources in particular for the district or (sub) locations or sub-catchments.

[8]The County Water Officer is yet to stamp his authority in Wajir as the devolved government structures and their sources of funding are yet to become fully operational.

6 Expected demand and current access to water

6.1 Demand

The total demand for water in an area should be based on information on water use for all different uses, which for the rural ASAL areas include:

- water for domestic use
- water for institutional and small businesses *(The Chief of Eyrib believes that with adequate water availability, it would be possible to expand the primary school which is currently has only classes 1-3 and also construct a health facility. On their part, the communities in all three sub-locations indicated that if water is made available, water-related small scale trades would be initiated by some people)*
- water for livestock
- water for crop agriculture, in particular through small-scale irrigation
- water for seasonal population with their livestock
- water for wildlife

For determining the demand we looked both at entitlements (norms or guidelines used by the Government of Kenya (GoK) and the Implementing Partners (IPs – see annex 1) and at the ideal water demand from the perspective of the user.

Water demand and water availability are also dynamically related, as higher water availability in general will trigger higher use (including new uses) and higher demand. The reverse is also true: in areas where water is scarce, uses are more prioritised and demand focuses on primary needs first, which in general will provide a lower demand.

For all the tables presented below, the following assumptions have been made:

Assumption 1:	Population data used for calculations are taken from the **CENSUS 2009**	
Assumption 2:	Average number of people per household is	**6.0**
Assumption 3:	Annual population growth rate considered is	**3.2%**

Figure 6-1:Assumptions on population and growth rate

<u>Comment about the annual population growth rate:</u>

While the national growth rate is pegged at 2.7 by the 2009 census, the national average for the former North eastern Province including Wajir County is normally higher than the national average. According to CRS, he average for Wajir (and north-eastern region) is 3.2.

All figures presented here remain best estimates and should be treated as guidelines only.

6.1.1 Demand based on the general MUS ladder

The Multiple Use Services (MUS) ladder can be used as a proxy to determine MUS water demand, in cases where not sufficient information can be found locally and/or extracted from interviews and focus group discussions. It is a 4-stages ladder which gives a water demand range per level of service.

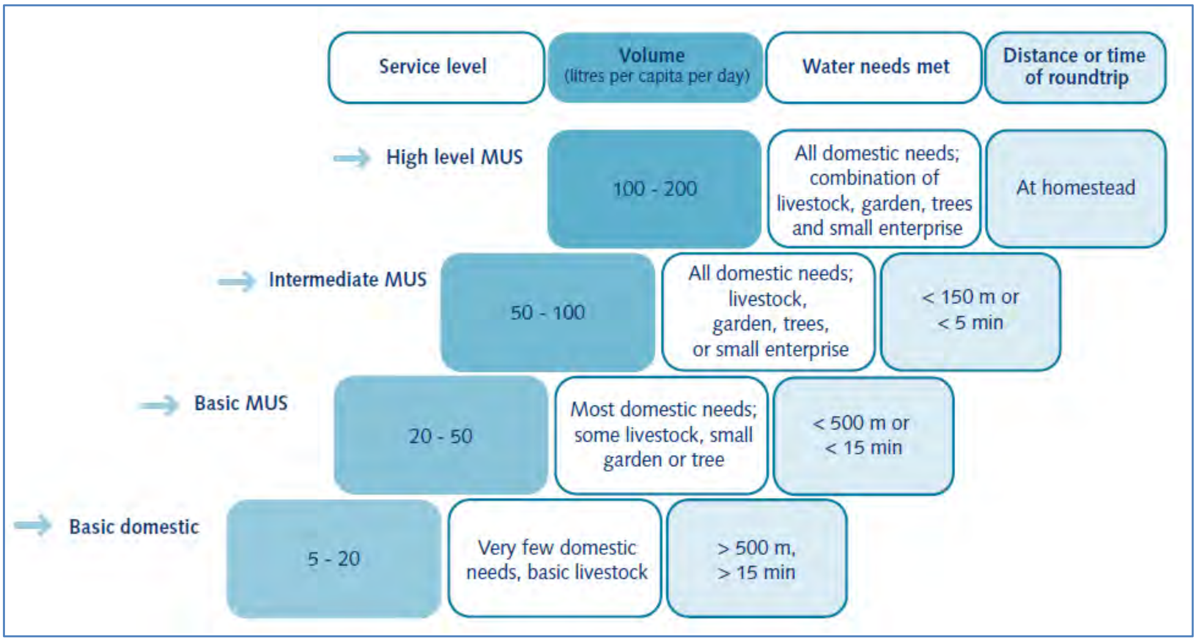


Figure 6-1: MUS ladder

The official norm for rural domestic drinking water infrastructure in Kenya is set at 20 l/h/d (litre per head per day). For all water uses in the ASAL areas, the aim is put between “basic MUS” and “intermediate MUS” service levels. Therefore, the MUS minimum water demand is set at 50 l/h/d and for the optimal (future) demand at 100 l/h/d which allows for some livestock and small agriculture activities. The high level MUS, set at 200l/h/d, aims at covering all water demand linked to all rural activities and is given for information purposes only.

In accordance with these assumptions, the MUS water demand using the MUS service ladder ranges between the following values:

Year	Population	HH	Water demand (L /h /day) Basic MUS 50		Intermediate MUS 100		High level MUS 200	
2013	3,219	537	160,954	L / d	321,908	L / d	643,815	L / d
			161	m^3/d	322	m^3/d	644	m^3/d
2023	4,411	735	220,545	L / d	441,091	L / d	882,182	L / d
			221	m^3/d	441	m^3/d	882	m^3/d
2033	6,044	1,007	302,200	L / d	604,401	L / d	1,208,802	L / d
			302	m^3/d	604	m^3/d	1,209	m^3/d

Basic MUS: Most domestic needs, some livestock, small garden or tree

Intermediate MUS: All domestic needs, livestock, garden, trees, small enterprise

High level MUS: All domestic needs, combination of livestock + garden + trees and small enterprises

Figure 6-2: Water demand projections based on values MUS ladder

6.1.2 Demand per type of use

While the MUS ladder gives an indication of water demand which encompasses all water use (domestic, livestock and agriculture), the following calculations will, on the other hand, detail the water demand per type of use, based on the data that have been collected during Focus Group Discussions in the communities.

Demand for domestic

The Government of Kenya norms have set the domestic entitlement to water at 20 l/h/d although 15 and 10 l/h/d are allowed in certain cases as design norm. The maximum distance is 1 km.

For the 3R/MUS pilot area (Eyrib, Boji South and Sukela sub-locations), the domestic water demand is calculated using 20 l/h/d.

Year	Population	Water demand (L /h/day) Basic domestic 20	
2013	3,219	64,382	L / d
		64	m^3/d
2023	4,411	88,218	L / d
		88	m^3/d
2033	6,044	120,880	L / d
		121	m^3/d

Figure 6-3: Water demand projections for domestic use

Demand for livestock

Different methods for calculating the livestock water demand can be used, depending on the data available:

- Methodology 1: data using FEWS.NET estimates, which gives an average number of livestock head per household
- Methodology 2: number of livestock from existing census
- Methodology 3: data providing from on-the-ground sources through focus group discussions conducted with the targeted communities or Key Informant Interviews

For Methodology 2, the following assumptions were made:

- The total number of livestock for the 3R/MUS pilot area comprises the livestock of Eyrb, sub-location, the livestock of Boji sub-location and the livestock of Sukela
- In all three sub-locations, the average figures given by the community are for each livestock category per household, and for the purpose of water demand calculation, livestock numbers for the majority of the population – about 75% - have been used (see the wealth ranking for indicative figures) for methodology 3.

Livestock water demand calculations by all 3 methodologies give discordant results:

- Methodology 2 gives un-realistic results; it was therefore assumed that census data provided were not reliable and results were not considered,
- Methodology 1 and 3 both give results which are within an acceptable range, but with water demand ranging from simple to double between methodology 3 and 1.

➔ As a result, and in order not to under-estimate the water demand, the methodology with the highest result was chosen, in this case Methodology 1, which uses the FEWS.NET estimates.

<u>Methodology 3:</u> Using FEWS.NET estimates

The following assumptions have been made for the calculations:

<u>Assumption 1:</u>

	FEWSNET estimate on livestock per HH	FAO LU
Cattle	10	0.5
Goats	40	0.1
Sheep	40	0.1
Camels	30	1.1
Donkey	2	0.6

<u>Assumption 2:</u>

Water Demand L / head (LU) / day
50

FEWSNET estimate: The average household keeps 10-30 goats, 10-20 camels, 5-10 sheep and 5-15 cattle

FAO LU: FAO Livestock Unit (Sub-Saharan Africa) - Not available for donkeys

Figure 6-4: Assumptions for livestock water demand calculations

* An additional comment regarding the average number of head per household:

Although the given FEWSNET data are lower, the actual averages given from the focus group discussions in Wajir were as presented in the table. It seems that FEWSNET averages may be too low for Wajir since pastoralism is the predominant occupation here.

As a result, for the 3R/MUS pilot area, the livestock water demand is estimated to:

	Number of livestock heads					Livestock Unit
Year	**Cattle**	**Goats**	**Sheep**	**Camels**	**Donkey**	**Livestock Unit**
2013	6,480	18,190	18,190	12,095	946	8,646
2023	8,879	24,925	24,925	16,573	1,296	11,847
2033	12,167	34,153	34,153	22,709	1,776	16,233

	Water demand (L or m^3/day)
	Livestock
Year	*Methodology 3: Field data*
2013	432,294 L / d 432 m^3/d
2023	592,347 L / d 592 m^3/d
2033	811,658 L / d 812 m^3/d

Figure 6-5: Water demand projections for livestock use

Demand for agriculture

At present agriculture is very limited and most of the food required for subsistence is 'imported' into Eyrib from Wajir town, into where it is in turn imported from neighbouring Meru and Mandera Counties. The little rain-fed farming (and kitchen gardening) that is practiced is negligible as most of the food crops grown, according to the Chief of Eyrib, are on 25m^2 each for water melon, tomatoes and cow pea; 0.5 acre (about 2,000 m^2) for millet/sorghum, and 0.25 acres (1,000m^2) for beans per household. The exception is with regard to maize which, according to the Chief is grown on a one acre piece of land (about 4,000m^2) by the few people who practice farming[9]. However, all communities have expressed their interest and willingness to get more engaged in agricultural activities if adequate irrigation water and infrastructure could be provided, and therefore the need for irrigation schemes. This is because, as they said during the FGDs, the changing weather and the recurrent drought conditions which happen in ever shorter intervals, demand that people begin to think seriously about diversifying livelihood bases. It is therefore assumed that up to 40% of the sedentary population would take to small scale farming if water (and related inputs and technical training) is made available.

[9] As farming is not a main preoccupation currently, it was not possible to get the precise number of 'the few' households that practice small-scale rain-fed farming on the 25m^2 of land during the rainy season.

As shown above, the main crops are beans, sorghum and maize, tomatoes and melon, but other fruit and vegetable consumed in the area include: banana, cabbage, citrus, onion, pepper, potatoes and tomatoes.

Irrigation water needs are calculated using the methodology detailed in **Annex 3**. For the assessment of the agricultural water demand in the 3R/MUS pilot area, the following assumptions have been made:

Assumption 1: Eto = 8.5 mm/day

Assumption 2:

Crop	Growing period (days)	Harvest 1	Harvest 2
Beans	110	August	
Cabbage			
Groundnut			
Maize	180	October	
Melon			
Millet	140	September	
Onion dry			
Sorghum			
Spinach			
Tomato			

Information are provided only for crops selected within the targeted area

Assumption 3: Rainfall station used: Wajir

Assumption 4:

Surface of land per HH (acre): 0.25
% of HH having a garden: 40%
% of the surface in drip irrigation: 90%

Assumption 5:

Crop	% of each crop in the garden	% of water saving with drip irrigation
Beans	15%	50%
Cabbage		
Groundnut		
Maize	55%	50%
Melon		
Millet	30%	50%
Onion dry		
Sorghum		
Spinach		
Tomato		

Some definitions

Eto: reference crop evapo-transpiration (in this case, grass is taken as reference crop)
Kc: crop factor; factor between the reference grass crop and the crop actually grown
ETCrop: crop water need; amount of water needed to meet the loss through evapo-transpiration
Growing period: period between sowing to the last day of the harvest

Figure 6-6: Water demand assumptions for agriculture use

Based on these assumptions, the water demand for agriculture is evaluated to be:

		Irrigation water need (m^3/month and average m^3/day)											
		Agriculture											
		January	February	March	April	May	June	July	August	September	October	November	December
2013	month	0	0	0	0	133	304	304	304	272	135	0	0
	day	0	0	0	0	4	10	10	10	9	5	0	0
2023	month	0	0	0	0	182	417	417	417	373	185	0	0
	day	0	0	0	0	6	14	14	14	12	6	0	0
2033	month	0	0	0	0	250	572	572	572	511	254	0	0
	day	0	0	0	0	8	19	19	19	17	8	0	0

Figure 6-7: Water demand projections for crop agriculture use

	Irrigation water need			
	Agriculture			
	Year		Average / day	
2013	1,454	m^3/year	4	m^3/day
2023	1,992	m^3/year	5	m^3/day
2033	2,730	m^3/year	7	m^3/day

Figure 6-8: Total water demand projections for crop agriculture use with small-scale irrigation

Demand for seasonal migration

During the community meeting in Eyrib, members of the community emphasized on the additional population and livestock flows which occur during the rainy seasons (April-June and Oct-Nov), and which significantly impact the water demand.

As for the target area, the following assumptions of seasonal additional population and livestock were made:

Assumption 1:

Number of livestock and people coming to the area at peak period:

Seasonal livestock	# heads	LU	Population
Cattle	15,000	25,900	1,000 people
Goats	30,000		
Sheep	20,000		
Camels	10,000		
Donkey	4,000		

Assumption 2:

Months for which seasonal population was considered:

Month	Migration	Month	Migration
January		July	X
February		August	
March		September	
April	X	October	X
May	X	November	X
June	X	December	X

Definition:

LU: Livestock Unit

Figure 6-9: Assumptions made for seasonal migration

Based on these assumptions, the calculated seasonal water demand is the following:

		Seasonal water demand (m³/month and average m³/day)											
		Migration of people and livestock											
		January	February	March	April	May	June	July	August	September	October	November	December
2013	month	0	0	0	38,870	38,870	38,870	19,435	0	0	38,870	38,870	3,887
	day	0	0	0	1,296	1,296	1,296	648	0	0	1,296	1,296	130
2023	month	0	0	0	53,261	53,261	53,261	26,631	0	0	53,261	53,261	5,326
	day	0	0	0	1,775	1,775	1,775	888	0	0	1,775	1,775	178
2033	month	0	0	0	72,981	72,981	72,981	36,490	0	0	72,981	72,981	7,298
	day	0	0	0	2,433	2,433	2,433	1,216	0	0	2,433	2,433	243

Figure 6-10: Water demand projections for seasonal migration use

	Seasonal water demand	
	Migration of people and livestock	
	Year	Average / day
2013	217,672 m³/year	605 m³/day
2023	298,263 m³/year	829 m³/day
2033	408,692 m³/year	1,135 m³/day

Figure 6-11: Total water demand projections for seasonal migration use

Demand for wildlife

During the MWA workshop of Nairobi August 2013 it was agreed to add 50% of the seasonal water demand for use by livestock

Year	Water demand (L or m^3/day) Wildlife
2013	263,785 L / d 264 m^3/d
2023	361,450 L / d 361 m^3/d
2033	495,273 L / d 495 m^3/d

Figure 6-12: Total water demand projections for wildlife use

6.1.3 Total water demand of the target area

The total water demand for the whole area, calculated on the average amount per day (in m^3), is the following:

Year	Water demand: Basic domestic Based on 20 L/h/day	Livestock Based on FEWSNET estimates	Agriculture	Seasonal livestock + population	Wildlife	**Total**
2013	64 m^3 / d	528 m^3 / d	4 m^3 / d	605 m^3 / d	264 m^3 / d	**1,464 m^3 / d**
2023	88 m^3 / d	723 m^3 / d	5 m^3 / d	829 m^3 / d	361 m^3 / d	**2,007 m^3 / d**
2033	121 m^3 / d	991 m^3 / d	7 m^3 / d	1,135 m^3 / d	495 m^3 / d	**2,749 m^3 / d**

Figure 6-14: Total water demand projections based on multiple uses

All details on water demand calculation are obtained by using a Water Demand Excel sheet, specially developed for the KALDRR-WASH program. The figures of table 6-8 are higher than ‘high level MUS’, compared with the MUS ladder values of table 6-1. It should be noted that the total water demand for seasonal livestock and wildlife is higher than all other demands related to the population of the area.

6.2 Access

6.2.1 Availability of water points in the area

In the entire Eyrib location (Eyrib, Sukela and Boji sub-locations), there is only one earth pan at Eyrib village/sub-location. The community of Eyrib sub-location (350 HH) uses the water pan located about 10minutes' walk from the settlement which has the capacity to store water for upto 3 months from the end of rains if it is conserved for only domestic use, a regulation which the Chief of the area together with the settlement's *Gudi* try their best to enforce. Otherwise, the community is dependenton water trucking (water is stored in community-owned 10-15m^3 water tanks) in the dry season. There are three types of water trucking initiatives: (1) the first is community initiative in which, for example, the people of Eyrib sub-location through the Chief or *Gudi* members, requests the government to support them with a water truck. In such cases, the government provides a water truck while the community caters for fuel for the truck and Per Diem for the truck driver. (2) Private initiative by an individual or a group of individual community members. In such cases, the trucked water is for income generation for the individual or group of individual and users have to pay for it at the fees set by the water trucker, which is uniform in all 3 sub-locations at Kshs 300/20lts. (3) In extreme drought situations, government and NGOs come to the aid of the community by providing free trucking services to save lives.

In Sukela sub-location (50 HHs) and Boji sub-location (73 HHs), there is no water facility in the form of earth pan, shallow wells or scoop wells. Instead, people rely on water that collects in natural depressions/ponds or roadside drainage during the rainy season for both domestic and livestock use and from the Leheley wells during the dry season for livestock watering and from the Leheley open shallow wells located about 27 km away.

The well-being of the livestock comes as a priority in pastoralist communities including Wajir. However, sedenterization is take place at a fast rate and many settlements spring up by the year. For example, Eyrib villages is only 5 years old, Boji is 8 years while Sukela is 2 years. The people of Sukela and Boji are however afraid that their villages may not grow if the water problem persist.

As for settlement or moving around, the community meetings and focus group discussions confirmed that only some members of the household/family[10], those that are capable of taking good care of livestock, usually the first wife and 2 to three youth are given the task of taking care of the family's livestock in the *Badia*, while the rest of the family is settled. The *rer badia* (those who move around with livestock), rely on their sedentary family members for food ration floor and other grocery while their sedentary family members rely on them for milk and meat. The *rer badia* move around with their portable materials for constructing temporary huts and will settle down temporarily according to the availability of grazing land or reliable sources of water for their and camels, goats and cattle.

Wet season grazing lands are found closer to each ofthe three settlements and in areas located outside Eyrib Location (Eyrib Sukela and Boji sub-locations) such as Tesorey, Luqun Goroyo and Hara Adey. On the other hand, the dry season grazing areas are located in the Boji/Sukela area which lies between Eyrib sub-

[10] A family in the Somali context (Wajir is inhabited of almost 99% a Somali community) is composed of the male family head and his wife or wives and his children from each of his wives. It is common to find a man with up to 3 or more wives in conformity with Islam which allows a man to have up to 4 wives at any given time. The extended family includes close relatives such as brothers and uncles.

location and the Leheley open wells. Others are located outside the Eyrib location at Tesorey, Barakalja, Gore Haris and Lasore. (See the sketch map of Eyrib Location showing the three sub-locations, the dry and wet season grazing areas and water sources etc.)

6.2.2 Accessibility

Focus group discussion in Eyrib, Boji and Sukela sub-locations showed that the people usually use the same water sources for different purposes, basically domestic and livestock watering. To a small extent, the same water is used for tree planting. The little agriculture that is practised is 100% rain-fed and no attempt has been made to practice irrigated agriculture.

*Access for domestic and livestock watering during the wet season:*During the wet season, the people of Eyrib (and neighbouring satellite villages) use the earth pan water and water in the natural ponds and depressions for both domestic and livestock purposes. The use of earth pan water is regulated through payment of agreed tariffs (see 5.3 above for water tariffs). In the period immediately after the rains, the Chief and *Gudi* try to enforce a ban on livestock watering at the earth pan, but without a fence around it, this rule is a challenge to enforce. The study team witnessed a lot of activity around the pan, including watering of camels and donkeys (mostly used for transportation of water), ruminants and cows.

Access by livestock and nomadic pastoralists during the dry season: During the dry season, livestock can be watered at Machesa or Kusin boreholes (located about 40 km away from Eyrib village) for those who can afford the cost, or the Lehely open wells, located about 43 km away from Eyrib, but closer to Sukela and Boji settlements (about 27 km). The people of Boji and Sukela also have the opportunity to access dry season water at the Lag Boghal borehole, but this is currently non functional due to both mechanical and management problems. However, the common practice is for the majority of people to take their livestock to the Leheley open wells where livestock watering is free of charge due to the extended family/clan system and available throughout the year.In addition, there is plenty of pasture as one heads towards the Leheley open wells in the Sukela/Boji area. All a pastoralist family/sub-clan does is to seek the permission from his kin/family/sub-clan who owns the wells, and the permission is always granted. Nevertheless, the pastoralists have to adhere to the rules set by the respective *Gudi* concerning livestock watering, e.g. a pastoralist may be required to access water every two or alternative days depending on the number of family/sub-clan livestock from various locations – not just Eyrib – that have turned up for watering at the wells. In such situations, livestock watering is first and foremost for the well owner or owners, followed by close blood relatives, the extended family and finally the sub-clan members.

Access for domestic purposes: These days, the sedentary women (those who live permanently in the respective villages) don't have to walk long distances to the traditional dry season water sources, thanks to water trucking which is specifically designated for domestic use and for watering young livestock. A few able villagers may even truck water for their shoats. However, for the *badia* women who in addition to taking care of their family's livestock herding and watering must also take home water for domestic use, the burden of water fetching continues and the walk home with water on donkeys or camel can be a whole day's affair depending on the distance of the temporary residence vis a vis the water source.

In Eyrib, water trucking for domestic purposes begins about 3 months after the end of the rains, while in Boji and Sukela, water trucking for domestic purposes beginsas soon as the rains stop. Trucking is either done through community initiative as was the case in Eyrib and Boji or through private trucking services as was the case in Sukela. In Eyrib, money obtained from the sale of earth pan water is used to truck water during the dry season while at Boji, a three person committee is tasked with trucking water for community use. The water is sold to the people and the money ploughed back into water trucking. In addition, there are private water truckers at both Boji and Eyrib but people prefer to use the community initiative water trucking as it is comparatively cheaper. (See water tariffs in section 5.3 above).Due to long queues at the selling point, some people may wish to defy the set rules for queuing, often resulting in conflicts over water, which call for the intervention of either the Chief or the *Gudi.*

In Sukela, there were five private water truckers with each having a collapsible 15m^3 water tank, making a total of 75m^3 of water available to the people at any given time. For this reason, the people of Sukela indicated that water availability for domestic use is not the problem provided one has the required money – Kshs 30/20lts - to buy it. Those who could afford said they accessed as much as 100lts+/day for both domestic use and watering of young livestock. At Sukela, there was no water rationing. A household could get as much water as they can afford due to the number of private water truckers in the village.

In Boji on the other hand, there was a 45m^3 underground water container with corrugated iron roof from which water is drawn using a rope pulled container. It is managed on behalf of the community by a group composed of 2 women and one man and sold to the people at Kshs 20/20lts. Here, water is rationed to enable each household get some water. E.g. a household with 5 people or more (3 children and parents) gets 60 litres of water/day while a household with 4 people and below gets 40 litres of water/day. This is because the management can only afford to truck 15m^3 every two days.

In all three communities, people who are unable to pay for water upon collection can do so, on credit, provided they make payment upon the next collection. The very poor people may be allowed free water for basic use – cooking and drinking - on alternative days.

Methodology of the seasonal calendar exercise is detailed in **Annex 4,** and the seasonal calendar for Eyrib (Eyrib, Sukela and Boji sub-lcations) is presented on the next page.

Calendar A: Seasonal activities (by men and women) and diseases

Activity/Season	*Jilal* (Dry and Sunny)			*Gu* (Long/main rains)			*Hagar* (Dry and windy)			*Der* (Short rains)		
	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Water Sources in Eyrib location (Eyrib, Sukela and Boji sub-locations)												
Earth pans constructed by government and managed by the *Gudi* and Chief; natural ponds and depressions; depressions on the roadside. Fetching time for domestic use is 5 to 20 minutes 2 waysas there are no queues												
Open wells for dry season domestic and livestock watering by the *badia* women and men: Fetching time for domestic use is between 8-12 hrs, 2 ways												
Water trucking (by private vendors and through community initiative) for domestic use and driving livestock for watering to the Leheley open wells 20 minutes to 1 hr+ for 2 ways once water is in the village due to long ques. This is true for Eyrib and Boji but not Sukela												
Activities undertaken by women												
Taking milk and firewood for sale to Wajir by women												
Bringing vegetable by women or sale in the village												
Selling of mats, clothes etc within the village by women												
Domestic chores												
Fencing of homestead by women												
Construction of huts by women												
Dipping of livestock (shoats) to prevent ticks and tsetse fly												
Milking of goats												
Fetching of grass for kids (baby goats)												
Kitchen gardening during rainy season												
Clearing shrubs around the homestead												
Performing traditional dances to thank God for rains												
Herding goats and kids												
Activities undertaken by men												
Organizing for water trucking by liaising with truck owners or government and non government actors												
Paying school fees												
Paying for food, water and other bills												
Preparation of farmland												
Planting and weeding (of maize, millet, cow pea, beans, tomatoes, water melon)												
Harvesting of crops												
Herding camels, cattle, shoats												
Duksi teaching												
Movement of livestock on foot from Wajir to Garissa (for sale)												
Formation of livestock buying and selling groups + buying and selling of livestock												
Construction of concrete houses												
Human diseases												
Malaria												
Pneumonia												
Dysentery												
Diarrhoea(mostly affecting under five children)												
Urinary tract infection (pain when urinating)												
Small pox												
typhoid												
Diarrhoea												
Trachoma												
Common cold												
Cough/TB												
Gastric and ulcers												
Livestock diseases/problems												
Tsetse flies												
Ticks affecting livestock												

Overcrowding/over population of livestock at the Leheley wells												
Time table for livestock watering due to huge numbers												
Weakness/death of livestock												

Calendar B: Seasonal problems and possible solutions

Problems	***Jilal*** **(Dry and Sunny)**			***Gu*** **(Long/main rains)**			***Hagar*** **(Dry and windy)**			***Der*** **(Short rains)**			**Possible solutions to the problems**
	Jan	**Feb**	**Mar**	**April**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	
Poor water quality													Provide safe water for human consumption Separate human water from livestock water
Water scarcity													Drilling of boreholes; disilting and constructing new earth pans
Vulnerability due to Food insecurity and Hunger: the most vulnerable include pregnant women, lactating mothers, under five year old children and the disabled													Government to give women and youth loans with which to initiate small scale enterprises and other income generating activities Government to provide farm inputs prior to onset of rain; Initiate irrigated farming by providing adequate water and irrigation infrastructure
Deforestation													Provide adequate water to facilitate reforestation activities
Poor road condition, leading to high food prices													Tarmac the Garissa-Wajir-Mandera road
Human Diseases: The most vulnerable include pregnant women,under five childrenand the elderly													Construct and equip health facilities/dispensary in the area
Weakness ad death of livestock													

Water dependent livelihood (income and non-income) activities that the people of Eyrib Location could undertake if they get adequate water

The people of Eyrib Location (Eyrib, Sukela and Boji South sub-locations) are concerned about the fact that a good portion of their household income leaves their respective villages and benefits people who are not their own – owners of water trucking lorries - with the result that their social and economic growth is stunted and are not able to expand. This money could be unleashed for livelihood expansion if the people get water. Some of the activities that they could undertake if they got adequate water include:

- Expanding the kitchen gardening into small scale farming so that the village can be self-sufficient especially in vegetables;
- Planting of trees;
- Expansion of the school. Currently, Eyrib has a school with only three classrooms which caters for a total of 221 pupils (143 boys and 78 girls) in standard 1-3. The challenge is how to retain and attract more girls to school since there is no water for ablution and there are only one toilet structure with two doors, one for girls and one for boys, denying the girls the privacy that they need to stay in school;
- Construction of a health facility as there is none in any of the three sub-locations;
- Take care of all domestic chores that are water dependent. Currently, some people are unable to pay the high cost of water, forcing them to take water on credit but at reduced volume, thus being unable to meet all domestic chores such as body washing and washing of clothes;
- Small scale enterprises such as tea kiosks and restaurants etc

Challenges to improving the water condition in the arid lands
• Climate change which has resulted in an ever increasing drought and longer drought cycles • The depth that one has to drill to get adequate water but which sometimes turns out to saline, as is the case in Kusin, a village that neighbours Eyrib • "Absence' of the formal/official water governance structures – the WSB, WSPs, WRMA and weak WUAs in the area • Weak water management committees and traditional governance system – the *Gudi* - which is no longer effective due to the influence of the formal administrative structures – the DC, DO and Chief.

Livelihood groups

Pastoralism is the principal livelihood base in the arid lands of Kenya, of which Wajir is a part, and almost 90% of the population is engaged in it in varying degrees. Livestock is therefore the key productive social asset and source of livelihood. For the drought prone arid lands areas, the drought resilient livestock include camel, goats and donkey in descending order. Cattle and sheep (the weaker animals) are to be found in areas where it is comparatively easy to access water frequently as they need water almost on a daily basis and certainly cannot go without water for more than two days.

In Eyrib Location (Eyrib, Sukela and Boji sub-locations), two kinds of livelihood groups are found: (1) the sedentary households which are permanently settled in the respective villages and who, in addition to pastoralism, are also engaged in petty trades such as selling of vegetables, milk and clothes (by women); tea kiosks and village level restaurants (mostly by men, but also some women) and livestock trade by men. The little kitchen gardening/maize farming that is done during the wet season by some families is hardly counted in Eyrib. (2) The nomadic pastoralists who are members of the households in the settlement but who are only engaged in livestock herding and careon behalf of the household or relatives in bigger tows such as Wajir or Nairobi. There are hardly people in the settlements who do not have livestock in the *badia*, except very poor households.

<u>Wealth Ranking measured in terms of livestock: Indicative Household Wealth Levels in Eyrib Location</u>

The Rich (10%)	•In all three sub-locations, these households make about 10% of the village population •Each HH in this category has: 40+ camels; 20+ cattle; 150+ shoats; and, up to 4 donkeys
The Middle (75%)	•Households in this category make up the majority of the population in the village at 75% •Each HH in this category has: upto 30 camels; upto 10 cattle; upto 80 shoats; and, upto 2 donkeys
The Poor (10%	•Households in this category, like the rich, make up about 10% of the population of the village •Each HH in this category has: 1+ camel; 1-3 cattle; upto 30 shoats; and usually no donkey
The poorest of the poor	•These make upto 5% of the village population. They consist of the aged, orphans and the serverly disabled. They have no livestock or means of livelihood but are taken care of by the traditional system of dependence on relatives and the Islam zaqat system of alms giving

6.2.3 Quantity

There is little knowledge on the effective quantity of water used per household in Eyrib location, but (1) the quantity of trucked water in the dry season, and (2) price, are the factors that influence the quantity of water that is available to the household for domestic use and young animal watering. In Eyrib sub-location for example people from the settlement and the satellite settlements collect water from the earth pan which is about 5 minutes from the Eyrib settlement with donkeys or camels (burden animals). The average number of donkeys for the majority of households is two while the poor people without donkeys borrow donkeys from their neighbours for purposes of fetching water. A donkey or camel in most cases carries four 20lt jerricans, which translates to about 80 litres. If it is assumed that most households would use their two donkeys for fetching water (the wealthier members of the village have four donkeys), then that would translate to 160 litres per household. This assumption is also based on the fact that at Eyrib, each household is required to pay a flat rate of Kshs 300/month in order to access water at the Eyrib pan in the wet season. As this quantity is fetched on a daily basis during the wet season because the water is also used for watering the young kids, lambs and calves, and since according to the people of Eyrib one donkey (80 litres) would be for the young livestock, this would translate to about 13lts/h/day.

The volume of water available to the household changes significantly during the dry season when water trucking is the only source of water for domestic use. While the people of Sukela can have as much water as a household can afford – at the cost of Kshs 30/20lts because of the many private water truckers - in Eyrib and Boji, water is rationed. It is sold at Kshs 15/20lts in Eyrib while in Boji, it is sold at Kshs 20/20lts from the community initiative[11] tank every three days and Kshs 30/20lts for the privately trucked water. In Boji and Eyrib, the quantity of water a household can access per day is limited due to the limited quantity of water that it trucked while in all sub-locations the quantity of water that a household can access per day is further limited due to the price that is pegged to the 20lts jerrican. At Boji for example, the people said that a five persons (+) household is allowed 60lts/day while a four person (-) household is allowed 40lts/day. Assuming that 20 litres would be for young livestock (which is priority in terms of water need), the quantity of water per person per day would translate to 8lts/h/day for a five persons household and 5lts/h/day for a four persons household.

Summary of estimated water consumption by sub-location

Sub-location	Estimated average consumption per head by season		Assumptions made
	Wet season	Dry season	
Eyrib	80 lts/HH =13 lts/h	80 lts/HH = 10lts/h	1. During the wet season, water is available within easy reach at the earth pan. This amount excludes the 80 lts for watering young livestock 2. This is the average for most HHs during the dry season as the trucked water is rationed while poorer HHs may afford only 20 lts due to high 3. Out of the 80 lts, at least 20 lts would be for watering young livestock, leaving 60lts for an average of 6 people per household
Sukela	80 lts/HH =13 lts/h	80 lts/HH = 10 lts/h	1. During the wet season, water is available within easy reach in the natural ponds and depressions. This amount excludes water for young livestock 2. While there are many (5) private water truckers during the dry season, it is assumed that most HHs can only afford 80 lts out of which 20lts is assumed to be for young livestock, leaving 60lts for a 6 person HH
Boji South	80 lts/HH =13 lts/h	60 lts/HH = 6.7 lts/h	3. During the wet season, water is available within easy reach in the natural ponds and depressions. This amount excludes water for young livestock 4. During the dry season, water is rationed. Of the 60lts available to the HH, 20 is assumed to be for young livestock leaving 40lts for a 6 person HH

Although the water pan at Eyrib in principle was designed for bridging the dry periods, in practise the water pan at Eyrib lasts only for 2-3 months after the end of the rains. Of course this varies with the amount of rainfall, but depends strongly on whether the Chief and the *Gudi* succeed in enforcing the ban

[11]The underground tank was constructed with Constituency development Fund (CDF)

on livestock watering so that the pan is used for domestic only. While the management of the use of the water pan plays a crucial role for the actual access to the water, the Chief and the people at the community meeting in Eyrib acknowledged that enforcing the requirement is a challenge since the pan is not fenced off and most times, the Chief is not in the village, as was the case during the field work for this report.

Water demand is a dynamic component, and water demand tends to increase with the amount of water made available. Although 20 L/h/day has been considered as an average for all calculations throughout the study, discussions with the population have shown that in times of high water scarcity, quantity of water for domestic use can drop to a level as low as 5-10 L/h/day. On the other hand, when sufficient water is made available, another set of activities develop. In the pilot area in particular, community members of Eyrib Location for example, have clearly mentioned that they are willing to initiate small scale irrigation if water and irrigation infrastructure become available, in addition to other income and non-income activities. For this reason, expected changes for future water demand encompasses two components: the growth of population, which comes with a growth of livestock, but also a development of activities which requires water. Another factor, more difficult to assess, is the increase of migrating population towards new water points. Exact figures of number of people moving around seasonally with their livestock to the water points is already difficult to assess currently, and only broad assumptions regarding how it might look like in the future have been made. However, in Wajir and the entire North-eastern region of Kenya, it is a well-known socio-economic and political fact that settlement and sedentarization is closely linked to water availability. If a politician wishes to create a new voting area, the first thing is to construct a water point in the specific area to attract people and then pressurise the government to declare the area as either a location or sub-location. It is also for this reason for example, that the names of Eyrib, Sukela and Boji South are not found in the 2009 national housing and population census' public document.

6.2.4 Quality

It is very common that people use the water from the water pans, natural ponds and roadside depressions for their domestic and livestock needs. Water treatment products such "Waterguard" was mentioned but there is little knowledge on whether people actually treat the water before drinking on a regular base or not, given that during the wet season (April-May and October-November) when any pool of water is used for domestic purposes, and during the dry season (Late December-March and July-Septemebr) when water trucking is the order of the day– with the water source not known - diarrheal and other water related diseases such as dysentery, diarrhoea and typhoid are common (see the seasonal calendar). The situation is made worse by the fact that in all three sub-locations, there is no health facility. It will be interesting to further investigate household habits towards the storage and treatment of drinking water.

6.2.5 Reliability

Reliability of the earth pan at Eyrib as a water source is erratic as it depends on the amount of rainfall in a season.The pan only holds water for 2-3 months after the rains and depends heavily on the quantity of precipitation of the season. In addition, the pan and its catchment surfaces suffer from siltation as the traditional desilting methods are no longer effective. People prefer to wait for government and nongovernmental actors to help with desilting. Also, the climate change phenomenon means that people are no longer able to predict the exact time when the rainy season will start or end. While in the seasonal calendar above, *Gu* (the main rainy season) is shown to be between April and June, the fact is that the drought cycle is become shorter and shorter by the year, and the start of rains cannot be predicted with precision any more due to the influence of climate change, which is made worse by the environmental degradation (deforestation) of the fragile ecosystem.

7 3R potential in the area

At locations with water shortage the implementation of 3R interventions can help to resolve the shortage by increasing the amount of water that is available in the dry period. For this several different techniques can be chosen (see 2.2.1). Which technique fits best depends on both the kinds of water demand, and on the physical possibilities for water recharge and retention within the physical landscape. This chapter focuses on the latter, describing the landscape characteristics of the target area in zones where different 3R techniques are most beneficial.

Based on the combination of various sources of information to characterize the area, and the evaluation in the field visits, we made a map which indicates the potential for the interventions in different zones (Figure 7-2). The lessons learned in different areas may be beneficial to export to other areas, of which examples are included in the 3R potential analysis. For each of the zones the characteristics and examples identified for the most promising interventions are described below.

7.1 Introduction in the 3R zones

The target area is divided in different zones, each of which has its own characteristics, and its own potential for the implementation of 3R interventions. A division is made based on the geological and morphological features that have an impact on the potential for recharge and retention. Important factors in this are:

(1) The distinction between mountainous and plane areas. In mountains on the one hand the run-off velocity is generally high, and deep gullies may be found. The erosion can be more severe in mountains than in plane areas, and may provides more sediment in the rivers. Further, the slopes of mountains may be used as natural edges for the creation of a water reservoir. In plane areas on the other hand, interventions that cover a larger area may be easier to realize. For example a dam in a gently descending river can create a long stretched reservoir, and floodwater spreading may be beneficial to increase the infiltration and the soil moisture over a larger area.

(2) The porosity or permeability of the subsoil. The porosity of the rocks or the vertical permeability of the soil determines how fast water infiltrates to deeper layers. When the porosity is low, the infiltration is limited, and the subsoil can serve as a good base for a reservoir to retain the water. Contrary, with a high porosity or permeability, water may be lost from a reservoir to deeper groundwater. When the purpose is to recharge the groundwater this may be desirable. When the purpose is to store water in the reservoir, a sealing may be required, which can consist of natural deposition or siltation, local available clay, or plastic or concrete.

(3) The weathering products and sediments. Locations with sandy sediments may provide the opportunity to create sanddams, and -when a sandy riverbed is already present- subsurface dams. When the sediment consists of clayish material, it can provide the opportunity to reduce the infiltration losses of reservoirs. It may also increase the soil moisture potential, e.g. when combined with floodwater spreading. Since the

sediment load is determined by the weathering products from the rocks and the soils, the 3R potential depends on whether the weathering products in the vicinity or upstream are suitable for storage (sandy products) or not (clayish products).

The zones are grouped in five categories, and several subcategories. The first category (zone 1) contains basement rocks, these rocks have generally a low porosity and weathering products suited for storage. The second category (zone 2) are the lowlands that receive the weathering products through the larger rivers from the basement rocks in zone 1, but do not consist of basement rock themselves. Zone 3 exists of the volcanic rocks, which have variable porosity and weathering products, therefore this category is subdivided in a number of subzones (zone 3A - F). Zone 4 covers the sedimentary formations which are generally plane. Finally zone 5 indicates the mountainous areas with steep slopes.

7.2 3R zones present in the target area

In the Wajir target region the following 3R potential zones are present:

- Zone 4A: Alluvium along rivers, variable permeability, potential for shallow groundwater
- Zone 4C: Variable sedimentary formations, variable permeability and storage potential
- Zone 4D: Recent limestones, high secondary porosity, shallow groundwater potential
- Zone 5A: Soils with slow surface drainage or stagnant properties

	A Pans and valleydams	B Sanddams	C Subsurface dams	D Shallow, freatic groundwater: wells and riverbank infiltration	E (Flood)water spreading and spate irrigation	F Gully plugging, checkdams, and other run-off reduction /infiltration options	H Closed tanks	G Deeper, confined aquifer groundwater: wells / boreholes
Zone 4A	x			**x**	**x**		x	x
Zone 4C	x		?	(x)	x	?	x	x
Zone 4D	x			**X**		?	x	x
Zone 5A	**x**					x		

Figure 7-1: Indication of the kind of 3R interventions that may be possible in the zones. This study focuses on the shallow (ground)water system, deep groundwater is outside the scope of the study and is only indicated as alternative possibility. The crosses denote the potential: x. possible; **x**. high potential; **X**. very high potential; (x). limited potential; ? unknown, and the superscripts denote: 1. possibly sealing required; 2. combined with 3B, 3D, 3F, 4C, 4D, if impermeable layer is present. Zone 5 should be combined with the layer below the hatch; the potential specifically indicated in zone 5 replaces the potential in the underlying zone.

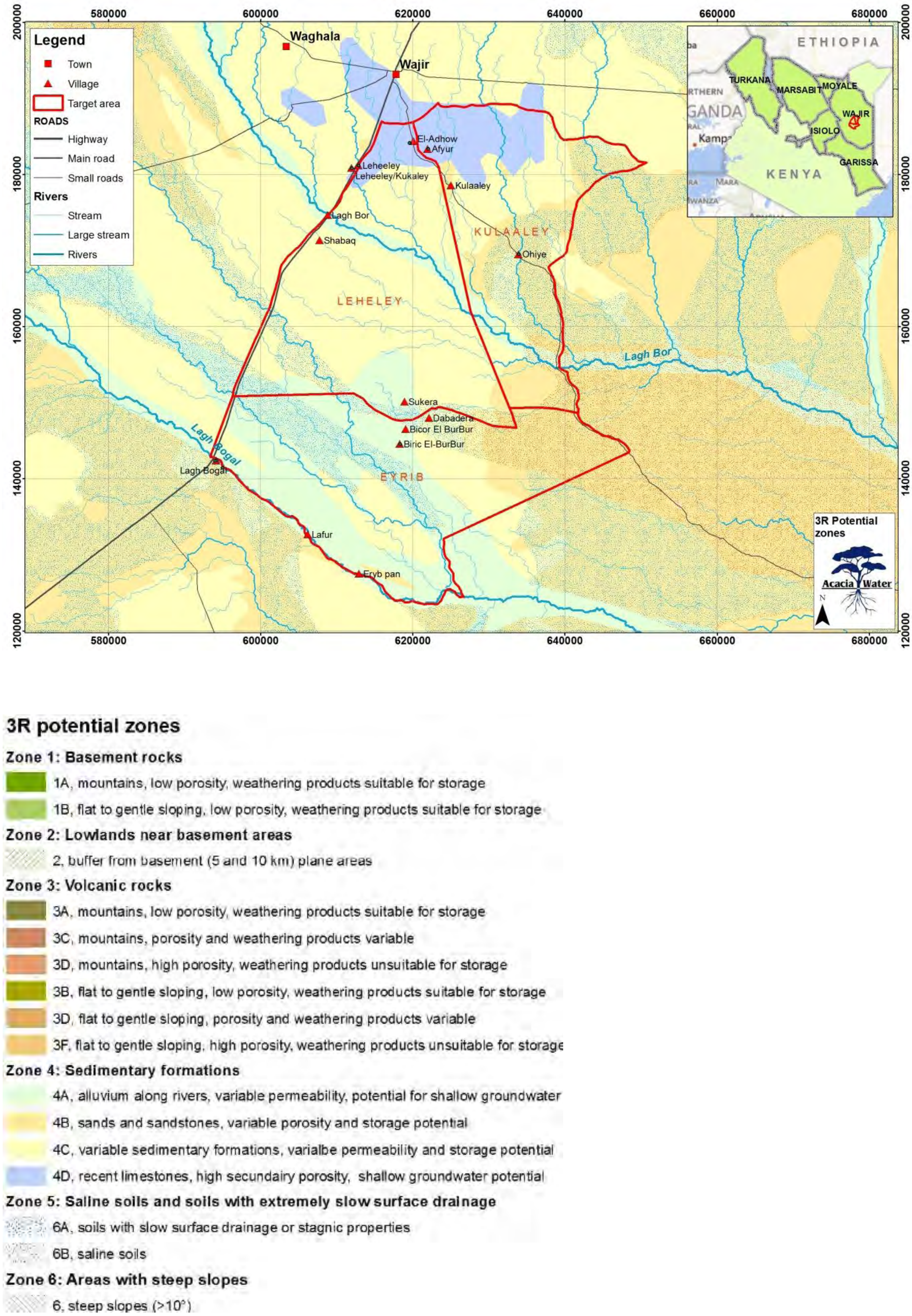


Figure 7-2:3R potential zones in the Moyale target area. The different colors denote the zones, the numbers the examples described in the text.

7.3 Zone 4A: Alluvium along rivers, variable permeability, potential for shallow groundwater

Appearance of the zone in the target area

In the target area some locations with unconsolidated, alluvial sediments along the river are found. Two of these, where each year substantial rivers flow, are further investigated. This first is situated along Lagh Bor, which is located approximately 20 km south of Wajir town and crosses the Wajir Habaswein road. The topography of the river is relatively flat. The area is a depression filled with alluvial deposits as a result of the river run-off water. Its noted that this deposition takes place during the floods. The riverbed is dominated by reddish brown soils overlying limestone, the soil composition varies between clay, fine to medium grained sand, clayey sands and sandy clays. Loam soil which have been cemented, compacted, and consolidated were observed in this zone.

The second visited appearance of this zone is situated along Lagh Bogal, located approximately 50-80 km south west of Wajir town. The riverbed is dominated by alluvial soils, consisting of grey to brown sands and clays. Alternating series of these contemporaneous sediments occur at shallow depths, with some members not exceeding 10 cm thickness. Below the sands compacted, clay -cemented sediments were observed at a location near Lafur, and hard compacted rock was observed at less than 2m depth at the site of the Eryb pan.

The vegetation is green along the Lagh Bor and includes acacia trees and grasses among other species, and dense luxuriant vegetation is found on the gently sloping river valleys of Lagh Bogal. For Lagh Bor an indication of the peak flow of 1.5m above ground level was given by the community.

Pans; Lagh Bor

The discharge of Lagh Bor is currently not used in any viable way. There is a good opportunity to develop pans at strategic sites along the rivers. For construction of pans and dams, proper lining should be carried out in the sites to ensure long sustainability of water in the pans. The observed local appearance of clayey soils and observed variation in the infiltration rate along the river, indicates that the infiltration can be limited by siting of pans at locations and in layers where the infiltration is relatively low. The river valleys are not well pronounced and the flowbed of the river appears not fully reliable. Therefore the pans can be located either in expected riverbed, or in the vicinity of it, and the water from a larger upstream area containing the possible streambeds should be channeled towards it (see checkdams below). Construction of silt traps, infiltration galleries and abstraction wells for the pans/earth dams are recommended (see annex 6).

Pans; Lagh Bogal

Along Lagh Bogal several sites for development of pans are determined, pans could be constructed upstream from Eryb before the Wajir –Habaswein road because the soils are fine clay to sandy and they have low permeability and thus can support pan development. Near Lafur a low permeability of less than 0.08 cm/hr indicate the presence of clay soils which are good for the development of pans and dams. At two locations at relative shallow depths compacted clays or rocks were found. These can be used as a foundation for the pans. For successful pans and dams, excavation of the top sand and successive compaction is recommended on sites for pans and dams development.

Pans; improvement of existing intervention

The existing dam near Eryb can be improved since it suffers currently from a number of problems. The reservoir behind the dam is recharged by Lagh Bogal, which brings into it a lot of suspended waste from the Lagha thus causing siltation of the reservoir. To reduce sedimentation of the reservoir a silt trap could be constructed upstream of the reservoir. Soil conservation structures in all zones upstream of the dam e.g. trenching channeling the water into the pan/dam should be considered. The floods were reported to break the dam wall. This risk may be reduced by installing a spillway. Additionally, compaction of the dam embankment to avoid undermining of the dam wall is recommended.

Infiltration of the water leading to drying up could be reduced by proper lining to sustain the water. The high evaporation rate could be reduced by covering the pan with dry vegetation or any other readily available material. The water quality could be improved by fencing of the pan to avoid water contamination by livestock. Additionally, abstraction wells for the pans/earth dams could be set up near the water reservoir and infiltration galleries could be considered.

Ground tanks

In alluvial soils, underground tanks or tanks could be constructed. These are recommended to be excavated into the soils to the depth of compact limestone base on which it can be constructed. The tanks should be roofed with either iron sheets or concrete slab.

Check dams

To store more water in the riverbed, and reduce the loss of the water in a short period of time when the peak flow occurs, dams could be applied in the rivers. However, it should be noted that the boundaries of the seasonal streams are not easily recognized, since the longitudinal and transverse gradient of the streams is so low such that the lateral width of the streams is not clear. It is therefore not easy to locate sites for check dams along the seasonal streams.

The channeling of water in locations upstream of the suggested pans or underground tanks could serve as a solution. The extent of the lagga should therefore be established. For example concrete walls could be built to concentrate the water towards one channel along which a pan or (underground)tank as described above can be set up.

Shallow groundwater storage

Currently no shallow well abstractions are found along the rivers Lagh Bor and Lagh Bogal. The area may nonetheless have potential for the use of shallow groundwater. Both the observed soil composition, with at some locations a relative shallow layer of compacted clay or rock, and the greener or more lush vegetation in the riverbed compared to the surrounding indicate that the riverbed may contain shallow groundwater. This could provide a new source of water in these areas.

Exploration drilling to determine the sub-surface geology and lithologic composition and the presence of shallow aquifers is therefore recommended. When shallow aquifers are indeed determined interventions to subtract the water, like wells, can be considered. These interventions can possibly be combined with measures that increase the recharge of the aquifer, like infiltration pans, i.e. pans without compacted lining or a check or subsurface dam. Currently the Eryb pan, which appeared to lose water to infiltration may already serve as such a groundwater recharge pan.

Floodwater spreading to enlarge green flood planes

The greener vegetation found along the seasonal rivers Lagh Bor and Lagh Bogal may be extended to a larger area by floodwater spreading. For this the peak flow should be diverted over a larger area, to allow the water also to infiltrate outside the current riverbed. Additionally, this may lead to improvement of the soil fertility by the sedimentation of the alluvial deposits. The current river bed is not very distinct, which indicates that spreading of the water can be done by installing relatively low features. However, when installing waterspreading dams care should be taken to prevent a change of the course of the river. Alternatively, irrigation flow paths to lead water outside the main bedding also be considered in this plane area.

7.4 Zone 4C Variable sedimentary formations, variable permeability and storage potential

Appearance of the zone in the target area

Variable sedimentary formations (besides alluvium, sandstone and recent limestones) are found in various parts of the area. This area is in the geological map characterized as colluvial deposits, pebble sheets, and red soils. In this zone Lafaley (approximately 6 km north of the town) and Shabaq (about 10km south of Wajir) are visited and investigated in more detail. The area near Lafaley was found to be dominated by reddish brown sandy soils overlying limestones. The sands are siliceous and loose, while the limestones are compact but with joints. At Shabaq medium to low grain sand to sandy clay silt is found.

Pans - Shabaq

It is noted that there is a natural pan about 3km from Lagh Bor just a few kilometers from the Wajir-Habaswein road, the Shabaq pan, which can be further developed and thus is a potential water storage site. The Shabaq pan is a natural depression with potential of being a good water source if well developed. De-silting and deepening to increase the capacity is necessary for it to be productive. Proper water channeling into the pan should be done to increase the capacity of the pan.

Permeability test indicate a value of 3.5 cm/h, an indication of sandy loam soils. This indicates that much water will be lost from the pan due to infiltration. Development of the pan requires therefore excavation and lining of the pan to ensure water sustainability in the pan. For this a sealing of plastic of concrete may be required.

Pans - Lafaley

Near Lafaley additional pans can be sited in the village and its vicinity. The infiltrometer tests indicated a value of 0.7 cm/h, which is relatively low. This can form a very good site for pans and dams so long as good excavation and lining are applied in any selected site. The compacted limestone layer was observed, but it appeared to contain joints. Excavating the pans to a base on the limestone could help to limit the infiltration loss. In that case it is recommended to fill the joints in the limestone at the base of the pan.

Construction of silt traps and infiltration galleries In the existing pans/dams, de-silting, trenching and proper channeling of water into the reservoir is recommended to sustain the storage. Seasonal streams or the road run-off water harvesting along the Wajir-Tarbaj road can be a source of water for the pans.

Ground tanks

In addition to the pans the construction of ground tanks along the seasonal streams and roads can be considered. Underground tanks could be constructed near the seasonal streams, to harvest the water from these streams. When the underground tanks are excavated into limestone outrocks this can provides a good basis, it should be cemented on the inside surface to provide a water proof wall. The tanks can be roofed with a iron sheets or concrete slab. Construction should be such that the ground tank is at least partly below the ground surface.

Rangeland improvement

Next to drinking water and water for the livestock, the grazing grounds are important in the area. It is noted that creating new water points in existing grazing areas may induce the risk of overgrazing around these points. Many of the grazing areas are suffering from overgrazing and related land degradation. The uncovered soil has a higher runoff coefficient and soils erode during the rains after the dry season. This causes a variety of problems, including loss of the (fertile) top-soil, flooding and related damage to infrastructure and reduction of soil moisture storage and groundwater recharge. In relation to water infrastructure, it contributes to siltation of open water reservoirs and damage to wells and pipeline during flooding. Land conservation, including erosion control, contour bunds, and rangeland management are recommended as an important aspect from the perspective of water resources and water infrastructure.

Shallow groundwater

At locations where shallow groundwater is present this may be used as a source of water. In Lafaley shallow wells were already found, but the quality was not good and the water in the wells did not last for the full dry season. Here shallow aquifer infiltration with water from ponds or seasonal streams can increase the availability of fresh water from the shallow aquifer in the dry period.

7.5 Zone 4D Recent limestones, high secondary porosity, shallow groundwater potential

Appearance of the zone in the target area

Below Wajir town and its surroundings a aquifer is found, which consists of limestones, underlain by a less permeable layer, which prevents the loss of the groundwater to greater depths. Near Wajir and to the south of it, the limestones are found close to the surface. Extended from this area, the limestone aquifer was still observed at slightly greater depths. The villages visited in this zone were: Leheeley, Leheely/Kukaley, El-Adow, and Kulaaley. In the latter the characteristics of zone 4D (recent limestones with shallow groundwater potential) were observed, even though it is according to the lithological map just outside the zone. The actual appearance of the zone thus seems to extended somewhat over the edges indicated in the map.

The more detailed investigated locations are approximately 8-16 km south of Wajir town. The area is dominated by reddish brown soils overlying limestones. Several depressions are found in the area which exist as sink holes resulting from karstic dissolution. The limestones in the depressions is highly decomposed forming clayey calcareous sandy soils.

Shallow groundwater; Well improvement

Zone 4D is dominated by shallow wells. Many of the shallow wells are not in a good condition and need to be improved to function to their full potential. The water for human and livestock consumption is not separated to an extent that water that remains in the livestock water points is getting stale thus being a source of pollution. The stagnant water near the shallow wells is a health hazard. The used water which accumulates in the area could be recharged into the ground instead of being allowed to evaporate and to go stale on site. Additionally, it is recommended that the water source improvement be carried out. Water points for both domestic and livestock consumption should be constructed away from the wells, and away from the depression that recharged the shallow wells. To improve the quality, animals should be controlled not to access existing water facilities (shallow wells and surface water) by fencing and construction of animal watering facilities (troughs and canals).

Shallow groundwater; Direct aquifer infiltration

The various shallow wells in this zone were observed to have various quality, and the extend of the water availability of the water in the wells also differed. In Leheeley / Kukaley the wells were reported to contain water the full year, with water levels at 0-10m below the surface. Also in El-Adhow the water was reported to be perennially available from the wells. However, here the salinity appeared to increase throughout the dry season and while the water level was reported to decline in the dry season. Slightly more to the south, in Kulaaley, the wells were reported to be seasonal and to only have water a few months after the wet season.

Depending on the location, the wells can thus be improved in terms of quality and/or quality. For both the application of measures that increase the recharge of the aquifer, like infiltration pans, i.e. pans without compacted lining or a check or subsurface dam, could be applied. This direct aquifer infiltration can increase the water level, and it can create a fresh groundwater bubble in a further saline aquifer, thus creating an (extended) fresh water source.

The direct aquifer recharge was observed to present in a natural manner in the area: the best quality shallow wells were found close to depressions (e.g. in Leheeley/Kukaley and El-Adhow) and along seasonal streams (e.g. Kulaley). Apparently fresh water infiltrates here into the shallow aquifer, naturally recharging the water that can be subtracted with shallow wells.

This natural recharge can be extended. For example near Leheeley the current depression can be increased to store more water which can infiltrate to recharge the shallow groundwater. Also, additional ponds can be constructed, so that recharge can take place at more locations.

Also in the area along Kulaley the soils are good for further development of direct aquifer infiltration, and shallow wells. Along the seasonal river where the shallow wells are concentrated the development of (subsurface) dams can be very promising considering that there is a concentration of sands along that seasonal river. The extent of the seasonal river should be established after which concrete walls should be built to concentrate water to one channel along which subsurface or normal dams can be set up. With the purpose of these dams to recharge the shallow aquifer, the bottom of the reservoir should allow infiltration, in contrast to the locations that are selected for pans and ground tanks.

Additionally, the groundwater storage can be increased by the use of infiltration wells, possibly including filters to improve the water quality before infiltration. When the fresh water is inserted at a deeper level than where it is subtracted, a larger amount of the infiltrated water can be retrieved, because the fresh water floats upon the more saline groundwater surrounding it.

Pans

In many parts of this zone there is no noted overland flow. Nonetheless, water which floods along the seasonal streams can be trapped and developed into a pan. The compact limestone rock that underlie the entire site can be a good foundation for a pan, where the sealing of cracks may be required.

A quarry was found just opposite El-Adhow, it is recommended to develop this quarry site as a water pan. The augured hole indicates a formation dominated by fine to medium -sized sands interbedded with clays. The latter clay layers may possibly form a proper pan foundation. A check on how long water is available in the current situation can provide more insight in whether a artificial sealing is required.

7.6 Zone 5A Soils with slow surface drainage or stagnic properties

Appearance of the zone in the target area

Spread over the target area are locations with soils with slow surface drainage or stagnic properties. Two of these appearances are visited and further investigated. The first is located approximately 40 km south of Wajir town. It is dominated by grey to reddish brown soils, clays and calcareous sands. In this zone the communities visited were Dabader, Bur Bur,Shabaq and Sukera. The second appearance of this zone visited was near Ohiye, at the eastern side of the target area.

The area around Dabadera is observed to be a flood zone, even though the flow accumulation analysis indicated just a limited accumulation of water in this area. This can be apparently be attributed to the fact that the water does not percolate quickly after the rains. Soil tests indicated low permeabilities and several natural pans have been noted in some natural depressions and the community depend on them soon after the rains for a period currently not more than 3 months.

Zone 5A, the area with the extreme slow surface drainage appears to extend somewhat behind the boundaries of the area indicated in soil map. For example the Sukera site was located just outside the edge indicated by the soil map, but was nonetheless observed to have a low infiltration rate. This indicates that the edges of the zones should be regarded as indication, rather than as strict boundaries.

Pans; Creating more water locations in the floodplains

Within the flooding areas and riverbeds, stagnant water remains often available in puddles and small pools. Zone 5A can therefore be very beneficial to develop pans because a lot of water floods during the rains. This water collects in depressions and often goes to waste. It is recommended that these depressions be further improved by increasing the size of the depressions, such that the water stored is substantial and is used more economically to save the water in the big pans and to retain it for longer. The water should be well channeled into the pan by trenching to increase the volume. Further, de-siltation, compaction and proper lining is necessary for the pans to be of good value to the community.

This phenomenon is well pronounced in Sukera, Dabadera and Biric Bur Bur villages where several natural depressions are observed. Water floods in the entire area during rains and this water can be preserved for the future. Once improved they can create more water locations and the large pans are able to store water to provide a sustainable water supply for domestic and livestock consumption for a longer period of the year.

In Ohiye a pan is already available. It could be improved to store water for a longer period after the rains. Proper channeling into the pan to improve the catchment area from which water is harvested should be done to increase the amount of water that enters the pan. The inlet channel should be rehabilitated to ensure that all water enters the pan from only one direction to prevent damage to the walls. Also compaction of the embankment is recommended. De-siltation is necessary and silt trap should be constructed, to reduce ingress of silts into the reservoir. Finally, proper compaction and lining of the pan are required to ensure efficiency of the pan. In addition to this current pan, the construction of other pans in the region could be considered to increase the water storage capacity.

Care should be taken that the soil layer that causes the slow surface drainage is not removed when constructing the pans. The low-permeable layer may be thin, and excavating may lead to the removal of this layer, thus reducing the feasibility of the site for storing surface water in a pan. In that case, the construction of a pan should not take place by excavation, but by construction of a dam or earthen walls on top of the low-permeable layer, without disturbance of this layer. In advance of the pan construction research is recommended to check the depth of the low-permeable layer, and whether at greater depth layers are found that can form a solid base with small infiltration for the pan.

7.7 Other 3R options in the area

Closed tanks

Closed tanks are interventions that can be applied for water storage, independent of the physical properties of the landscape. This technique can therefore be introduced in the full target area, at the locations where water is available to fill the tank. This can be achieved with water from roofs, other surfaces (e.g. roads), or streams. Water harvested from clean surfaces like roofs generally has the best quality. However, the roofs should be suited for water harvesting, which was very limited in the visited areas. Rain water harvesting is recommended for all iron roofed institutions. For example in Kulaaley Health centre the storage can be optimized.

Improvement of existing water pans

The existing water pans can be improved, providing a better water quality and a larger water volume. The first could be accomplished by better management, and concentrated watering of the cattle. A larger volume can be accomplished by the removal of silt, and the installation of a silt trap. Other areas can serve as an example for this, like the pans which were found in the Moyale District. In that region quite a number of water pans were found, which were constructed during the colonial time between 1950 to 1960.These pans were still in excellent condition, including banks with a good grass cover, well fenced with thorns, depths of over 2m, some are regularly desilted by the community , and cattle is watered on the edge of the reservoir where the soil is reinforced with logs, in traditional troughs of logs and clay. During the time of the visit these pans were strictly fenced and spared for the dry season, after other, natural sources have dried. The key to this success is partly the appropriate siting and construction, but mainly the strict traditional management structure imbedded in the community.

Road water harvesting

The road provides opportunities to create more water storage, amongst others by creating good opportunities for open water storage reservoirs. Directly after the rainy season many natural ponds and puddles are present along the road, and the road quarries store water often for much longer. Therefore, it is recommended to reinforce these quarries into full functioning pans, including proper water management. For example in Afyur an abandoned quarry is noted and this can be developed into a pan. In Lafaley, a very good site is noted some two kilometers from Lafaley towards Wajir. It used to be a quarry and if further excavated to increase the volume can be a reservoir pan. Additionally harvesting water from the road can form a resource of water to store in the pans or (ground) tanks.

Part of El-Adow Primary school whose roof is not guttered and can serve a very good source of water harvesting.

8 Developing solution strategies for the pilot area

8.1 Introduction

In the previous chapters an overview was given of the available resources in the target area, the current infrastructure and management, the expected water demand, and the potential for improving and creating new interventions. In this chapter a first step is made towards finding long-term sustainable solutions for the 3R/MUS pilot areas. These solution strategies cover a wider range of areas and also have a longer time perspective than the KALDRR project, which has a two-year timespan only and has a strong infrastructure development focus. It is also key that all different stakeholders, including communities, government, civil society and private sector will take up responsibilities and play a role to realise the solutions. This report covers mainly the situational assessment of the cycle presented in figure 3-1, and makes a start with developing a vision and water resource and service management strategy for the pilot area. Chapter 8.2 summarises the key problems, chapter 8.3 presents a sketch map of Eyrib Location (Eyrib, Sukela and Boji sub-locations) as well as a summary of the building blocks of a vision for the pilot area as developed by stakeholders during a first meeting on 19th August 2013.

Chapter 8.4 provides as number of recommendations that can guide the solutions strategies that will be developed by the stakeholders during the next step: visioning and strategic planning.

8.2 Summary of the RIDA problem analysis

Water is only shortly abundant and not made fully available for use

With certain regularity the target area suffers from multi-year droughts and occasional flash floods. Due to the water shortages and the resulting loss of grazing lands complete communities can lose their livelihood. An important factor in this problem is the fact that the current water infrastructure and management do not provide for sufficient buffering of water to bridge the dry periods. The resources of water consist of rain, overland flow, streams and seasonal rivers, and groundwater. Except for the groundwater these resources are available only in a short period of the year. Currently most of this water is lost from the area by a short and large discharge. Therefore, to decrease the water shortage, more water should be stored to make it available in the dry season. Groundwater is available at several locations, and a number of boreholes is present in the area. However, the infrastructure to access the groundwater is often not functioning correctly.

Problems of conflicts between clans or sub-clans, and the attitude of aid dependency in the larger Wajir County (up to now, there has been little reliance on external aid in Eyrib, Sukela and Boji sub-locations) are mainly caused by this shortage of water.

Poor water management

Another main area of problems is that the organisations responsible for direct management and provision of the water services and the water resources are not only weak at the overall level, but are actually absent from the three sub-locations. Where Water Management Committees responsible for a borehole were already struggling with the basic O&M tasks, very few formal Water Service Providers, as stated in the Water Act of 2002, have been successful in the ASAL areas. The Water User Associations that are created seem weak in representing the interests of the users in terms of the services they receive. All local organisations are weak in terms of accountability, transparency, internal governance and their capacity to fulfil their role. The WMCs have the advantage of being closer to the community and its users, but have the disadvantage of smaller scale, which is bad for the financial viability. The financial sustainability of the services and the organisations is basically unknown despite the impression that people actually pay for water services (if the information on having to pay in order to access water from the Eyrib earth pan is anything to go by). The fact that people report that their traditional management structures (water pans) work much better, as well as the fact that in most cases, the Gudi's continue to play a prominent role in water management even when there is a committee points to a problem of cultural acceptance of the management model that has been designed under the Water Services Trust Fund. For water resources, the situation is even worse. Practically there are no Water Resources User Associations or is there any water resources plan that looks at an integrated way and with a longer term vision to match the water needs with the potential supply of water. Most interventions are rather ad hoc and take place in a project context, aiming at solving (part) of a water problem of a specific community. Few interventions seek to solve the problems at a higher level or for a larger area.

This points to the third category of problems, which is the lack of support to the agencies that are supposed to provide the necessary services. The WMCs, WUA, and WMCs hardly receive any support from the government structures. They clearly lack the capacity to carry out key tasks as monitoring of services, oversight of the services providers and coordinate the longer term planning. Coordination has more the character of fire fighting. On top of this, there is a confused institutional set up where the DWOs are providing most of the support to the communities. But they are part of the system from before the sector reform and their role should have been taken over by the Water Services Boards, but which are at a very big distance from the communities and their organisations. At the moment it is still unclear if the decentralisation under the new constitution will improve this situation. Part of this problem is also that the market doesn't offer much technical capacity nor are options for low cost solutions and technologies available.

A last category of problems can be found at the service level. On the one hand users have clear demands for higher service levels. For domestic people want clean and safe water that is nearer to their houses. They have the ambition to start small scale agriculture and ask for a water source and irrigation infrastructure near the wet season grazing lands in order to make better use of these pastures. According to the people of Eyrib (Eyrib, Sukela and Boji South sub-locations), the future should bright as they hope to see more action in the water sector both by the government and by nongovernmental actors, a fact that was confirmed by stakeholders at the visioning and mapping workshop. There seems to be little belief that they are themselves the key to any solution in the area. This optimism is also premised on the devolved governance structure but people are not certain when the water governance structures articulated in the Water Act 2002 will become a reality in Wajir County.

Water users and service levels

A last category of problems can be found at the service level. On the one hand users have clear demands for higher service levels. For domestic purposes people want clean safe water and water that is nearer to their houses. They have the ambition to start small scale agriculture and ask for water sources and irrigation infrastructure near the wet season grazing lands in order to make better use of these pastures. According to the people of Eyrib (Eyrib, Sukela and Boji South sub-locations), the future should bright as they hope to see more action in the water sector both by the government and by nongovernmental actors, a fact that was confirmed by stakeholders at the visioning and mapping workshop. There seems to be little belief that they are themselves the key to any solution in the area. This optimism is also premised on the devolved governance structure but people are not certain when the water governance structures articulated in the Water Act 2002 will become a reality in Wajir County.

8.3 Visioning by the stakeholders

During the stakeholder meeting at the end of the field visit for the situational assessment, a map of the 3R/MUS pilot area was drawn, and a plenary discussion held to make a start with a longer term vision for the area (fig 8-1: sketch map of Eyrib Location showing settlements in each of the three sub-locations, current water points and wet and dry season grazing areas)

Figure 8-1: Water map of 3R/MUS pilot area drawn by stakeholders (dry season and wet season)

The visioning discussion provided the first building blocks for a vision and longer-term plan for the area. Stakeholders worked in a facilitated plenary session and were asked to look back at the water situation 25 years ago (1988); look at the current water situation (2013) and based on their past and current assessment, look to the future and decide on the ideal water situation that they would wish to see in the year 2025. Their responses are presented in the tables below.

Visioning for Ideal Water Situation for Eyrib Location: Eyrib, Sukela and Boji Sub-locations

Water Situation 25 years ago (1988) in each of the three Sub-locations	***Current (2013) Situation***
Eyrib Sub-location *(This area became a settlement only 5 years ago)*	
Water source • Eyrib Earth Pan constructed by the government in the 1970swas the main water source in the area • Eyrib was a catchment area for dry season grazing and livestock watering for various communities • There was no settlement in the Eyrib catchment area and no human-wildlife conflict • Perennial wells at Leheley were the only dry season water areas	**Water source:** • Now there is a five year old settlement - Eyrib sub-location - in this former dry season grazing area • Eyrib earth pan is still the main rainy season water source • Leheley wells are still the only reliable and free dry season water source for livestock • There is a borehole at Kusin village – about 45 km away – which people can access for dry season livestock watering upon payment of required fees set by the water committee. (The water is too salty to be used for human consumption) • Conflicts are frequent at the boreholes due to long queues and many people prefer to go to the Leheley wells where water is in plenty and is free • For domestic use, people now rely on water trucking from Wajir
Sukela Sub-location: *(This area became a settlement only two years ago)*	
Water Source: • Sukela earth pan constructed by the government in the 1970s and natural depressions that hold storm water during rainy season Sukela was both a wet and dry season grazing area for livestock from various communities that were brought here in order to access the Lehely open shallow wells for dry season watering • There was no settlement in the Sukela area	• There is now a 2 year old settlement in the Sukela dry season grazing area as people move closer to the Leheley dry season water wells • The Sukela earth pan has dried up due to siltation • The two natural depressions near the village are the main sources of water during the rainy seasons • During dry season people now rely on water trucking from Wajir for domestic use, • Leheley wells are still the most reliable sources of water for livestock in the dry season
Boji South Sub-location *(This area became a settlement only 8 years ago)*	
Water source:*Natural depressions during rainy seasons* • There was no formal water source in Boji but it held water in the natural depressions and served as a wet season grazing area when livestock accessed water from the natural depression. It also served as dry season grazing area for livestock watering at the Leheley open wells • Due to natural depressions, the Boji area was able to retain storm water underneath, leading to growth of good pasture and rejuvenation of forage • There was no settlement in the Boji catchment area	**Water source** • The Boji dry season grazing area is now settled. It became a settlement – Boji Sub-location - eight years ago • Natural depressions and storm water along the roads still the rainy season water source, as long as there is rain • For domestic use and young livestock, people now rely on water trucking from open wells in Wajir • Leheley wells are still the most reliable sources of water for livestock in the dry season. • While it would have been cheaper and quicker to ferry water from the Leheley wells, there are no water trucks at Leheley, despite being the Habsweyn District headquarters

<table>
<tr><th colspan="2">Water demand in all three sub-locations 25 years ago (1988) and today, 2013</th></tr>
<tr><th>1988</th><th>2013</th></tr>
<tr><td>
First and foremost water demand was for domestic use, mostly for human needs such as cooking and drinking, ablution, washing of utensils, bathing and washing clothes. In this category was also water for kids (baby goats/sheep) and calves. Together with this was water for livestock watering as livestock is the economic and livelihood mainstay for the people of Eyrib and the entire pastoralist community in the North-eastern region of Kenya where other sources of livelihood are limited
The second but non priority water demand 25 years ago was for agriculture. At that point in time, rainfall was fairly reliable and predictable. People practiced subsistence rain-fed farming of water melon, beans, cow pea and maize in the area that lies between Eyrib abd Boji.
There was no attempt at irrigated kitchen gardening since agricultural production was not a main a economic or livelihood base. Also, it was enough work for women to fetch water from the earth pans or the Leheley wells for domestic use and the young livestock
</td><td>
First and foremost demand remains water for domestic use, mostly for human needs such as cooking and drinking, ablution, washing of utensils, bathing and washing clothes. In this category is also water for young livestock for. Equally important is water for since livestock remains the main the economic and livelihood mainstay for the people of Eyrib
Alternative means of getting water especially for domestic use and for watering young animals – water trucking – is entrenched in all three communities.
Water trucking is done by private individuals; community initiative by groups such as the women group in Boji or the Water committee/Gudi in Eyrib; and, the government and NGOs which step in, in extreme cases to help
There are alternative water storage facilities for storing the trucked water such us underground tanks from which water is manually drawn or plastic tanks with taps
Today, because of sedenterization and the changing lifestyle, with more and more settlement coming up, people are willing and ready to diversify their livelihood bases including readiness to take to farming as an alternative means of livelihood.
The obstacle to farming is the non reliable and unpredictable rainfall. The drought cycle is becoming shorter and shorter, e.g. 25 years ago, the drought cycle was every seven (7) years. This reduced to 5 years over time and is currently happening in 2 year spans. Additionally, the rains are unreliable in the sense that they are either inadequate when they come, or they come in such a big way that they destroy crops. And there is neither water nor irrigation infrastructure to enable people practice irrigated farming
As a result of unpredictable weather conditions, livestock numbers are dwindling and people are taking to other means of livelihood such as petty trade, sending children to school with the hope of getting employment etc
At the same time, people are calling for support with irrigation infrastructure as they insist that the land is fertile enough to support agricultural production of maize, water melon, beans, kale, cow pea, Irish potato and other crop varieties
</td></tr>
</table>

Access: Dry season water and grazing area governance	
1988	**2013**
• There were no formal/legal institutions responsible for water use. Use of water and pasture in the dry season grazing areas was controlled by the traditional conflict resolution system known as the *Gudi* (Council of Elders). Each clan and its sub-clans had a *Gudi* that resolved intra clan/sub-clan conflicts. For inter-clan conflicts, the respective Gudid met and negotiated a resolution that was agreeable to both parties. In the case of access to water and pasture, the *Gudi* from the clan that claimed traditional ownership of the area in which the earth pan or pasture was located controlled the access. E.g. other clans coming to graze and water their livestock had to seek permission from the respective *Gudi* to be allowed access to the grazing area and to the water source. • Nomadic pastoralism was practiced and once earth pans and natural ponds dried up, people moved away • The *Gudi* guided users and arbitrated any conflicts that arose over water or pasture • The dry season grazing areas around the present day Boji and Sukela sub-locations were zoned by the respective *Gudis* agreeing among themselves according to the sub-clans that brought their livestock to these areas for purposes of watering at the Leheley open wells • For sustainability, there was no monetary payment for accessing water but the *Gudi* would ask livestock owners to disilt sections of the earth pan from which water had receded. In other cases, the *Gudi* would mobilize young men to undertake the disilting exercise. In this way, by the time the entire earth pan dried up, it would have been fully disilted in readiness for the subsequent rainy season • At the Leheley dry season water area, the open wells are either individually owned or owned by a group of individuals from the same family or sub-clan. Access to water is family and sub-clan based. The pastoralists seek permission from their extended families or sub-clans and the access is always granted. Nevertheless, because of the large numbers of livestock from family/sub-clan members, the respective *Gudi* may prepare a timetable for livestock watering. For example, one may be required to water his livestock after two days and this may sometimes result in conflict. Such conflicts are resolved by the *Gudi.* • Prior to 1992, there was increased government intervention in the construction of boreholes, provision of diesel to for running the boreholes as well as technicians and spare parts for the operation and maintenance of boreholes • In 1992, the World Bank led Structural Adjustment Programme (SAPs) introduced issues of cost sharing and community management of community-level projects such as boreholes in the ASAL and other areas of Kenya. • With SAPs came the establishment of community water/project management committees and the district level Pastoral Associations (Pas) to be in charge of range management and the operation and maintenance of water projects, especially	• The WUA/PA/Water Committee management system is associated with boreholes. Attempts to introduce this system to earth pan management have remained lukewarm while the *Gudi* has remained the main decision making system for earth pans. For example, at Eyrib, the community reported that there is a management committee (only one person was at the meeting) assited by the Gudi and the Chief. This means that management of water is both traditional and administrative. • The role of the Chief in the Eyrib earth pan management is to enforce a ban on watering loivestock at the pan to enable it provide domestic water for a slong as possible • The Eyrib earth pan which formerly belonged to evEyribody is now controlled by the Eyrib Sub-location *Gudi* and the office of the Chief (central government administrator at the Location level) • Now the earth pan water is paid for. E.g. for the Eyrib earth pan, payment is pegged at Kshs 10/= for a camel, 4/= for cows, 3/= for donkeys and 1/= for goats/sheep. On the other hand, water for domestic use is pegged at a flat rate of Kshs 300/month per household regardless of volumes or quantities required by a household • At Sukela, there were up to five (5) 15000 litre Flexible Water Storage tanks that are privately owned (by individuals) while at Boji, there was a 45000 litre underground community tank with corrugated iron sheet roof but the women group that runs it could only afford to truck 15000 litres every two days. In addition, there were privately trucked water sources • At Sukela, there is no water rationing. A household can get as much water as they can afford • People who are unable to pay for water upon collection are can do so on credit but make payment upon the next collection • The very poor people may be allowed to free collection after every alternative trucking • Comparatively rich people could afford to truck water for their shoats while the poor families share their water ration with the young livestock • Increased settlements has made it easy for the government to reach people with water trucking in extreme draught situations • There is a change of attitude as people no longer look only to the government for all their water needs but are willing to buy from private water traders • At Eyrib location (Eyrib, Sukela and Boji South sub-locations) the formal/legal water institutions that were created by the Water Act, 2002, are unknown. The legal institutions such as the WSP and the WUA would be found in areas with boreholes and as there is no borehole in Eyrib, these institutions are none existent. Nevertheless, people know about them from their interactions with boreholes such as the one in Kusin • There is still overcrowding of livestock and people at the Leheley dry season water wells forcing sub-clan *Gudis* to prepare livestock watering timetable to ensure that all sub-clan

boreholes. • On their part, users at the project/borehole level were required organize themselves into Water Users Associations (WUAs). • Control and decision-making on water access at the boreholes became the responsibility of the water committees while O&M became the responsibility of the PAs • Users were required to pay for access to water which for pastoralists was a tall order as payment was established according to the types of livestock – camels, cattle, ruminants (goats/sheep). • This was a difficult time for pastoralists in the ASAL areas as people were not used to this type of formal management of water (or grazing) which are the main preoccupations for pastoralists. • In most cases, sub-clan or community level *Gudis* also doubled up as water committees. • The time of SAPs also saw an upsurge of non government actors in the ASAL areas and most of them stepped in to also provide water – both boreholes and earth pans, and generally intervened in repairs of boreholes and provision of spare parts to the district level PAs • This was also the stage that saw the introduction of water trucking services which were initially provided by government but later because the responsibility of the communities • In 2002, a new Water Act was enacted – the Water Act, 2002 – both to rationalize the water service and water resources management in the country and to entrench community participation in the water management into the law. • The institutions that were created by the Water Act, 2002, include the various water service boards (WSBs), the Water Resources Management Authority (WRMA), Water Service Providers (WSPs) and the Water Users Associations	livestock are watered • Some people may still defy the set rules such as watering timetable leading to conflicts. These are resolved by the respective *Gudi*
Problems experienced 25 years ago (1988)	***Problems that are currently being experienced (2013)***
• There was no alternative means or ways of getting or storing water as: (i) water trucking was unknown; (ii) there was no underground water tanks or plastic tanks • Water for domestic use was transported by burden animals such as camels and donkeys driven by women • There were conflicts over water despite existence of the *Gudi* • During dry seasons, women walked 24 hours to and from the perennial Leheley open shallow wells (with donkeys and camels as the means of transport) for domestic water • Only about 80 lts of water was available to a household and young and lactating livestock regardless of household size • Despite the disilting arrangements by the Gudi, some earth pans were never fully disilted, e.g. the Qoqar earth pan	• The Sukela earth pan is completely silted while there is reduced holding capacity of the Eyrib earth pan. The holding capacity of the natural depressions at Sukela and Boji have also reduced due to siltation • Water tariff is very high for trucked water. The cost of a 20 litre container (jerrican) of water is pegged at: KShs 15-20/20lts if it ferried by government trucks (fuelled by the community who also pay per Diem for the driver) or through community initiative, and Kshs 30/20lts if it is privately trucked by a group or individual • At Boji, water is rationed to enable each household get some water. E.g. a household with 5 people or more (3 children and parents) gets 60 litres/day while a household with 4 people gets 40 litres/day • Paying for water is a burden on Household income as most of the household income is spent on water – up to 4500/=+ (about $ 50+) every month. This is

• The Leheley wells were the only reliable dry season water source for both livestock and for domestic use • There were no external actors that could help with water provision **Note:** Due to the above reasons, the water problem was worse than it is today	money that could be used to initiate other income generating activities such food kiosks and restaurants, sale of clothes and other small scale enterprises • Improved communication – cell phones – has helped to reduce the cost of water trucking. E.g. instead of going to Wajir, private water traders can make deals with the truck owners on phone • Water trucking is a lucrative enterprise for the few private individuals who can afford it **Note:** (i) Despite the above difficulties, the situation in 2013 is much better than 25 years ago since women no longer walk the 24 hours to Leheley wells to collect water for domestic use. (ii) Settlement in the dry season grazing areas – Boji and Sukela – has reduced the distance that people walk with livestock to the Leheley watering wells
Other water related activities and other comments	
• Rain-fed farming of beans, cow pea and maize was practiced in the general area between Eyrib and Boji (see sketch map) • In general, settlements were few and most of the population was nomadic • Livestock was watered during the day while wildlife accessed the water source at night. For this reason, and because there were no settlements in the dry season grazing/watering areas, there was no human/wildlife conflict	• Due to erratic rainfall and long periods of draught, rain-fed farming is no longer practiced by many people • Due to settlements near the formerly "all-purpose" water sources such as the Eyrib earth pan, there is now human wildlife conflict as wildlife still come to these sources for their water needs

Desired Future: Vision for water (demand and access) in 2025	
Issue	**What and how**
Demand: for what purpose is water needed?	• Water for: Livestock; domestic use; small scale irrigated agriculture complete with irrigation infrastructure; water related small scale enterprises such as food kiosks/restaurants; environmental conservation/tree planting; consumption by wildlife; expansion of primary and secondary schools, health facilities
*Infrastructure:*What types of water sources and infrastructure will meet the demand?	• Rehabilitated/disilted and improved (existing) earth pans and waterways/channels; new earth pans; construction of boreholes; piped water to households; harvested rain water – both roof and run off; and, livestock watering toughs for all categories of livestock
*Responsibility for service provision:*Who will be responsible for water services provision?	• Government institutions such as the Northern Water Service Board and the related WSPs; Non government actors in the water sector such as Caritas
*Strategy for infrastructure management:*How will the water infrastructure/facilities be managed and accessed?	• Management by overall water committee and an overall WUA in each community supported by user type/sectoral sub-committees; • Access by sectoral WUAs which will be organized according to type of use, e.g. livestock watering WUAs; irrigated farming WUA and enterprise WUA; • All users and management groups to be trained in respective roles and responsibilities; • Each management level to have by-laws, including arbitration process in case of conflict
*Stratgy for service provision and management:*How will the demand for water service and accountable management be achieved?	• Integrated and holistic water use planning; involvement of communities and their respective *Gudis* in planning and identification of various water project sites; community participation through contribution of unskilled labour, security and storage of materials and equipment; • WUAs and water committees to be registered to give them appropriate legal recognition; • Audit to be done be undertaken the government's water office; • All sectoral WUAs to report to report to an overall community level WUA
Any foreseen challenges/obstacles/difficulties that may hinder achieving the desired future: Important issues to think about	
• If the *legal instruments* responsible for water provision such as the Northern Water Service Board or Water Service Providers will not be active in the area; • If non government actors continue to intervene in *small unsustainable* ways, leading to *insufficient water* provision; • If *irrigation infrastructure and livestock watering troughs* will not be part and parcel of the water source design and implementation; • As a result of settlements in the dry season grazing areas, there is already overgrazing in these areas which may lead to future *conflict over pasture*; • If there is no proper *education to users on tariffs for various uses*, then some people may fail to pay for water after taking it on credit, which may lead to conflict; • Need for health facilities; • Need for additional educational infrastructure (classrooms and more toilets) in Eyrib and construction of a school in Boji South.	

8.4 Recommendations

The recommendations listed here should be regarded as building blocks for the long-term strategies for the 3R/MUS pilot area. They are based on our field studies and interactions with the different stakeholders. The development of a plan for integrated water resources and services management for the pilot area will be developed by and anchored in the institutions and stakeholders of the area and will be part of the next step in the process. The ambition of the recommendations below is high and they should be matched with realistic actions and outputs in a phased manner. The ultimate aim of the master plan will be to make the area resilient in terms of water access and livelihood against prolonged periods of drought, but the shorter term objective and interventions will aim to increase water availability to bridge a dry season. Some of the recommendations are already implemented (partly) and probably quite some other measures are in place, which the field visit didn't reveal at this stage and should be regarded as part of the recommendations here.

The recommendations can be taken on board when the stakeholders develop their vision and strategies for the pilot area, which will be based on a quantitative analysis of bridging the gaps between the ideal demand and the actual use in the future with 3R information on the water resource development potential in the area (see chapter 3.4 and annex 9). The potential for 3R interventions is discussed in detail in chapter 7.

The Local Integrated Water Resource and Service Management master plan

- Make a water master plan for the Eyrib Location area integrating water resources & services management. The plan will guide all water related interventions, both hard- and software, based on a longer term vision. The foundation of the plan should be in the traditions and socio-cultural values of the population and matching with the Kenyan institutional and planning policy and framework.
- The master plan will be anchored with the stakeholders by a MoU that will spell the different roles and responsibilities of the partnership and will include commitments from each stakeholder. Traditional governance and leadership institutions will be represented in the MoU. The MoU will form the basis to strengthen accountability amongst the stakeholders. The MoU can serve also as a first step to establish an operational Water Resources Users Association.
- The master plan should include a simple monitoring framework that allows for reflection and a regular update of the plan. The indicators will cover the services provided, the performance of the different stakeholders and progress indicators on the strategies/activities.
- A key strategy of the master plan will be to direct interventions to bridge the gaps in water availability between the wet seasons for all water uses (domestic, institutional, livestock and small scale agriculture), by increasing the water buffer in the area.
- An important element of the master plan will be a capacity building strategy, to ensure that stakeholders are able to implement their tasks. Part of the capacity building strategy will be to enhance the capacity of the private sector and too strengthen marketing mechanisms. This will increase the availability of low cost technologies and technical assistance and improve the 'self supply' options for households and the communities.

General directions to improve the water supply

To improve domestic water use, interventions to be considered are:

- Improve financial viability of the water services by analysing the total costing (both capital and recurrent costs (including the direct institutional costs)) and identify and agree on sources for financing. The latter including user fees and tax and transfer subsidies.
- Make clear arrangements for O&M to ensure that the water facilities are kept functional. The arrangement and agreement should be part of the MoU.
- For rural domestic water supply the most feasible water supply techniques in the 3R/MUS target area include: shallow wells, rooftop harvesting, and closed (ground)tanks.
- To make sure that the WMCs/WUAs/WSPs/traditional water supervisors can do their job, the support to these organisations need to be committed and integrated in the MoU.
- If water pans are the only possible water source near the settlement:
  - Consider to construct water pans solely for domestic use with the aim of improving the water service level in terms of quantity, accessibility and reliability, ensuring in the design that they are able to bridge a dry season which has a 1 out of 10 probability.
  - Evaluate options to improve the quality of water abstracted from the pans including construction of an infiltration gallery with an collection well and handpump.
  - Find out if increasing household water storage is increasing the domestic water use.
  - Find out what are the main barriers that prevent the large scale use of Household Water Treatment (HWT) and/or consider alternatives, like treatment at source or treatment at cluster level

To improve livestock water use, interventions to be considered are:

- Develop and implement zoning strategies, which balance the use of dry and wet season grazing lands. As the use of grazing lands is influenced by the status of neighbouring grazing lands and the varying rainfall, regular coordination by representatives of the area with the neighbouring communities.
- Strengthen the capacity of grazing lands by applying 3R techniques for soil moisture storage, runoff- and erosion reduction, including floodwater spreading, contour bunds and checkdams.
- Optimise the use of grazing lands by developing water sources near the grazing lands, taking into account the risk of overgrazing and/or increasing the influx of herds from other areas.

To improve agricultural use, interventions to be considered are:

- Build on the willingness and first small scale initiatives of the population to diversify the livelihoods by increasing water availability and infrastructure for small scale agriculture. This may focus in first instance on kitchen gardening, catering in principle for feeding the own families and households, but can gradually be expanded to growing products to sell on the market.
- Find out the potential for food production for the local market.

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ANNEX 1: Norms or guidelines used by Government of Kenya and IPs

I. Government guidelines for design of rural water infrastructure

CONSUMER	UNIT	RATE	REMARKS
1. General Population			
-Individual Connection	L/H/D	60	
-Non individual Con.	L/H/D	20	
2. Low Class Hotels	L/Bed/D	50	
3. Secondary Schools/ Institutions with WC	L/H/D	50	
4. Shops	L/D	100	
5. Bars	L/D	500	
6. Dispensary/Health Center			
- In patient	L/H/D	100	
- Out patient	L/H/D	20	
- Residential Staff	L/H/D	60	
7. Day Schools	L/H/D	5	
8. Livestock Units	L/Liv. Unit	50	

II.

Unit	FAO Livestock Unit (Sub-Saharan Africa)	Tropical Livestock Unit (*Unité Bovin Tropical*)
Abbreviation		TLU, UBT
Region	Sub-Saharan Africa	Tropics
Unit equivalent to		Tropical cow
Weight equivalent of one unit		250 kg (550 lb)
Dairy cow	0.50	0.70
Dry medium beef cow	0.50	
Medium beef cow suckling	0.50	
Bull	0.50	
Horse	0.80	
Medium sheep	0.10	0.10
Goat	0.10	0.10

Water buffalo	0.50	
Camel	1.10	1.00
Pig	0.20	

III. *Design manual of Ministry Water and Irrigation*

Consumer	Unit	Rural areas			Urban areas		
		High potential	Medium potential	Low potential	High class housing	Mdium Class housing	Low class housing
People with individual connections	1/head/day	60	50	40	250	150	75
People without connections	1/head/day	20	15	10	-	-	20
Livestock Unit	1/head/day	50			-		
Boarding schools	1/head/day	50					
Day schools with wc/without wc	1/head/day	25 5					
Hospitals Regional District Other	1 bed/day	400 200 100	+20l/outpatient/day (minimum of 5,000 l/day)				
Dispensary and Health centre	1/day	5000					
Hotels High class Medium class Low class	1/bed/day	 600 300 50					
Administrative offices	1/head/day	25					
Bars	1/day	500					
Shops	1/day	100					
Unspecified industry	1/ha/day	20000					
Coffee pulping factories	1/kg coffee	25 (when re-circulation of water is used)					

Source: Ministry of Water and Irrigation design manual

ANNEX 2: Quick water infrastructure assessment

Date:		Area:		Collected by:		Organisation:	

1. Name water resource	2. Water point type	3. GPS coordinate	4. Status (in use, damaged, not working at all)	5. Capacity (if available)	6. Are there seasonal variations? (Yes or No)
7. Who is managing this water point? Is there a legal framework to the use of this resource?	8. Who is using it? (for what uses?)	9. Is the quantity available (4) meeting the demand?	10. If no, why?	11. Are some user groups (7) using more water than others?	12. Other

ANNEX 3: Tools for assessment of water demand

I. Calculation of water demand for a sub-location

<u>Population</u>

Population sub-location (census 2009): A0

A1. Estimated Population 2013 = $(1.027)^4$*(A0) =1.112*(A0)

A2. Estimated population 2023 = $(1.027)^{14}$*(A0) = 1.452*(A0)

A3. Estimated population 2033 = $(1.027)^{24}$*(A0) = 1.895*(A0)

[use average annual growth rate of 2.7%]

<u>MUS water demand using the general MUS approximate (example for MUS = 50 l/h/d):</u>

B1. MUS water demand range 2013 = (A1)*50 *0.001= **x1** m3/d

B2. MUS water demand range 2023 = (A2)*50 *0.001= **x2** m3/d

B3. MUS water demand range 2013 = (A3)*50 *0.001= **x3** m3/d

<u>Water demand for domestic use for the sub-location</u>

[The projections below do not take into account (1) the fact that most rural households do not collect more than 10 l/h/d when collecting water with 20L jerry cans or water from a source >30 min walking distance, (2) changes in service levels in the future: a higher service level will in general increase demand and (3) general changes in the context of project area, which may influence general development and therefore also water demand].

C1. Domestic water demand 2013 = (A1)*20 l/c/d *0.001 = **y1** m3/d

C2. Domestic water demand 2023 = (A2)*20 l/c/d *0.001 = **y2** m3/d

C3. Domestic water demand 2033 = (A3)*20 l/c/d *0.001 = **y3** m3/d

<u>Water demand for livelihood: livestock</u>

Most determining factor for estimations for water demand of livestock is the numbers of livestock in the area. These numbers fluctuate strongly with as main factor the availability of water.

Water demand is calculated using different methodologies depending on the estimate of the number of livestock in the sub-location:

D1. Use FEWSNET estimates which gives the average number of animals per household in pastoral zone: 5-10 cattle, 20-25 goats, 15-20 sheep, 0-5 camels and 0-1 donkey.
Calculate total number of households for 2013, 2023 and 2033 = B1,B2 and B3
Calculate total number of livestock for 2013, 2023, 2033
Calculate total number of Livestock Unit (LU) (using FAO table) for 2013, 2023, 2033
Calculate water demand: LU*50 L/LU*0.001= **z** m^3/day for 2013, 2023, 2033

D2. Use data of number of livestock based on survey/evaluation or data from local government, and/or census data.
Then calculate the water demand like in D1.

D3. Use data of number of livestock based on information from FGD in the field during the MUS study.
Then calculate the water demand like in D1.

<u>Water demand for livelihood: agriculture</u>

[NB 1: Experiences show that kitchen gardening in general only happens around community water points that are located in the village or when the water source is a family well. Secondly, it is well documented that water use increases when the distance to carry the water becomes shorter. In fact case studies show that water use for small livelihood purposes as some livestock or a kitchen garden starts already from 12 l/p/h/d, much lower than the official WASH norm of 20 l/p/h/d].

NB2: large scale irrigation schemes are not part of the KALDRR interventions. Crop irrigation will be calculated only if relevant for the long-term water management in the 3R/MUS intervention area; assumptions will also be made on the % of irrigation that will be made through drip-irrigation versus flood-irrigation].

FAO guidelines are used: http://www.fao.org/docrep/S2022E/s2022e07.htm

FAO explains how the irrigation water need can be calculated, using the following formula:

Calculation of the crop water need (ETcrop)

Etc = Eto x kc

kc = crop coefficient

ETo = reference evapo-transpiration (mm/day)

Etc = crop water needs (mm/day)

The following table provides indicative crop water need for different crops:

Crop	Crop water need (mm/total growing period)	Sensitivity to drought
Alfalfa	800-1600	low-medium
Banana	1200-2200	high
Barley/Oats/Wheat	450-650	low-medium
Bean	300-500	medium-high
Cabbage	350-500	medium-high
Citrus	900-1200	low-medium
Cotton	700-1300	low
Maize	500-800	medium-high
Melon	400-600	medium-high
Onion	350-550	medium-high

Peanut	500-700	low-medium
Pea	350-500	medium-high
Pepper	600-900	medium-high
Potato	500-700	high
Rice (paddy)	450-700	high
Sorghum/Millet	450-650	low
Soybean	450-700	low-medium
Sugarbeet	550-750	low-medium
Sugarcane	1500-2500	high
Sunflower	600-1000	low-medium
Tomato	400-800	medium-high

CALCULATION OF THE EFFECTIVE RAINFALL (PE)

Rainfall data in the area (P) is taken from available rainfall station. The effective rainfall Pe is calculated using the following simplified formula (valid in areas with a maximum slope of 4-5%):

- Pe = (0.8 x P)-10 if P>75 mmm/month
- Pe = (0.6 x P)-25 if P<75 mm/month

II. Calculation Excel sheet for calculating water demand

The calculation Excel sheet will be shared with the partners upon finalization.

ANNEX 4: Tools for assessment of water access

I. Water user categorisation: livelihood groups and wealth ranking

The facilitator shall try to find out together with the participants, how to categorize the different type of water users; the following questions can be used:

- What are the main livelihood activities in the village/community/area?
- For each of the livelihood category (fill in a table):
  - Is there water needed for this activity?
  - In which quantity (if no precise unit such as cubic meter or litres available, the group shall agree on an unit measure clear to all)?
  - What % of the village/community relies on this activity?
- Are there any differences between the poorest and the richest household? If yes, the table shall be done per wealth category (if – after discussing with the local partner – the option is feasible in terms of hurting sensitivities).

Example of table:

Wealth class / Livelihood class	Well-off	Medium	Worst-off / poor
Farmer	• Grows maize for sale to the market. • Has more than ten cows. • Brick house. 5% of the community.	• Grows rain fed maize for sale for home consumption and sells part of the crop. • May have seasonal additional income (migrant work). • Has a vegetable plot irrigated from wells. • Has some cows (less than five). 70% of the community.	• Grows rain fed maize for sale for home consumption May have seasonal additional income (migrant work) • Does not have additional income • Has a vegetable plot irrigated from wells. 20% of the community.
Families living on cash from elsewhere	• Lives in the centre of the village. • Lives on remittances • Does not grow crops. • Only has small garden next to house, with flowers and some vegetables. • May have some chicken. • Brick house. 5% of the community.		

Source: ZIMWASH, 2010 and Smits and Mejía, 2011

II. Seasonal calendar (understanding the seasonal conflicts over labour allocations and water access)

(Based on RiPPLE – A toolkit for assessing seasonal water access and implications for livelihoods)

In Kenya, drought-prone areas experience chronic episodes of water, food and income deficits, which can lead to malnutrition or famines. In order to prevent these episodes, disaster risk management systems are being designed in order to foresee these episodes and put in place prevention measures to mitigate the threat to the most vulnerable population. The WELS approach (Water Economy for Livelihoods) is one approach that has been developed by RiPPLE in Ethiopia.

The toolkit suggests looking at the following points:

- To understand seasonal access, it is important to identify areas that share similar water access patterns and livelihoods so that access to food, income and water can be assessed properly within those areas,
- Wealth status of the HH frames what assets households have available to secure access to food, income and water (e.g. in a poorer HH, less jerry cans will be available, or more household members dedicated to income generating activities – therefore less people available to collect water etc).

→ A simple tool that can be used to summarise conflicts over labour and time throughout the year is a **seasonal calendar** of water access and livelihood.

To do so

① - On a calendar for a specific group of population and/or area, is noted for each month:

- Water collection timing at the main source of water
- Seasonal activities requiring household labour
- If relevant, period of diseases (especially water borne diseases).

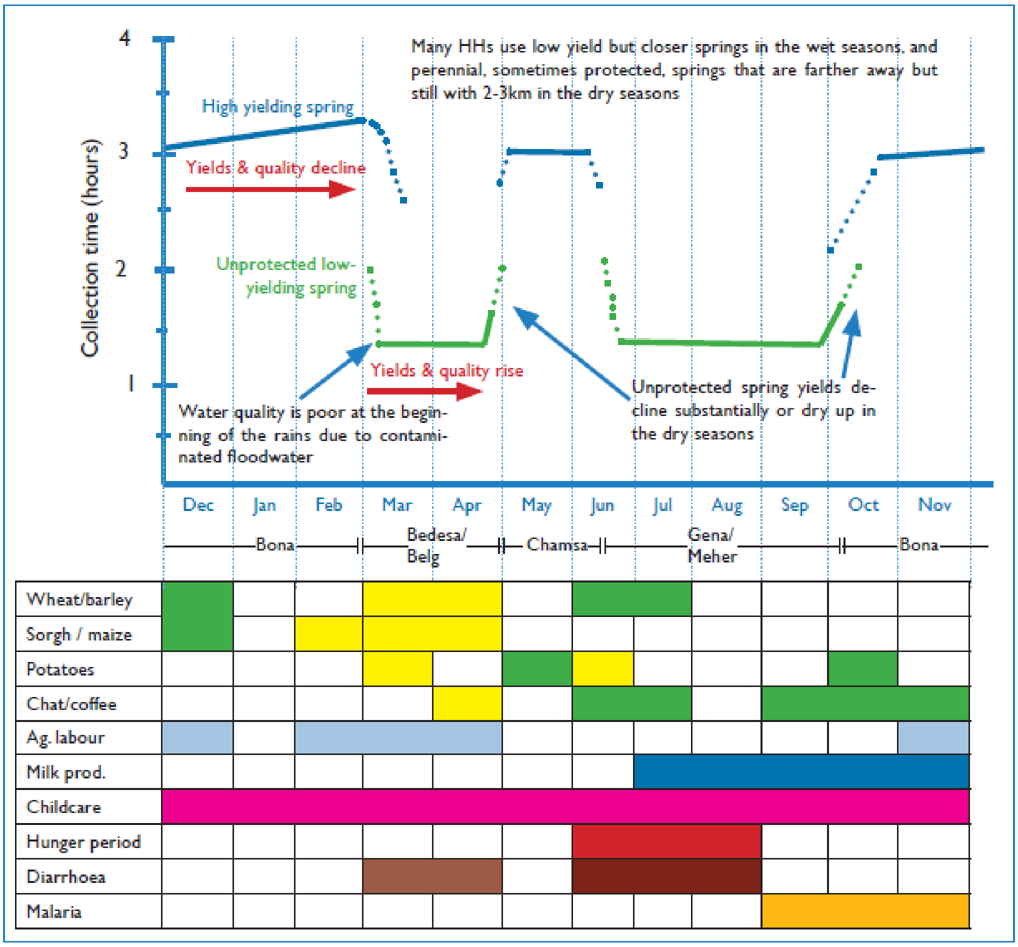
Periods of vulnerability are those where both assignments (seasonal labour and water collection) are high – where HH may struggle to obtain enough safe water for survival or livelihood protection.

Example of Calendar:

On the example, the agricultural activities and diseases have been put in a table, while water collection timing (in number of hours) has been out into a graph.

What can be seen in that:

- During the dry season (Nov – Feb), queue at the water source is very long (about 3 hours) while at the same time it coincides with a peak agricultural period → **threat to good quality water access** since they might (1) fetch water less frequently and (2) travel less far to get quality water, and may use more easily accessible unsafe water sources,
- During the Rainy season (March-April) peak of diarrhoea because of water runoff → less labour available for agricultural labour, thus **food security threat**
- During second rainy season (July-August), another peak of diarrhoea which is at the same time as the **hunger** gap.

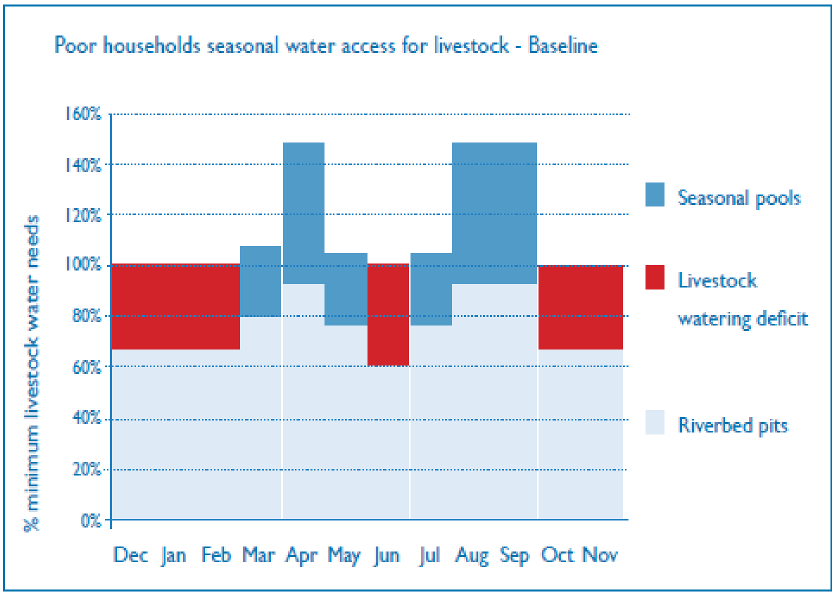


② – Based on the calendar, periods where households cannot obtain enough water to meet survival (drinking, cooking, hygiene and sanitation) or livelihood protection (livestock rearing, irrigation) can be identified. This seasonal water access and deficits can be quantified more precisely by defining per season, the water requirement. If possible, this analysis shall be conducted among each wealth group category.

Example of a table for Wealth group #1 (in an area with 3 wealth categories):

Daily water requirement	Dry Season	Rainy Season	Water available	Meets the needs?
Livelihood				
Livestock				
Irrigation				
Survival				
Drinking and Cooking				
S&H				
TOTAL				☐ Yes ☐ No

Example of a graphic illustration of water access and water deficit for livestock



③ Understanding how seasonality affects water access and livelihood helps putting in place mitigation measures to reduce vulnerability of the population. It can include the development of new water sources or distribution of Household water treatment units for example.

ANNEX 5: Methodology for participatory water map

The mapping exercise of the current situation of an intervention area aims at:
- Clarifying to the facilitators of the training: the context of the intervention area, its boundaries, water access and constraints,
- Helping the participants of the training to synthetize into a common document their knowledge of the intervention area and through this, reflect on the current situation.

The mapping exercise will take 1 to 2 hours. It shall not be prepared too much beforehand but really done "live" by the participants during the training session. Although participants shall feel free to create a map which is clear to them, directions can be given by the facilitators on elements to add to the map.

To do so

①Before starting the exercise, these points have to be thought through by the facilitators in partnership with the local partner who knows the area:
- Size of the area will impact on the design of the map. Do we map one village or a set of communities? In the case of pastoralism groups, it may be needed to draw a combination of villages + location of cattle? If different communities have to be mapped, it may be wise to divide the participants into groups so that they can work on separate maps.
- If reasonability impacts a lot on the water access and livelihood activities (location of grazing lands, etc), it might be necessary to draw a map per season (one for the dry season and one for the wet season). This needs to be discussed with the local partner beforehand.

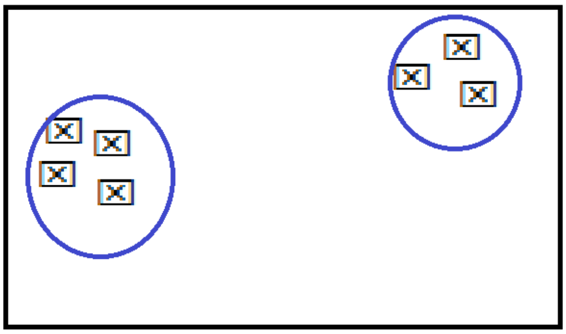
②Checking the logistic - for the map, make sure:
- That a good diversity of pens and pencils in different colors are available to the participants,
- As for the font used, the overall map of the area can be either drawn by the community on a simple blank A3 paper, or provided by the facilitator (Google map printing, map of the village, map of the area etc) if available. However, it might not ease the visibility of the map AND it might confuse participants who are not used to work on an existing map.

③Once participants are split into groups (if relevant), the facilitator can "guide" them on the steps to follow to draw the map:

1. Boundary of the village / mapping area
2. Location of buildings and houses (☒) with roads in between (official **full line** and non-official **dotted**) ,
3. Location of grazing land (stripy area),
4. Location of existing water points/resources in the area (one symbol per type of water points (to be defined by the group): wells , boreholes, pounds, …. In **Green i**f the water point is still working, in **Red** if the water point is not working).

5. Using circle which will be colored with a pencil, locate on the map where the water is being used for household and livelihood activities:
    i. For domestic use (Blue)
    ii. For the gardens (Green)
    iii. For the cattle (Red)
    iv. Other uses (black)

For example for domestic use, if water is used around the HH, a blue circle can be drawn around the houses.



6. Locating access constraint on the map, such as:
    i. Conflicting tribes,
    ii. Geographical constraints (river in the rainy season or mountain),

If putting constraint on the map makes it unclear, a numbering system can be developed where numbers can be put on the map, and detailed through a sentence in a table located at the bottom of the map.

④ Use the map as a base for discussion to discuss the constraints and difficulties faced by the communities when it comes to water access. Write down these comments and reflections on a separate flipchart.

ANNEX 6: Existing water infrastructure

GPS coordinates and properties of Shallow wells in El-Adhow

SW	TD (m)	WRL (m)	N	E	EL (m)	EC (µS/cm)	pH	TDS (mg/l)	Temp (⁰C)
1B			N 01°.39'66.9"	040°04'30.4	246				
2U	2	1	01˚39'56"	040˚ 04'29''	242	3388	7.41	1731	27.3
3	2	1	01˚39'55.1"	040˚04'27.3	241	3930	7.52	1990	25.6
4U	2	1.5	01˚39'55.6"	040˚04'26.2	246	3999	7.72	2000	27.1
5U	2.5	2	01˚39'56.1"	040˚04'25.9	244	3999	7.72	2000	28.9
Surface			01˚39'57.6"	040˚04'26.6	240	2146	7.93	1091	23.1
6U	2	1	01˚39'57.6"	040˚04'26.6	240	3640	7.52		26.7
7U	2	1	01˚39'58.9"	040˚04'27.3	241	1081	7.75	548	27.1
8U	2.5	1.5	01˚40'00.4"	040˚04'27.9	245	3840	7.46	1957	29.7
9U	2.5	1.5	01˚40'2.8"	40˚4'26.1"	238	3999	7.19	2000	30.1
10U	2m	1.1	01˚39'57.4"	40˚04'27.8"	247	3999	7.4	2000	27.4
11	5	3	01˚39'55.9"	40˚ 04'43.5"	249	3999	6.93	2000	32.1
12	5.1	3.2	01˚39'49"	40˚ 04'45.2"	245	3999	7.15	2000	31.4
13	3.5	3	01˚39'37.3"	40˚04'47.9"	241	3999	7.22	2000	30.7
14	3.5	3	01˚39'38.8"	40˚04'43.8"	242	3999	7.15	2000	31.5
15	5.5	5	01˚39'43.6"	40˚04'39.4"	256	3999	7.1	2000	30.9
16	5	4.5	01˚39'46.1"	40˚04'39.2"	253	3999	7.1	2000	31.1
17 U	2	1	01°39'56"	040°04'29	242	-	-	-	-
Kulaaley Shallow wells									
1	3	-	01⁰ 36' 50.8"	40⁰07'29.8"	220	-	Backfill	-	-
2	8	7	01⁰ 36' 5.8"	40⁰07'29.7"	222	3999	7.30	2000	32.1
3	8	7	01⁰ 36' 54.5"	40⁰07'27.9"	221	3999	7.6	2000	30.7
4	4	-	01⁰ 36' 54.5"	40⁰07'28.9"	221	dry	-	-	-
5	4	Back	01⁰ 36' 54"	40⁰07'27.4"	220	-	dry	-	-
Leheeley.									
1	4	0	01038'19.6"	040000'54.1	231				
2	4	0	01038'18.4"	040000'53.9	234				
3	3	0	01038'16.4"	040000'55.1	226				
4	3	0	01038'18.1"	040000'55.2	226				
5	4	1	01038'22.3"	040000'54.9	234				
6	4	1	01038'18.7"	040000'51.7	234				

U = In Use; B = Backfilled with stones

Coordinates of Points of Interest

Sub location	Water source	*Coordinates WGS84*			
	Type	*X*	*Y*	*Elevat ion*	*Capacity*
Lafaley	Storage Tank	040^{0}05’54.4”	01^{0}50’27.3”	284	
Lafaley	BH	040^{0}05’50.8”	01^{0}50’40.2”	290	
Lafaley	SW.1	040^{0}05’51”	01^{0}50’42.7”	293	
Lafaley	SW.2	040^{0}05’54.8”	01^{0}50’29.7”	291	
Lafaley	BH.Red Cross	040^{0}05’38.2”	01^{0}50’48.5”	293	
Leheley	SW’s	040^{0}00’53.1”	01^{0}38’20.0”	235	
El-Adow	SW 1	040^{0}04’30.4”	01^{0}39’56.9”	246	
El-Adow	SW 2	040^{0}04’29.0”	01^{0}39’56.0”	242	
El-Adow	Quarry	040^{0}05’54.1”	01^{0}50’27.1”	699	
Kulaaley	SW’s	040^{0}05’54.1”	01^{0}50’27.1”	699	
Eryb	Town	040^{0}05’54.1”	01^{0}50’27.1”	699	
Eryb	Dam/pan	040^{0}05’54.1”	01^{0}50’27.1”	699	
Biric Bur Bur	BH	040^{0}03’49.1”	01^{0}18’27.1”	205	
Leheeley/Kukaley	SW’s	040^{0}00’25.7”	01^{0}38’8.5”	230	
Ohiya	Dam/pan	040^{0}12’14.4”	01^0 31’ 59.1”	204	
AFYUR	Shallow well (not in	040^{0}05’49.6”	01^0 38’ 90.2”	211	
Lagh Bogal	BH	039^{0}51'14.0"	01^{0}16' 45.6"	206	40 m^3 Tank
Lagh Bogal)	Dam	039^{0}50'49.2"	01^{0}17' 17.6"	213	100*100*2
LaghBogal)Upstream	Dam	039^{0}50'41.8"	01^{0}17' 17.1"	210	80*120*3 m
KRCS	BH (not functional)	040005’38.2’’	01050’48.5’’	293	

ANNEX 7: Field observations

Table of Infilrometer tests results and sites description.

Location	WGS 84, 36N			Area/site description	Soil description	Infiltr. cap. (cm/h)
	Longitude	Latitude	Elevation (m)			
Lafaleey	040°05'54.1"	01°50'27.1"	283	Area has some trees grass and bare soil	reddish brown sandy soils overlying limestones. The sands are siliceous and loose, while the limestones are compact but with joints.	0.16675
Leheeley	E040°00'52.8"	N 01°38'20.1	236m	Several depressions are found in the area which exist as sink holes resulting from karstic dissolution.	It is dominated by reddish brown soils overlying limestones. The limestones in the depressions is highly decomposed forming clayey calcareous sandy soils.	5.4491
El-Adhow Infiltrometer test 1	040°04'28.9"	01 39'56.2"	245	Flat area, covered with some shrubs, grass and bare soilVolcanic plateau, many basalt outcrops. Covered with grass, some shrubs and bare soil There is a depression which has about 30 shallow wells, and an additional 15 shallow wells in the village.Lowland area is densly vegetated with grass and trees	The area is dominated by silty sand and limestone.	0.1305
El-Adhow infiltrometer test 2	040˚04'27.7"	01˚39'57.5"	237			1.46885
El-Adhow infiltrometer test 3	040˚04'26.7"	01˚39'57.5"	235			0.48285
Shabak Pan Infiltrometer test	039°58'9.8"	01°32'59.4"	240		Medium to low grain sand Sandy silt. Sandy silt(course silt). Sandy clay silt.	3.46985
Lagh Bor,infiltrometer test 1	039°58'43.4"	01°34'47.4"	222	Wide lagha, covered by reddish brown sands which have been cemented, compacted, and consolidated.The vegetation is mainly of acacia and scattered grass.The topography is flat where the lagga is fully filled with alluvial deposits.Its noted that this deposition takes place during the floods.	The site is dominated by reddish brown sandsSandy/silty soil,Silty/loam , Loam soil which have been cemented, compacted, and consolidated.	0.16385
Lagh Bor,infiltrometer test 2	040°01'49.1"	01°33'12.5"	220			0.2494
Lagh Bor,infiltrometer test 3	040°02'0.3"	01°33'04.9"	214			0.203
Eryb Infiltrometer 1	E 040° 00' 56.1''	N01° 09'11.9''	201m	The area has scattered vegetation of desert shrubs and grass .	The area is dominated by clays silts and sands overlying limestones Alternating series of these contemporaneous sediments occur at shallow depths, with some members not exceeding 10 cm thickness.	0.0812
Lafur Infiltrometer	039° 57' 18.3"	01° 12' 01.1"	204	Vegetation is Isolated thorny bushes on the slopes, dense Luxariant vegetation on the gently sloping river valleys.Windblown-reddish brown sands on the catchment underlain by compact consolidated and cemented members.	Grey to dark coloured alluvial soils and loose sediments, clayey along the river channel overlying reddish brown sands. Below the sands is compacted, clay -cemented sediments.	0.0841
Lagh Bogal Dam Infiltrometer	039°50'49.2"	01°17' 17.6"	213	Vegetation Isolated thorny bushes on the slopes, dense Luxariant vegetation on the gently sloping river valleys.	Soils dominating the site are Windblown-reddish brown sands on the catchment underlain by compact consolidated and cemented clays and fine sands	0.16385

Sukera Infiltrometer	*040^{0}04’10.2”*	*01^{0}21’28.7”*	208	The topography is generally flat with no gradients .Flood water flow is minimal and the area have characteristics of a flood plain with saveral natural depressions.Vegetation is desert shrubs ,acacia and scattered grass which is dry.	The site is dominated by sandy loam to silty /clay soils.	0.38425
Biric Bur Bur Infiltrometer	*040^{0}05’54.1”*	*01^{0}19’34.1”*	193	The vegetation is generally dominated by desert shrubs, acacia and scattered grass.	The soils consists of Sandy Silts and Sandy clay silt.	0.4901
Dabader Infilrometer	*040^{0}05’54.1”*	*01^{0}20’19”*	240	The area is flat with desert vegetation dominated by acacia, shrubs and scattered grass. There is potential for a pan once it is de-silted, compacted and well fenced. The area is a flood zone and the water is enough for a pan if only it can be channeled into the pan	Sandy silt ,Clayey silt and Sandy Clay silt soils	0.2639
Kulaaley				In Kulaaley the wells are aligned with the laaga. During rains the shallow wells are not used since the area is a lagga and water passes through it. The water presence can be attributed to the lagga which exposes the underlying water-bearing formation and on the other hand deposits water storage sediments	The geology is basically carbonate rock types Soils are generally red while the eastern part is covered by grey limestones.	

Table of investigated auger sites locations and remarks/description.

Auger Profiles			
Profile 1			
Location	**Lafaley Dam site**		
Latitude	**N 01°38’20.1”**	**Longitude**	**E 040°00’53.2”**
Depth	**Color**	**Texture**	**Remarks**
0-0.1			Manure with clay silty sand: Silt 20%, Manure 10% and Sand 70%
0.1-0.3			Silty fine sand (brown): Silt 20%, Fine Sand 80%
0.3-0.7			Fine to medium grained sand (brown to grey) : Silt 5%, Sand 95%
0.7-0.9			Medium to coarse grained brown sands: Silt 10%, Fine Sand 90%
0.9-1.0			Highly weathered limestones
Profile 2			
Location	**Lafaley Dam site**		
Latitude	**N 01°*50’27.1”***	**Longitude**	**E 040°*05’54.1”***
Depth	**Color**	**Texture**	**Remarks**
0-0.2			Greyish brown silty sandy soil
0.2-0.5			Brown sandy soil
0.5-1.5			Reddish brown calcareous silty sandy soils: Silt – 30%, sand - 70%
Profile 3			
Location	**Lafaley Dam site**		
Latitude	**N 01°38’22.3”**	**Longitude**	**E 040°00’53.7”**
Depth	**Color**	**Texture**	**Remarks**

Profile 1			
Location	**Lagh Bor**		
Latitude	**N 01°*34’47.4”***	**Longitude**	**E 039°*58’43.4”***
Depth	**Color**	**Texture**	**Remarks**
0-0.5m			Sandy soil
0.5m-1.0m			Sandy/silty soil
1m-1.5			Silty/loam soil
1.5-2m			Loam soil
Profile 2			
Location	**Lagh Bor**		
Latitude	**N 01°*33’12.5”***	**Longitude**	**E 040°*01’49.1”***
Depth	**Color**	**Texture**	**Remarks**
0-0.1			m-medium sand
0.1-0.3m			Sandy/Silt
0.3-0.5m			Silty soil
0.5-1.5 m			Loamy soils.
Profile 3			
Location	**Lagh Bor**		
Latitude	**N 01°*33’04.9”***	**Longitude**	**E 040°*02’0.3”***
Depth	**Color**	**Texture**	**Remarks**
0-0.1m			Sandy silt
0.1-0.3m			Silt
0.3-0.5m			Fine silty /Sand
0.5-1m			Silty sand.

Augter Profiles Continued'

Profile 1			
Location	**Shabaq pan**		
Latitude	**N 01°32'59.4"**	**Longitude**	**E 039°58'9.8"**
Depth	**Color**	**Texture**	**Remarks**
0-0.5m.			Medium to low grain sand.
0.5m-1m			Sandy silt. 80:20
1-1.5m			Sandy silt(course silt).
1.5-2m.			Sandy clay silt.80:10:10.
Profile 2			
Location	**Dabader Pan**		
Latitude	**N 01°20'19"**	**Longitude**	**E 040°05'54.1"**
Depth	**Color**	**Texture**	**Remarks**
0-0.5m.			Sandy silt 80:10
0.5-1m.			Clayey silt 90:10
1-2m			Clay silt, 95:5
Profile 2			
Location	**Sukera Pan**		
Latitude	**N 01°21'28.7"**	**Longitude**	**E 040°04'10.2"**
Depth	**Color**	**Texture**	**Remarks**
0-0.5m			Sandy Silt Clay.70:20:10
0.5-1m.			Sandy clay silt.70:25:5.

Profile 1			
Location	**Bicor El BurBur**		
Latitude	**N 01°19'34.1"**	**Longitude**	**E 040°05'54.1"**
Depth	**Color**	**Texture**	**Remarks**
0-0.5m			Sandy Silts. 80:20
0.5-1m			Sandy clay silt.60:30:10
Profile 2			
Location	**Bicor El BurBur**		
Latitude	**N 01°19'31.2"**	**Longitude**	**E 040°04'15.5"**
Depth	**Color**	**Texture**	**Remarks**
0-0.5m.			Sandy silt Clay.50:30:20.
0.5-1.2m.			Sandy Clay silt.60:30:10.

Profile 2			
Location	**Leheeley/Kukaley**		
Latitude	**N 01°38'8.5"**	**Longitude**	**E 040°00'25.7"**
Depth	**Color**	**Texture**	**Remarks**
0-0.3m.			Medium sand with Grit. 80:20
0.3-0.5m.			Fine sands
0.5-1m.			Fine sandy loam. 60:40

Profile 2			
Location	**Kulaley Village**		
Latitude	**N 01° 36' 5.8"**	**Longitude**	**E 40°07'29.7"**
Depth	**Color**	**Texture**	**Remarks**
0-0.2 m			sand
0.2 - 2m			Hard compact limestone

Auger Profiles Continued'

DProfile 1			
Location	**El-Adhow Village**		
Latitude	**N 01˚39'57.6”**	**Longitude**	**E 040˚04'26.7”**
Depth	**Color**	**Texture**	**Remarks**
0.0-0.7			Silty sand
0.7			Limestone
Profile 2			
Location	**El-Adhow Village**		
Latitude		**Longitude**	
Depth	**Color**	**Texture**	**Remarks**
0.0-0.7			Silty sand
0.7-1.5			Limestone
Profile 3			
Location	**El-Adhow Village**		
Latitude	**N 01˚39'57.6”**	**Longitude**	**E 040˚04'27.6”**
Depth	**Color**	**Texture**	**Remarks**
0.0-0.7			Silty sand
0.7-1.5			Limestone
Profile 1			
Location	**Lagh Bogal**		
Latitude	**N 01º17' 14.9"**	**Longitude**	**E 039º50'46.7"**
Depth	**Color**	**Texture**	**Remarks**
0-0.1			grey /brown silts and fine sand
0.1-0.3			grey/brown compacted silty fine sands clay -10%
0.3-1			Light brown grey sands, clays-15%, silts-20%, fine sand-65%.
Profile 1			
Location	**LAFUR**		
Latitude	**N 01° 12' 01.1”**	**Longitude**	**E 039° 57' 18.3”**
Depth	**Color**	**Texture**	**Remarks**
0-0.15			Dark to brownish sandy clay.
0.15-4			Dirty brown fine sand 80% silt 20%
Profile 2			
Location	**LAFUR**		
Latitude	**N 01° 12' 0.9”**	**UTM-y**	**039° 57' 19”**
Depth	**Color**	**Texture**	**Remarks**
0-0.1			Grey to brown silty sands
0.1-1			Grey to dark fine sands, claybands.
1-1.2			Clayey sands.
Profile 1			
Location	**Eryb pan**		
Latitude	**N 01º 09'11.7”**	**Longitude**	**E 040º 00' 56”**
Depth	**Color**	**Texture**	**Remarks**
0 - 0.1			loose medium to coarse silty sands: Clay: silt:sand = 10:40:50
0.1-0.4			Fine to medium greyish brown sands: Clay: silt:sand = 5:20:75
0.4-0.5			Clayey silty fine dark to brown sands: Clay: silt:sand = 10:30:60
0.5-0.7			Dark sandy clays: Clay 60%, silt 10% and sand 30%
0.7 – 1.9			Clayey silt sands-clay 40%,silt 30% and sand 30%
>1.9			Hard compact rock

ANNEX 8: General siting & design recommendations

1- Pans or valley dams

Open water storage in water pans is applied in all examined areas. However, sustainability and maintenance varies widely from source to source. Some good examples were found of water pans that were constructed many decades ago and still functioning well, while others may need improvement. Also, the amount of pans to store water may be extended. In the table below the physical requirements for the application of pans and valley dams are summarized, the table also shows in which zones the interventions may be applicable. In the next sections inspiring examples of the application of pans found in the target area are described, followed by the potential to improve the existing interventions, and the recommendations for new interventions.

Table A7-1 Physical requirements for pans and valleydams and their applicability in the 3R zones

Physical requirements	Applicability in different zones
- Water to fill to pan: from overland / road run-off, a rock catchment, or a stream (requires a sufficient large catchment upstream), or (diverted) water from a river - Clayish sediments to line the pan in a natural way by siltation. In case this is not present: artificial sealing should be applied - Preferably a gradual sloping valley to create a relative large aquifer behind a dam/dikes and to prevent to large turbulence for siltation	Applicable in all zones Sealing may be required in the zones with limited amounts of silt/clay: 1A-B, 3A-D and 4B Opportunities for large volume to surface ratios with dams are expected in mountainous zones 1A, 3A, 3C, 3E, and especially zone 5, while storage volume to dam height ratio migth be more favourable in plane areas.

Potential for improving existing interventions

Part of the pans visited in the area appeared to be functioning well. Some pans could use improvement, which was mainly related to management. Especially the double pans that were separately used for cattle and for domestic use showed a reduced management of the first one. In combination with the construction of such a separation, also improved management is this recommended.

Recommendations for siting and design

- The design of the construction should be made in such a manner that first a natural clay lining can be deposited to limit infiltration losses from the pan.
- The sedimentation of silt in the reservoir should be prevented as much as possible, to avoid reduction of the volume of the reservoir. Preferable, the intake water should have a low sediment load. This can be achieved by tapping water from floodplains of the streams. Here the water has reduced velocity and has lost sediment due to the vegetation buffer. If this is not possible, a silt trap should be created at the entrance of the reservoir.
- Preferably a large volume to surface ratio to limit evaporation loss, i.e. preferably relative steep edges and depths of more than 3 meters are recommended

- When siting a valley dam it is recommended to perform a catchment analysis to estimate the amount of water that can be captured, and to select location with natural narrowing in the valley, so that a relative small dam can be sufficient.
- It is recommended to improve the water quality by preventing that cattle enters the water, by fencing, and creating wells next to reservoir. Also the use of separate pans for the various demands is recommended to improve the quality.

2 - Sand dams and sub-surface dams

Natural subsurface dams are found in the examined areas in Marsabit, Moyale and Turkana. In the Turkana target area also man-made sanddams and subsurface dams were found. The natural barriers can serve as inspiring examples which can be artificially replicated at other locations. Additionally these existing barriers can be enhanced, and sanddams and subsurface dams can be applied at more locations. Examples of this are described below.

The interventions of sanddams and subsurface dams are in line with each other. They both prevent the sub-surface run-off of the water that is stored in the riverbed. The difference is that sanddams constructions exceed the riverbed, and can be applied to create or enlarge an aquifer in the riverbed, creating a larger water storage, while subsurface dams are constructed within the sandy sediment in the riverbed (i.e. no parts of the sanddam stick out of the existing sediment), and thus do not create an extra aquifer. An advantage of subsurface dams is that the stable construction for subsurface dams in rivers with a large peak discharge is easier than for sanddams. Additionally, the risk of changing the river bed is smaller when subsurface dams are applied. Large rivers often have high turbulent discharges, and wide riverbeds. These rivers may be less feasible for sanddams, and subsurface dams could be an alternative. Both for sand dams as subsurface dams the presence of a hard rock or clayish layer within the soil is required as a base.

In the table below the physical requirements for the application of sanddams and subsurface dams are summarized, the table also shows in which zones the interventions may be applicable. In the next sections inspiring examples of the application of sanddams or subsurface dams found in the target area are described, followed by the potential to improve the existing interventions, and the recommendations for new interventions.

	Physical requirements	Applicability in different zones
Sanddams	- Water to fill the sanddam: from the stream in which the sanddam is implemented - Coarse/sandy sediments supply in the stream to fill the aquifer behind the sand dam - An impermeable layer at which the sanddam can be based (e.g. basement rocks or clayish layer) - Stable, impervious river banks - Select a location with limited width of the river to limit the extend of the dam - Gradual slope in the river to create a relative large aquifer behind the dam	Applicable in zones with coarse/sandy sediment supply in the rivers. This is expected in zones 1A, 1B, 2A, 2B, 3A, 3B. In zones 2A-B there is only sanddam potention in the rivers that originate from areas which generate enough coarse sediments (zone 1A-B) and if they overlay areas with an impermeable layer, i.e. in zone 2A-B sanddam potential is expected when combined with (3D), 3F, 4C and 4D.
Subsurface dams	- Water to fill the subsurface dam: from the stream in which the subsurface dam is implemented - Coarse/sandy sediments already present in the riverbed - An impermeable layer at which the subsurface dam can be based (e.g. basement rocks or clayish layer) - Stable river banks/ a steady river course - Select a location with limited width of the river to limit the extend of the dam - Gradual slope in the river to create a relative large aquifer behind the dam	Applicable in the same zones as sanddams, see B. Subsurface dams have potential in these zones in rivers with an existing coarse sediment bed. Subsurface dams may have a greater potential than sanddams in larger, wider rivers with coarse sediments (expected to occur in plain areas, i.e. zone 1B, 3B and 3D, 3F, 4C-D combined with zone 2A-B).

Table A8-2 Physical requirements for pans and checkdams and their applicability in the 3R zones

Recommendations for siting and design

Some recommendations for siting and design are given:

- When cattle is allowed to walk directly on top of the aquifer, this may pollute the water stored in the aquifer, because the manure of the cattle may enter it. Therefore, it should be prevented that the cattle enters the area on top of a sandy aquifer, by fencing this area.
- This can be strengthened if the water is not withdrawn from the aquifers by scoopholes, but by wells placed next to the aquifer, in the river banks. For this see the next section: riverbank infiltration.
- When the construction of a sanddam is required and a suitable location needs to be selected, it is recommended to take the advantage of natural barriers where the bedrock is located relatively shallow. Based on the geology, it is expected that the natural barriers appear more or less parallel to the edge of the mountain ridge. In other sand rivers along the mountain comparable natural barriers are thus expected.

It is recommended to site the subsurface dams at locations where the riverbed is relatively narrow, and where the path of the river is stable (the river should not move towards other beddings in between the years). The latter can in sedimentary areas for example be indicated by the vegetation, stable river paths are generally recognizable by trees and older bushes.

Annex 9: Order of magnitude for storage capacity of 3R interventions

Each kind of intervention has its own typical storage capacity. In the table below the order of magnitude of storage that is associated with different interventions in provided. This is order of magnitude is based on common storage capacities of interventions in the program area, but individual cases vary.

To estimate the amount of water that is available for water use, the losses from the storage also have to be taken into account. For example, pans can store relative large amounts of water (about 5,000-25,000m3) however, the losses from pans are also substantial, about 5 mm is lost to evaporation during the dry period, which can add up to 1.5 m during a dry period of 10 months. Additionally, water is lost from leakage. When a good clay lining is available from the local material, the leakage can be limited. Nonetheless, still in that case the leakage loss can be in the order of 1 m/dry period or more. Therefore if pans are intended to be used for the full dry period an extra investment in proper lining (e.g. compacted lining, concrete or plastic lining) to reduce the water losses can be beneficial. Also the depth of the pan should be sufficient (>3-4 m), because otherwise most of the water will be lost to evaporation and possibly leakage. For the rest of the interventions we refer to the table below.

Table A9: Global indication of the order of magnitude of the storage capacity and the losses associated with different interventions.

	Intervention	Order of magnitude of the storage capacity	Losses
A	**Pans and valley dams**	About 5,000-25,000 m3 in the pans Volume of retention behind checkdams or valley dams depends of the elevation. E.g. 2,000,000-5,000,000 m3 could be stored in the reservoir proposed in Marsabit. From this volume the waterloss by evaporation should be subtracted.	Evaporation loss is about 5 mm/day. For pans of 3m depth this is about 50% of the volume. Leakage adds another loss, therefore locations with a good natural clay lining should be selected or concrete or plastic lining should be applied.
B	**Sanddams**	About 100-5,000 m3, depends on the steepness of the riverbed behind the dam. Since sanddams are mostly applied in elevated areas the storage is limited by the slope of the bottom of the reservoir behind the dam.	The evaporation loss is rather small. Leakage depends on the permeability of the layer on which the sanddam is based, this can be small in e.g. basement areas. Nonetheless, the efficiency loss can be tens of percent's.
C	**Subsurface dams**	1,000-30,000 m3 depending on the steepness of the riverbed, the depth of the impermeable layer and the width of the riverbed. 30,000 m3 can be achieved in flat riverbeds with a gradient of the bottom of the riverbed of < 1 promille	The evaporation loss is rather small. Leakage depends on the permeability of the layer on which the subsurface dam is based. This can be larger in e.g. the sedimentary areas. Therefore, depending on location of application the efficiency of sanddams may be somewhat smaller than that of sanddams.
D	**Shallow, phreatic groundwater: wells and riverbank infiltration**	Location dependent, depends on the aquifer characteristics	-
E	**(Flood)water spreading and spate irrigation**	See D, additionally, this techniques are often applied to create grazing grounds or to irrigate agriculture, rather than storing water.	-
F	**Gully plugging, retention weirs, and other run-off reduction/infiltration options**	Depends on the possibilities to retrieve the water (e.g. springs). Additionally, this techniques are often applied for erosion reduction and to create grazing grounds or agriculture, rather than to store water.	-
H	**Closed tanks**	Generally 5-200 m3, also depends on the amount of water to fill a tank. With e.g. rooftop harvesting this can be the limiting factor (a roof of 30m2 provides with 300mm rain 9 m3 of water).	When the tanks are properly constructed, the losses will be minimal. When the tank is filled, not all water may be stored, because the first flush may be excluded to improve the quality.

ANNEX 10: Example methodology for matching RI and DA

Location: Logologo, Marsabit, Kenya
Carried out by FH project partners of the KALDRR-WASH project
Disclaimer: this exercise was done to test the methodology only, the values and maps are fictive and should not be used for planning process.

Step 1: agreement on planning year in the future

Year: 2023

Step 2: Length of typical dry period in month

Length dry period: 10 months
(year that has only one wet season, whereas there are in general two wet seasons)

Step 3: Estimate of water gap for the whole area

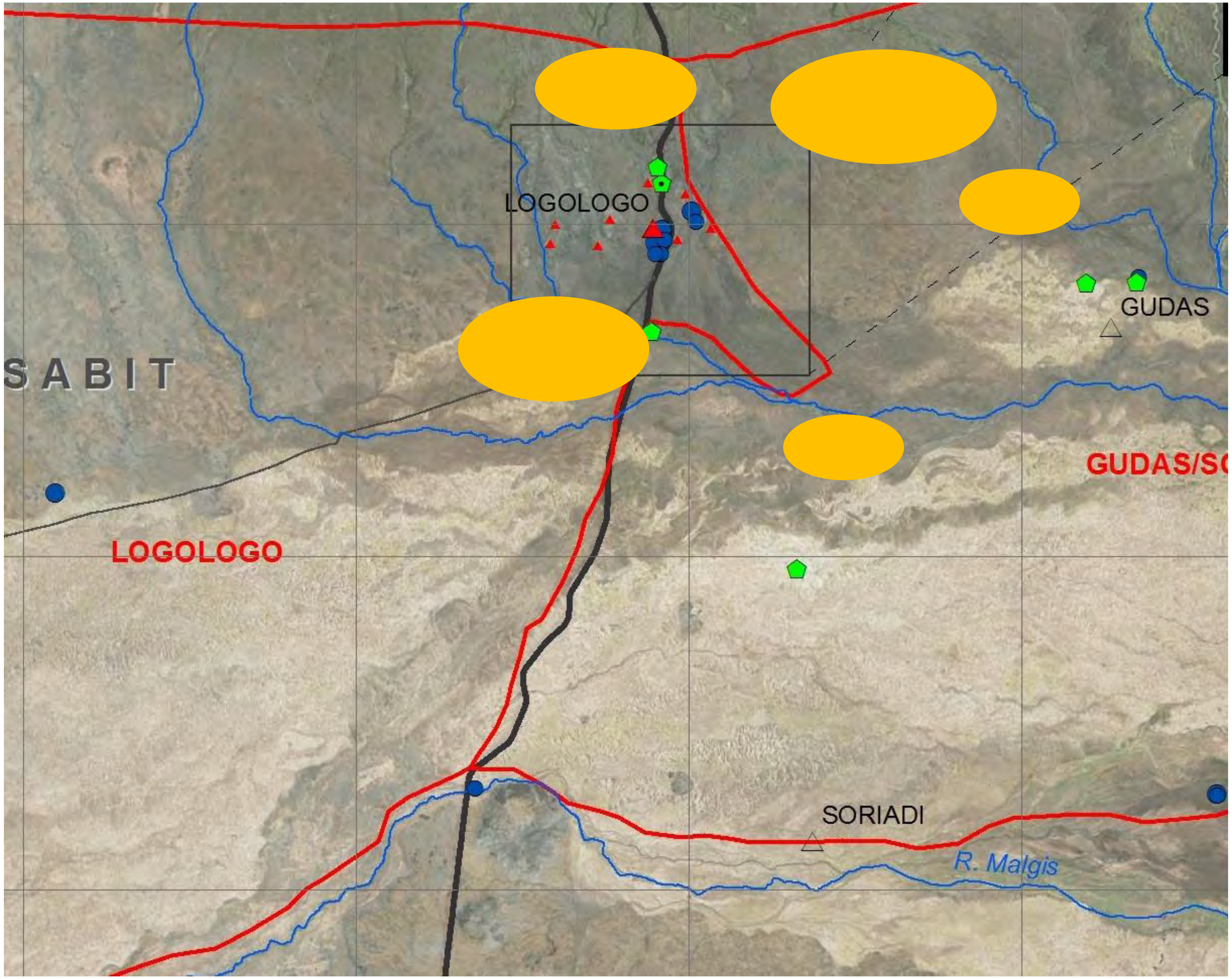
1. Using the estimate methodology of chapter 6, provides the values for the demand in 2023. In the case of Logologo, wildlife is assumed to make use of the same infrastructure (remote water pans), during the same periods as the migrating herds for a period of 3 months only
2. Infrastructure has been estimated based on:
    a. Boreholes, pumping 8 hours/day
    b. Water pans, using 50% effective storage of their capacity
3. In Logologo no difference between resource and infrastructure is made
4. Existing resources/infrastructure is assumed to supply the same volume in 2023 as in 2013

Type of water use	Water gap (resource)[1]	Infrastructure gap[1]	Demand in year 2023[1]	Existing water resources[1]	Existing water infrastructure[1]
Domestic	11,000	11,000	35,000	24,000	24,000
Livestock	48,000	48,000	74,000	26,000	26,000
Small scale agriculture	62,000	62,000	63,000	1,000	1,000
Migrating herds	21,000	21,000	23,500	2,500	2,500
Wildlife	21,000	21,000	22,000	1,000	1,000
Total	163,000	163,000	217,500	54,500	54,500

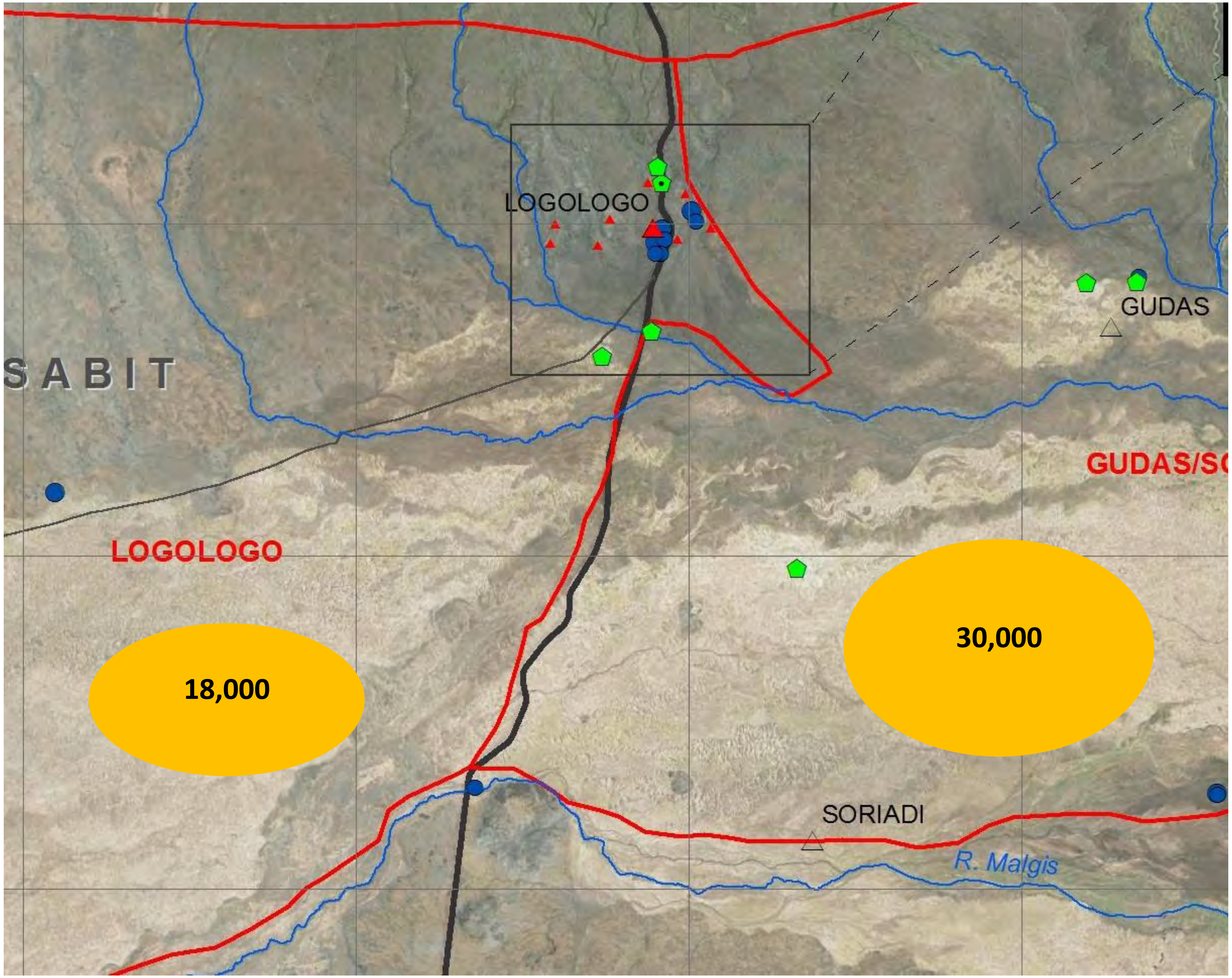
[1]: in m^3 covering an agreed dry period

Step 4: draw separate maps for each water use, locating where they are expected to occur.

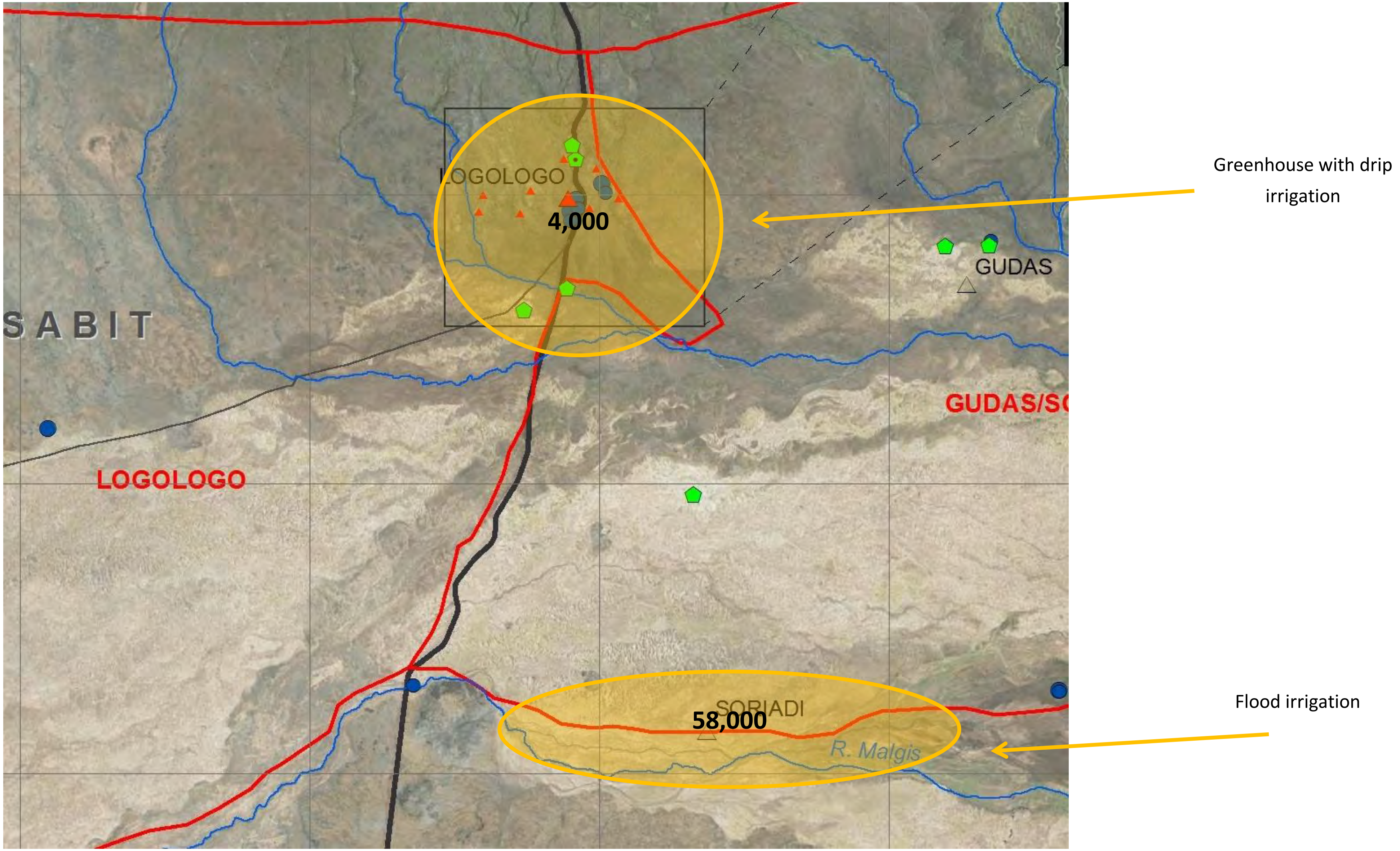
Gap domestic water demand Logologo 2023 (m^3)



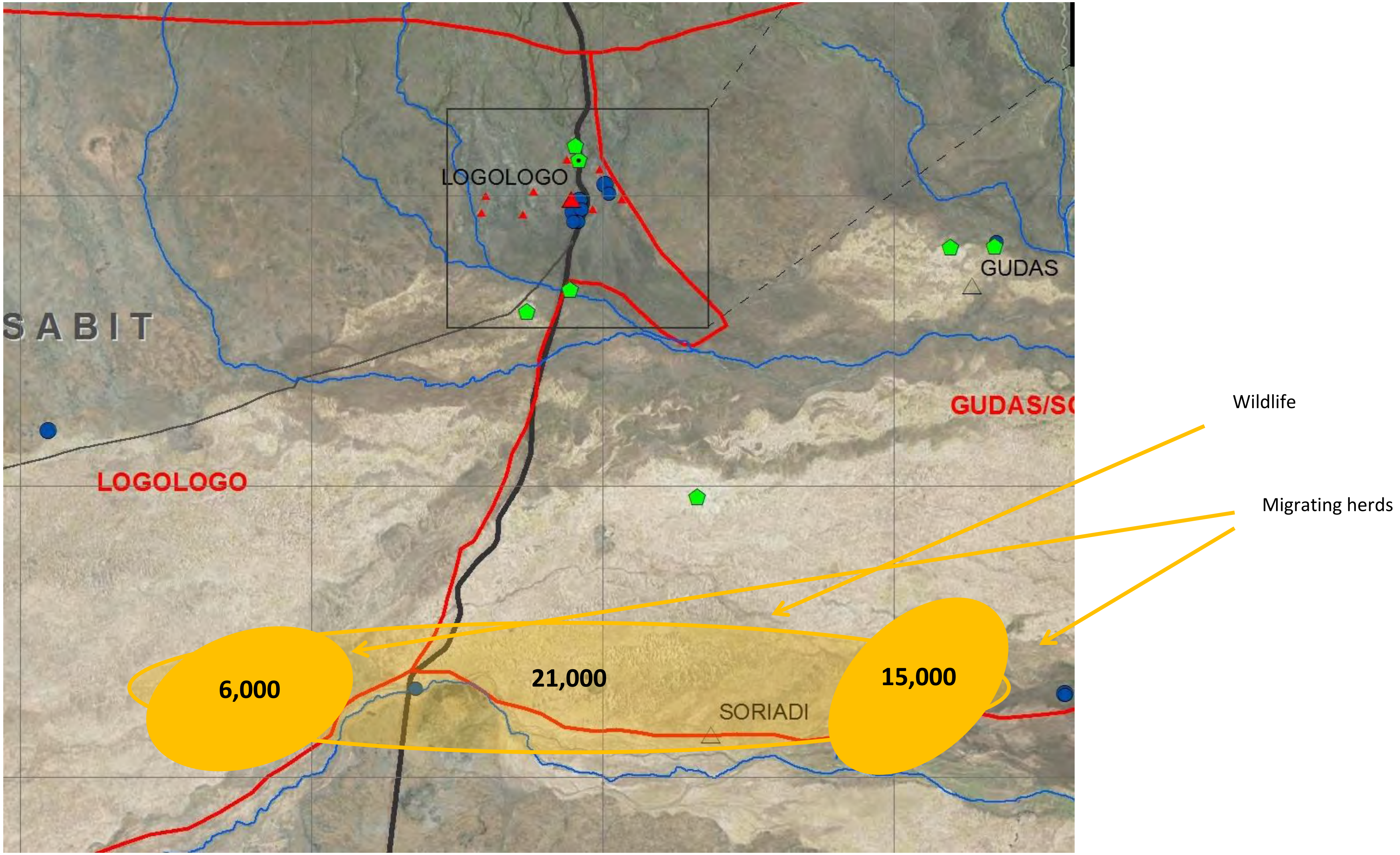
Gap livestock water demand Logologo 2023 (m^3)



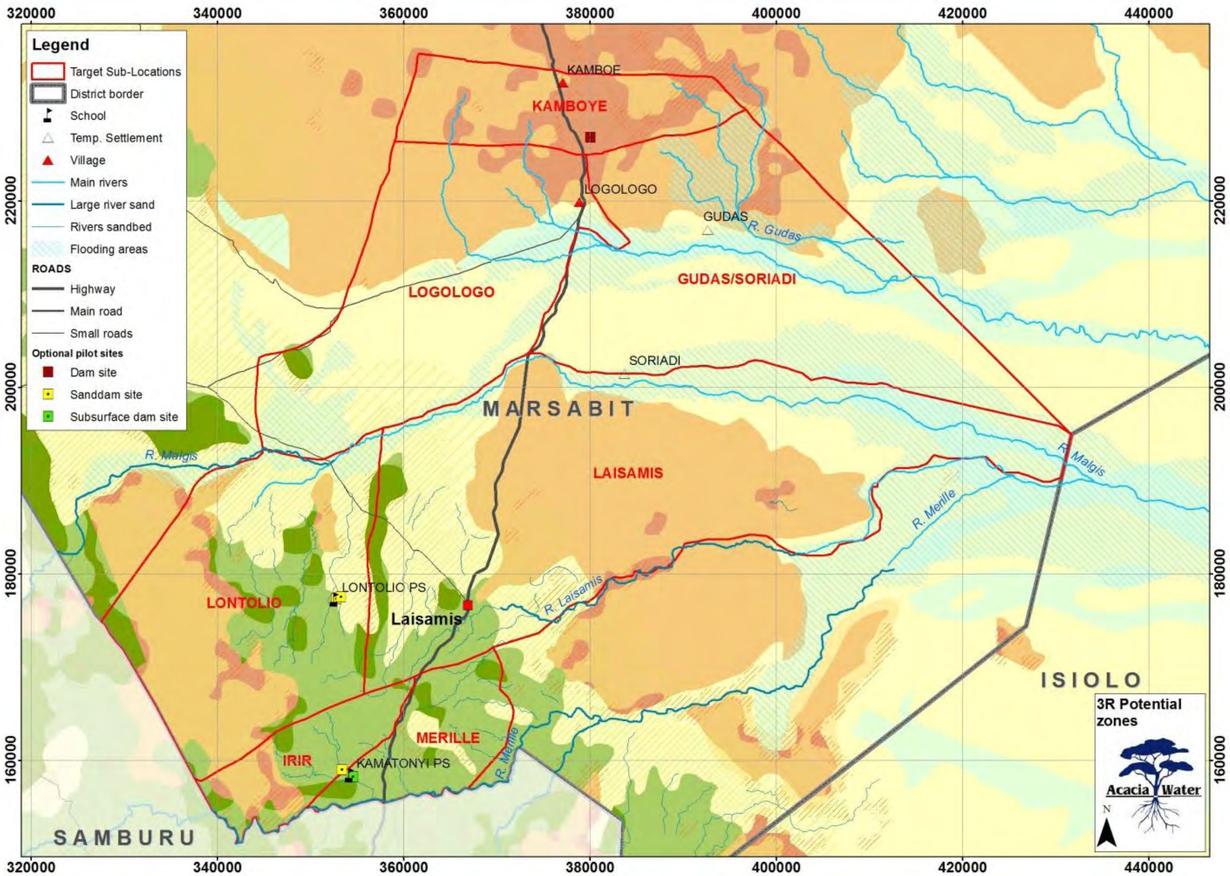
Gap agriculture water demand Logologo 2023 (m^3)

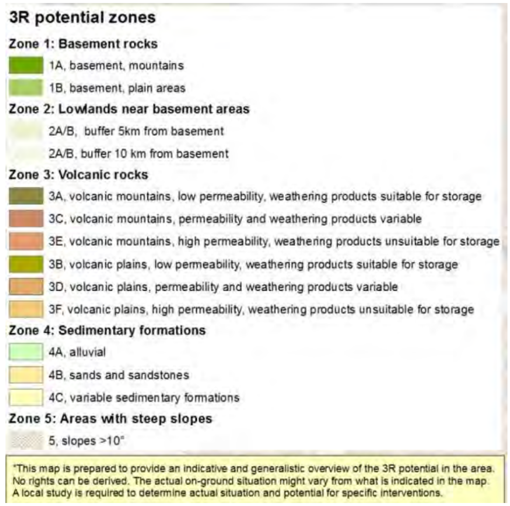


Gap migrating herds and wildlife water demand Logologo 2023 (m^3)



Step 5:Use the 3R map of the area to identify potential 3R interventions





	A	B	C	D	E	F	H	G
Zone 1A	x^1	x	x	x		x	x	x
Zone 1B	x^1	x	x	x	x	?	x	x
Zone 2A		x^2	x^2	x				
Zone 2B		x^2	x^2	x				
Zone 3A	x^1	x	x	x		x	x	x
Zone 3B	x^1	x	x	x	x	?	x	x
Zone 3C	x^1	?	?	?		x	x	x
Zone 3D	x^1	$?^3$	$?^3$	?	?	?	x	x
Zone 3E	x			x		x	x	x
Zone 3F	x			(x)		?	x	x
Zone 4A	x			x^4	x	?	x	x
Zone 4B	x^1			?	?	?	x	x
Zone 4C	x	x^3	x^3	x^4	x	?	x	x
Zone 4D	x	x^3	x^3	?		x^5	x	x
Zone 5	x			?			x	x
Zone 6	x			x			x	x

A	Pans and checkdams
B	Sanddams
C	Subsurface dams
D	Shallow, freatic groundwater: wells and riverbank infiltration
E	(Flood)water spreading and spate irrigation
F	Gully plugging, retention weirs, and other run-off reduction /infiltration options
H	Closed tanks
G	Deeper, confined aquifer groundwater: wells / boreholes

Kind of 3R interventions which may be possible in the zones. Deep groundwater is outside the scoop of the study , which focusses on the shallow (ground)water system, and just indicated as another possibility. The superscripts denote: 1. possibly sealing required; 2. combined with 3B, (3D), 4C, 4D; 3. combined with 2A-B; 4. Pronounced; 5. Increase infiltration.

Step 6: Use the table of annex 9 for planning of 3R interventions

Based on the location of the demand for the different uses; the potential for 3R depending on the different zones; and, the storage potential for 3R interventions (annex 9), a first tentative planning of 3R interventions is made.

For the Logologo area, the team identified the following interventions:

Disclaimer: all the interventions below are preliminary only, further feasibilitry and assessment on the ground are necesssary to determine final feasibility and choice.

A. For **domestic** water supply: extend infrastructure of existing boreholes and/or develop new boreholes. The geography of the area where settlements and extensions are expected is not suitable for 3R inteventions

B. For **livestock** water supply:

(1) Apply flood water spreading to increase grazing land area around Gudas and Soriadi

(2) Construct water pans west from the high way and east of the high way to allow for increase in livestock numbers

C. For **agriculture** water supply:

(1) Apply drip irrigation based on boreholes and/or water pans for irrigating in greenhouses around the settlement area of Logologo

(2) Apply flood irrigation in the Laisamis seasonal river

D. For **seasonal migration and wildlife** water supply: construct water pans around the Laisamis seasonal river, both on the east and west side of the highway.

ANNEX10: Photo gallery for demand and access consultations in Wajir: Eyrib-Sukela and Boji sub-locations