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 Logologo in Marsabit

Final version - September 2013

Authors:

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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.

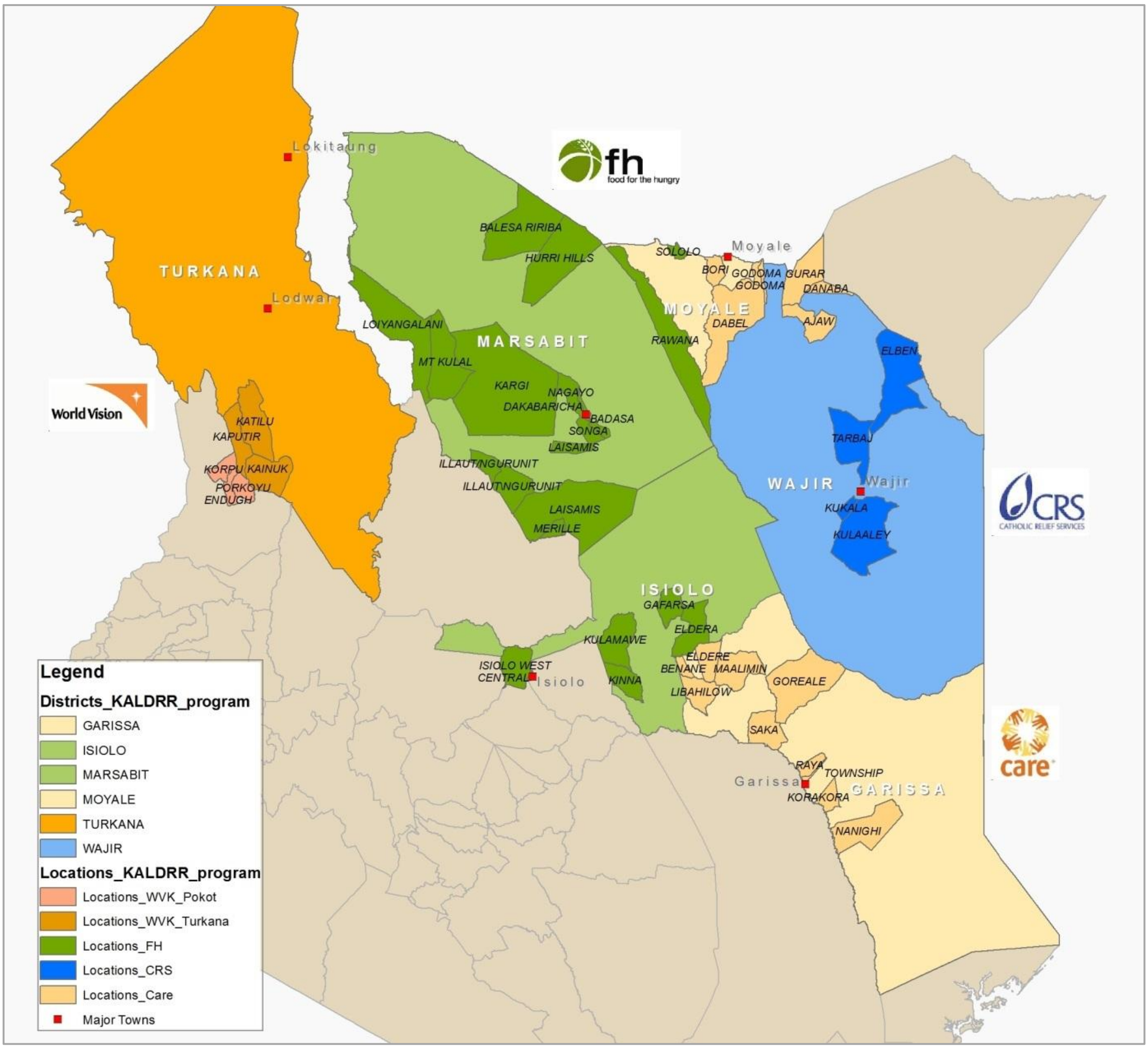

Figure 1-1: KALDRR project areas

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

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[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 of the evaluation in the 3R/MUS target area of FH, which is located in Marsabit 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.

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[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).

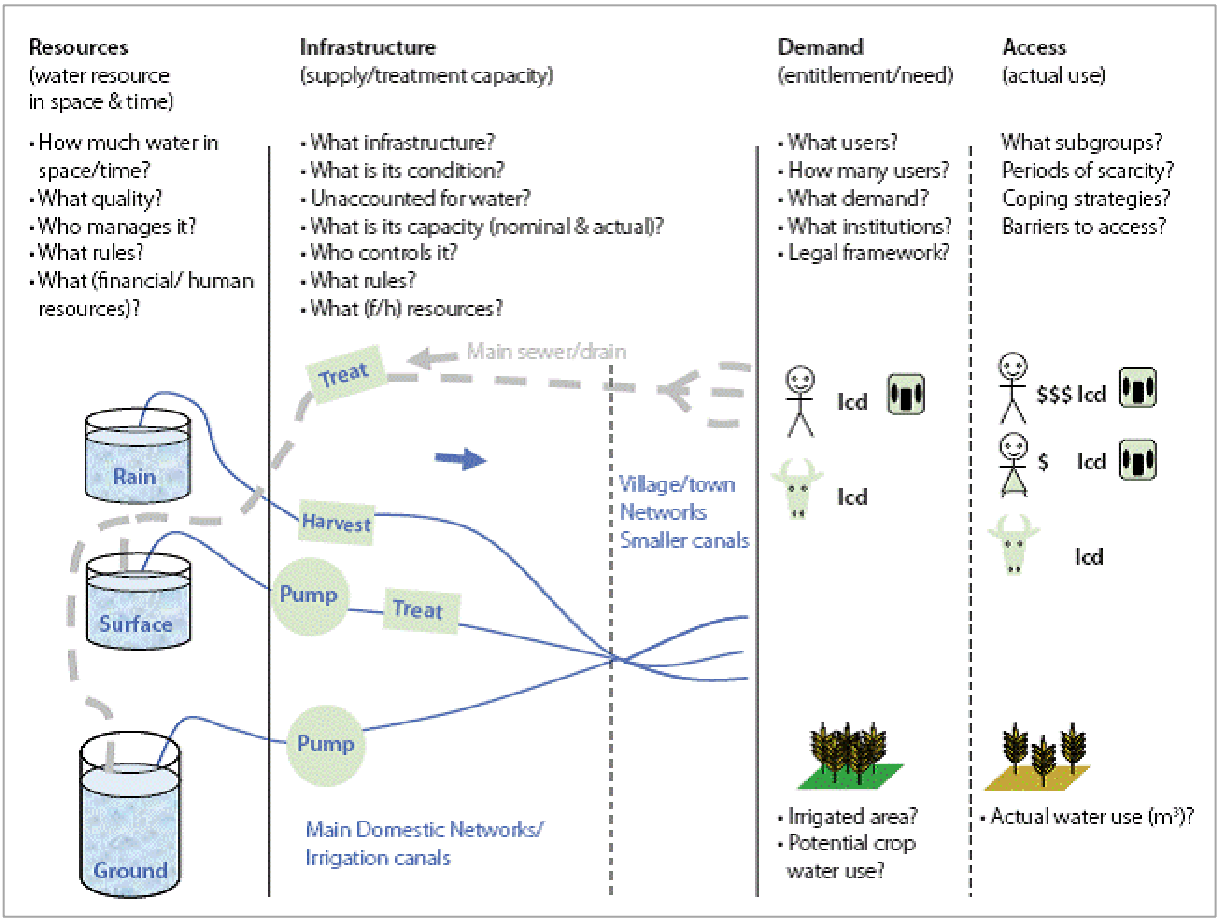


Figure 2-1: Example of RIDA (Empowers 2007)

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.

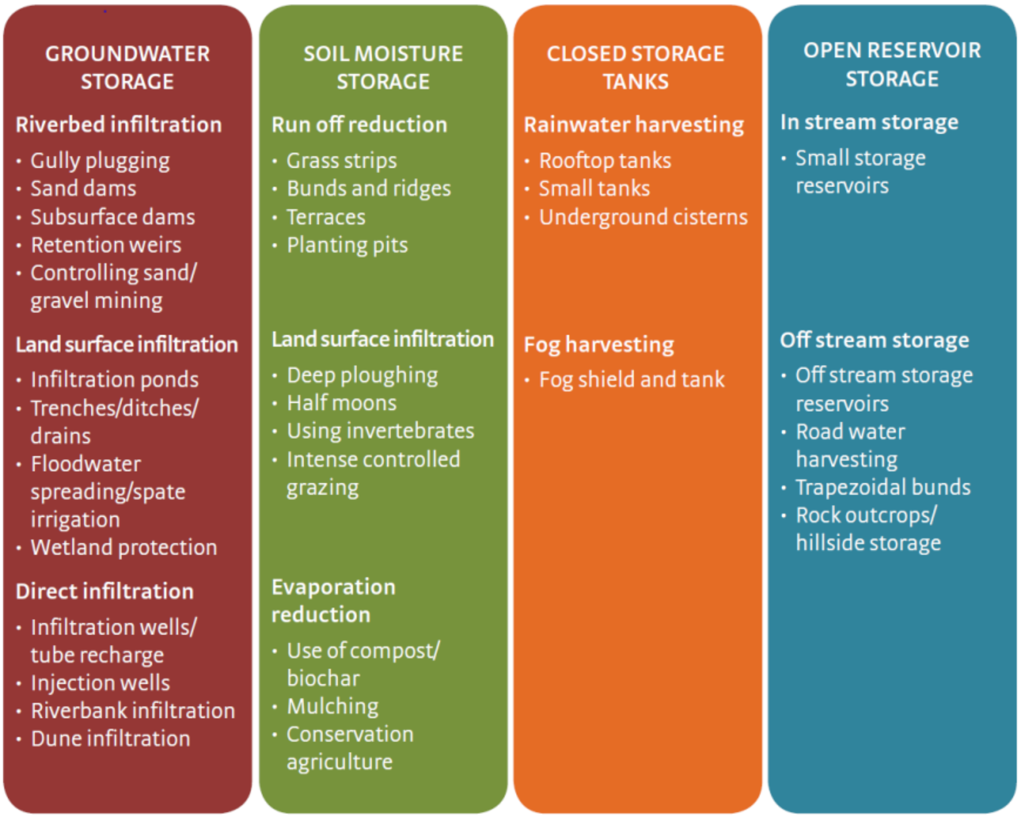


Figure 2-2: Overview of 3R techniques (replicated from tuinhof et al., 2013)

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:

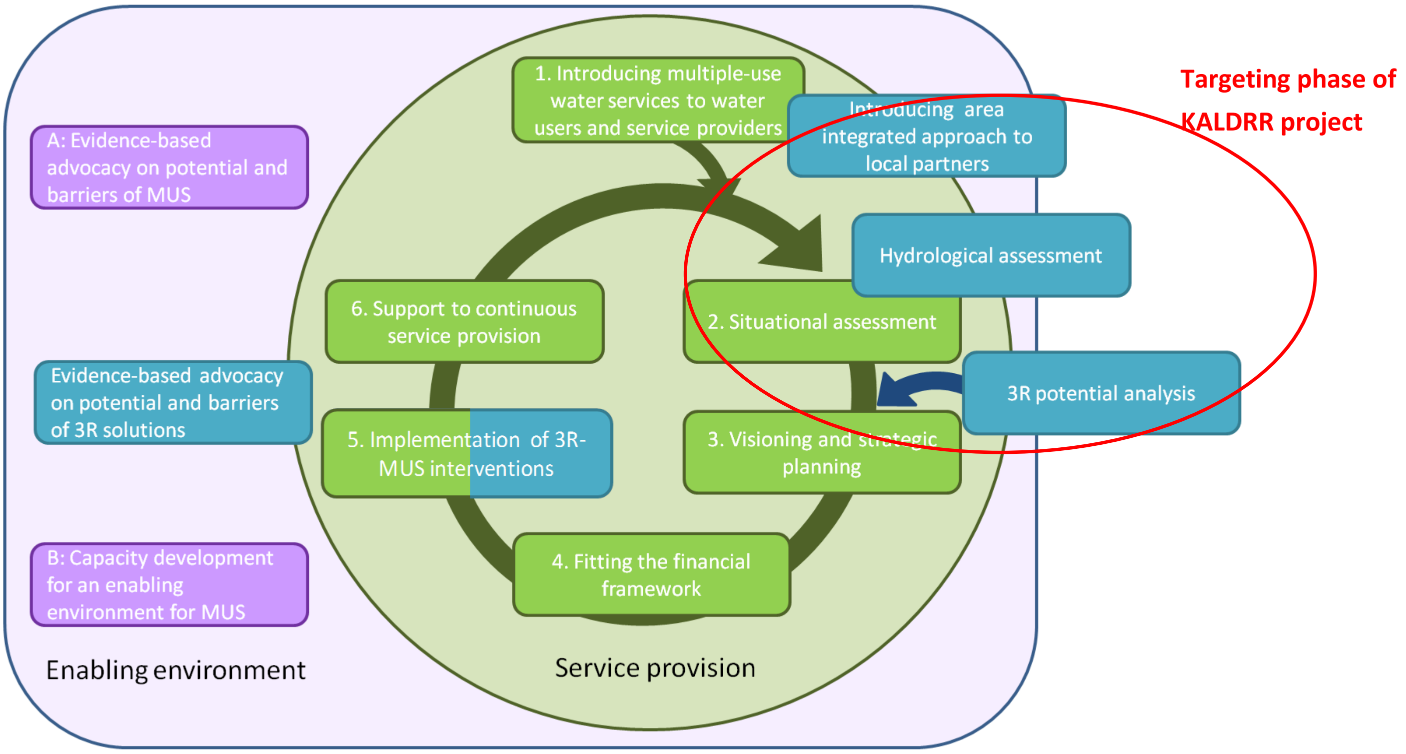


Figure 3-1: Process cycle, combining the MUS components (in green) with the 3R components (in blue)

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 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.

[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.

- 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.

Step 1: 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.

Step 2: 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.

Step 3: 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.

Step 4: 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).

Step 5: 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 Moyale County

The following is based on FEWSNET "Livelihoods zoning "plus" activity in Kenya", 2011 (Livelihood Zone 7: North-eastern Agro-pastoral Zone).

Northern Pastoral Zone (Marsabit and Isiolo)

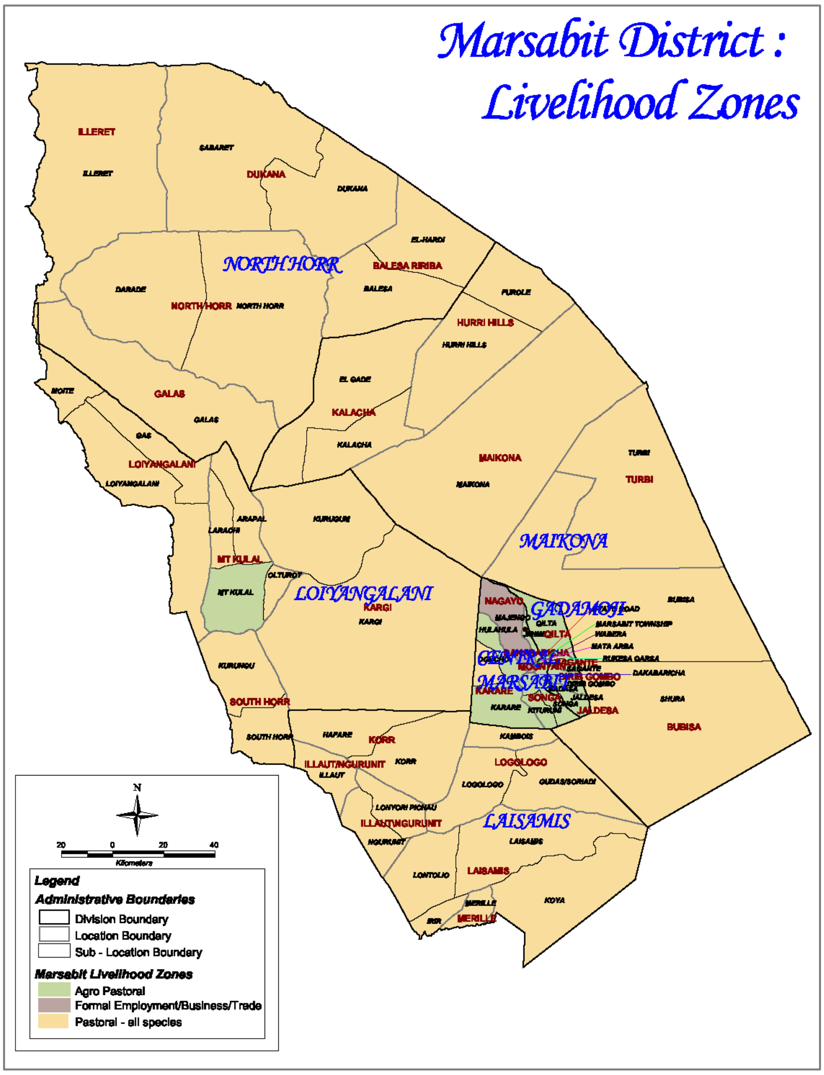


Figure 4-1: Marsabit District livelihood zones (source: NDMA)

This zone lies in one of the driest parts of the country. The rainfall patterns are bimodal and display both temporal and spatial variation. The zone receives between 200mm and 800mm of rainfall per annum. The average annual temperatures are hot, ranging from 20 35^{o}C. January to March and September to October are the warmest months with a mean of 30^{o}C. June and July are the coolest months with temperatures averaging 24^{o}C.

There are several ethnic groups in this livelihood zone including the Borana, Samburu, Burji, Gabra and Rendile/Ariaal. The majority of the inhabitants (80%) are semi-nomadic, while 10% are occasional nomads and 10% are fully settled.

Livelihood

A typical household keeps 5-10 cattle, 20-25 goats, 15-20 sheep, 0-5 camels and 0-1 donkey. Cattle provide the majority of income from household livestock production, followed by goats, sheep and camels. Camels and goats, on the other hand are the highest contributors (about 30%) to food from household livestock production. The majority of the food consumed by household in this zone is purchased. This includes maize, rice, sugar, various pulses, vegetables, cooking oil and beans. However, some food items such as meat and milk and other dairy products are obtained primarily through household production. Households in this zone also rely on wild foods including fruits and berries, honey, roots and tubers.

Livestock production is the highest contributor to household income (up to 85%). Income is generated from the sale of livestock products like meat, milk, hides and skins. Other income generating activities include firewood collection, hunting and gathering and casual wage labour. Remittances and gifts can contribute up to 10% of income for poorer households.

Food insecurity

Insecurity, poor road infrastructure and low levels of education are some of the underlying factors causing high food insecurity in the zone. Although markets are poorly integrated and characterized by high inefficiency, supplies often flow in from Ethiopia through Moyale and Marsabit (April-July) thereby contributing to food availability.

Other elements that hamper development activities in general in the area are:

- Insecurity due to conflicts caused by cattle rustling and competition over access and control of natural resources, in particular water and grazing lands.
- Although improving, both the communication and roads networks in the area are still poor and make interactive communication and logistics for support services a challenge.
- Droughts and intermittent floods set back development interventions and when they trigger emergency interventions these may interfere with the development related processes.
- Dependency culture in the community which translates to a laid back attitude to project participation, with many people strategically rely on support from NGOs and governemnt.

The resources from which water can be harvested exist of rain -which can be directly harvested and stored-, overlandflow, gully flow, seasonal rivers, groundwater and springs. These components and their occurrence are shortly described in this section. In chapter 5 their characteristics in relation to the different landscapes classes will further be described.

4.2 Area selection in Marsabit

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

The 3R/MUS pilot area is located in the middle to south of the Marsabit district. The selected 3R/MUS pilot area for the local inventory is the Logologo Location, consisting of Kamboe (about 25 km south of Marsabit town), Logologo (about 40 km south of Marsabit town) and Gudas/Soriadi Sub-Locations. For the 3R landscape analysis a larger area was used for evaluation. For this analysis the pilot area was extended to the north to include the area near Karare (just north of Kamboe), and to the south to include the Laisamis Location, including Lontolio and Kamatonyi (about 100 km south of Marsabit town). This area is further referred to as the 3R target area, and is shown in the figure below.

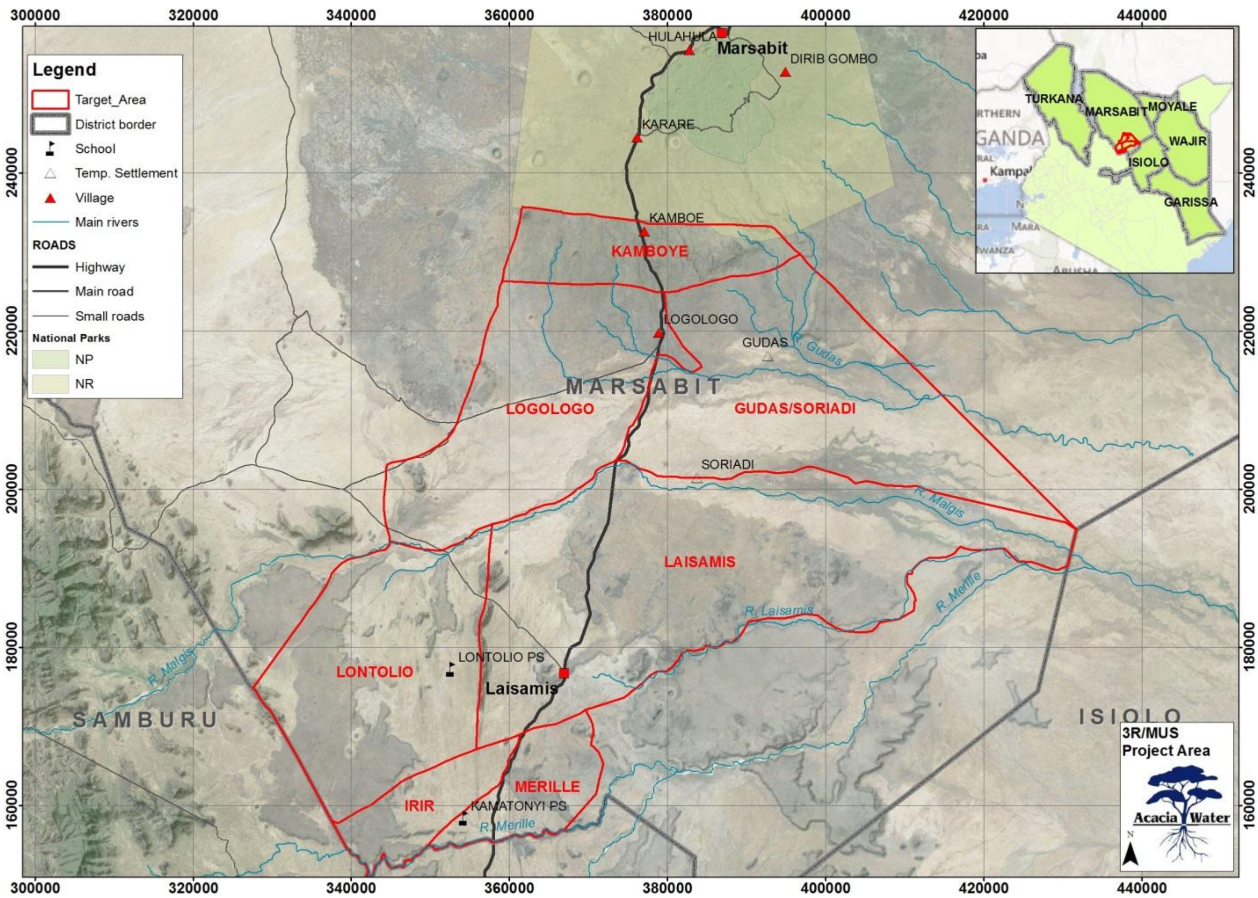
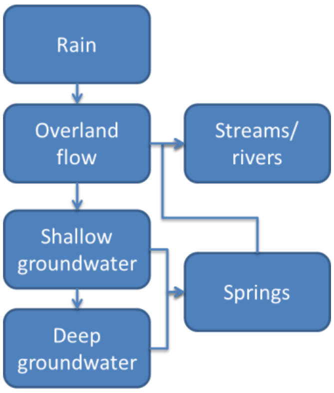


Figure 4-2: Selected target areas. In blue the 3R target area where the resources and infrastructure are evaluated, and in red the 3R/MUS pilot area for the long-term planning

As can be seen in Figure 4-2, the northern part of the target area consists of the middle and lower slopes of the volcanic Mount Marsabit in the North. A plane sedimentary area is present in the southern part of Logologo and Gudas Sub-Locaions. The Central part of Laisamis and the Western part of Lontolio Sub-Location are covered by volcanic plateaus, while the middle a relative plane basement area is present with some large rock outcrops. More details of the landscape characteristics, geology and soils are provided in Chapter 7.

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 total annual rainfall in the area is strongly related to the appearance of mountains. The highlands of Mount Marsabit receive a relative high annual rainfall of on average 700-800 mm. In the surrounding lowlands, the annual rainfall is much lower with an average of 300-400 mm. For the region rainfall data were not available yet (they are being requested at the Kenyan Meteorological Office). The general available data show that the rainfall generally falls in two wet seasons, which peak around April and August. During these wet seasons the rain tends to fall in short and heavy events.

Overland flow

At the slopes of Mount Marsabit (on the northern edge of the 3R target area) the intense rainfall events generate high surface runoff, discharged through the large gulley's and valleys present on the slopes. During the field visits it was observed that at the slopes of Mount Marsabit the overland flow is causing (substantial) erosion. The overland flow at the slopes is lost from the area, unless it is captured with interventions like pans or checkdams.

Also near the large riverbeds in the relative flat lowland toward the eastern part of the target area overland flow is found. Here the overland flow is caused by rivers which are spreading over a larger area when the slope of the riverbed becomes less steep. This was observed in the field from alluvial deposits, dense vegetation cover and flow patterns, and confirmed by local interviews.

The overland flow in the floodplains has a lower velocity, which may cause natural infiltration. Here sediment is likely to deposit and the clayish sediments combined with the natural infiltration provide fertile soils. The maps developed with the stakeholders and field interviews indicated that the main dry season grazing lands are located in the floodplains of the streams and rivers. These areas were also observed to have a much higher vegetation cover compared to other areas, which indeed indicates the occurrence of overland flow in these floodplains.

Streams and seasonal rivers

There are no perennial rivers in Marsabit County, as was concluded during the physical landscape analysis, which was confirmed by local interviews. In the target area small, short existing streams, and seasonal rivers of different sizes can be found. Figure 5-3 provides an overview of the existing water sources and rivers in the area. In the southern part of the target area the seasonal rivers contain a substantial amount of sandy sediment. Streams and gully flow are found at the slopes of Mount Marsabit. Other existing streams with a short seasonal flow are found around Lontolio and Kamatonyi, which partly discharge into larger seasonal rivers, and partly ‘disappear’ due to infiltration and evaporation. Field interviews indicated that the rainfall events create flash floods. Within an hour after heavy rainfall the discharge starts and after some hours the flow disappears again. Especially streams and rivers found on the mountain slopes were indicated to have a high periodical discharge directly after rainfall events, but to dry up quickly thereafter.

In the valleys at the eastern side of the mountain and at the foot of the mountain water from the streams accumulates into seasonal rivers. Additionally, seasonal rivers enter the pilot area from the western side, amongst others the Malgis river (see Figure 5-3). When the seasonal rivers enter the less elevated lowlands towards the eastern half of the pilot area, known as Kainut Dessert, the river floods spread out over a relative large area. Only a part of the water leaves the area at the eastern side of the pilot area, where most of it discharges towards the Lorian swamp. The water in the larger rivers and floodplains disappears within weeks after the rains have stopped, although the soils retains the moisture for much longer.

The streams on the slopes of Mount Marsabit vary from small streams or gulleys of 1 to 5 m with, up to larger seasonal rivers on the lower slopes with a width of up to 50 m. These streams have formed canyon like valleys with a width of up to several hundred meters and a depth of over a hundred meters (Figure 5-2). In one of these valleys, a large dam (Badasa Dam), is currently being constructed about 10 km south of Marsabit to supply the Town.

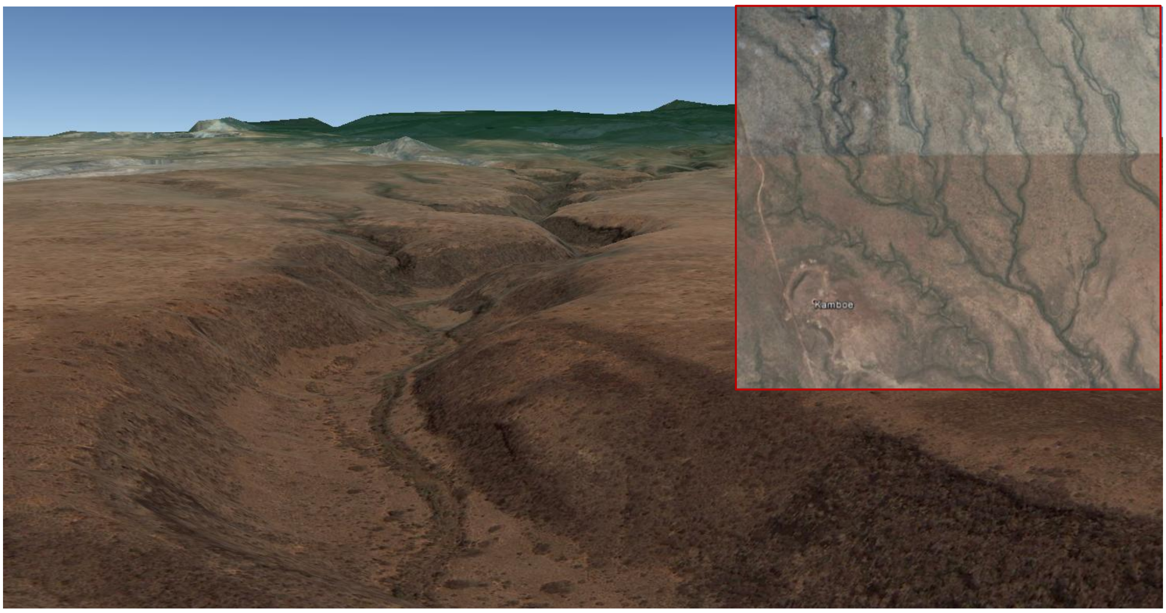


Figure 5-2: Large valley on the South-Eastern slopes of Mount Marsabit (source: Google Earth)

On the upper slopes the beds contain large stones and boulders and little sediments, while on the middle and lower slopes many of the beds contain loamy material. Some streams on the middle and lower slopes contain course sand, but the depth to the bedrock is unknown. At the lower slopes especially, water is expected to be lost to deep infiltration.

In Laisamis Location many of the water courses contain a substantial amount of sandy sediment, as was observed both on the satellite data from the area as in the field. In Figure 5-3 the distinction between streams with and without a sandy river bed are indicated. All the visited smaller rivers and streams have hardrock within several meters below the riverbed. Also the large rivers in this area have riverbeds with sandy sediment, including the Malgis, Laisamis and Merille Rivers, but the depth of the sandbed is unknown.

Groundwater

Many parts of Marsabit County are known to have productive deep aquifers, in the3R/MUS pilot area water strike levels in boreholes are varying from 50-120mbgl (meter below ground level). Limited drilling logs are available, although the borehole database from WRMA provides some details (see Annex 6). On the high altitude area surrounding Marsabit Town, borehole siting and drilling is challenging due to unstable volcanic formations, and deep groundwater levels (over 200mbgl). On the lower slopes within the 3R/MUS target area, groundwater has higher potential, as many good yielding deep boreholes are present. Water strikes generally vary from 50 to 100 mbgl. Deep aquifers in the area can have relative high potential; boreholes with a yield of up to 20 m^3/h are present. Generally the water quality is good, but some of these aquifers have water quality problems, due to high salinity.

In the project area shallow groundwater occurs within the volcanic formations of Mount Marsabit where a number of springs and shallow wells are present. Shallow groundwater is further found along the streams (laggas) on the upper slopes and some at the middle slopes of the Marsabit Volcano. They are located within the area that remains much greener than the surrounding areas, which is partly related to the National Park Boundary, which is located just north of the target area.

Other potential areas for shallow groundwater abundance are expected to be present in perched aquifers within the sedimentary formations and along the larger rivers, including the Malgis River.

Springs

Springs are present on the upper slopes, which are expected to have their recharge from infiltration on the upper plateau and crater lakes, which extrudes at the upper slopes where hard rock is surfacing. Some springs are also found at the foot of mountain, at the interface of the volcanic formations and the surrounding sedimentary formations at some places. Most springs have a perennial yield, but yield drop during the dry season. Field interviews indicated that especially during extreme dry years spring flow drops significantly.

5.2 Existing infrastructure

In the area already a number of different water infrastructures exist, including motorized deep boreholes with piped schemes, shallow (open) wells, pans and closed water storage tanks. Some of these were constructed by Food for the Hungry, others by other NGO's like for example Werldhungerhilfe. The map below provides an overview of the interventions in the target area, based on the data available in the databases of the Northern Water Services Board (NWSB), and refined with the information that was provided during the field visits. For details see annex 6, which provides an overview of the existing water sources, their location and functionality.

Throughout the target area boreholes are found, only part of which is functioning (see next section). Further a clear distinction can be seen between the northern part of the focus area and the shouthern part. The northern part has a relative high coverage of water infrastructure; around Logologo and Kamboe are in addition to the boreholes valley tanks and open water pans present. In the southern part on the other hand, around Lontolio and Kamatonyi, no water pans, but rather scoop holes, wells and rainwater harvesting tanks are found. 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 5.

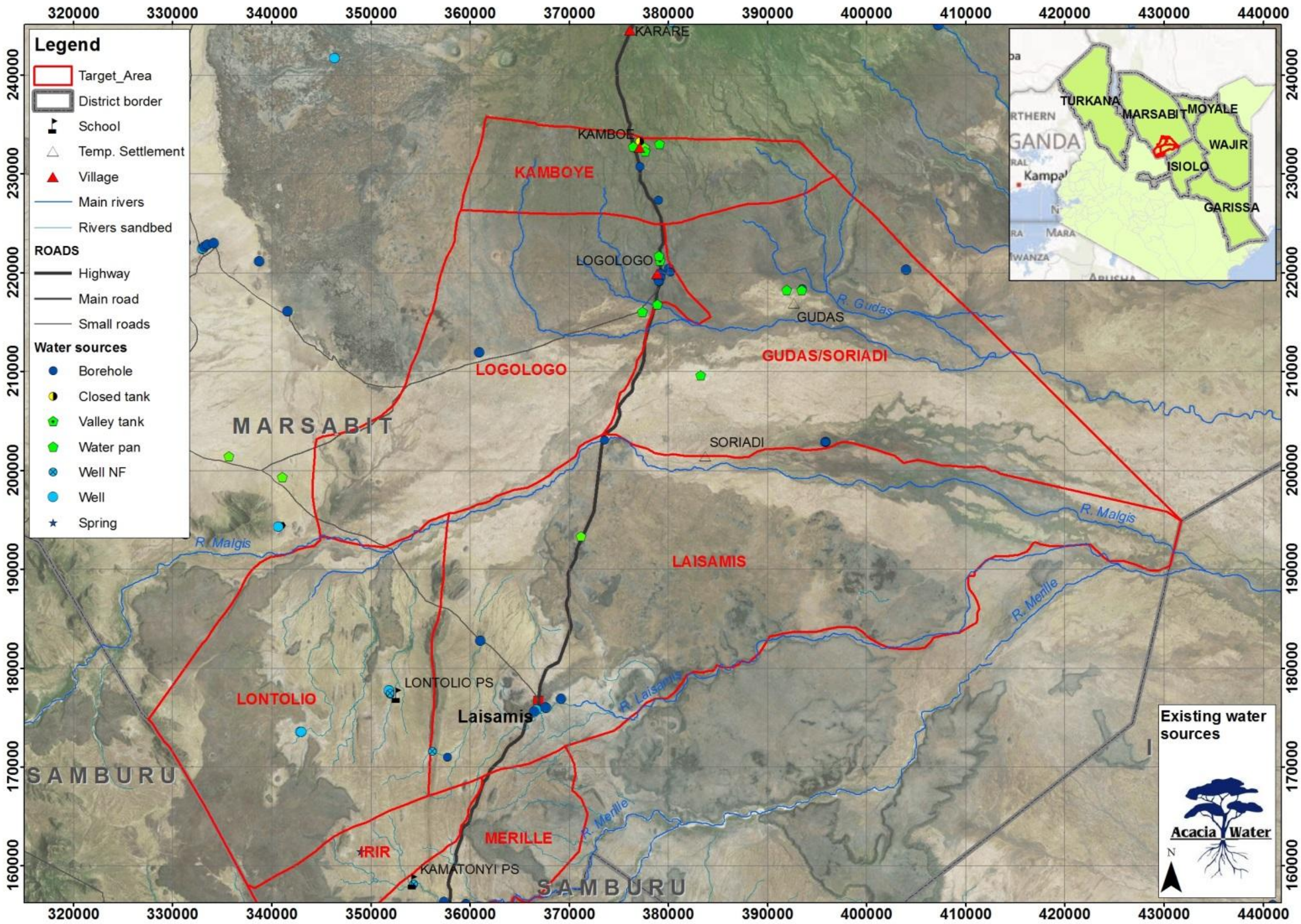


Figure 5-3: Existing water sources and rivers

Boreholes

Water from the boreholes is mostly extracted with submersible pumps which require diesel to function, no handpumps were found in the 3R/MUS pilot area. The borehole water generally has a high quality and low salinity according to the community, the local water authorities and water quality data.

Within Logologo Town the Lestima Borehole supplies a number of communities and the primary and Girls Secondary School. The pipeline to the Girls School consists of exposed PVC pipes which experience pipe breakdowns regularly, especially where passing seasonal streams. A second production borehole, the Sanjir borehole is serving the communities East of Logologo. The borehole has 4 generators and a windmill, but only one generator is working.

The road construction that is going on offers a number of opportunities for water supply in the area. There are at least four boreholes drilled, which will be available for the nearby communities after construction has completed.

Water pans and valley tanks

Open water storage in water pans is widely used in these areas. Most of the water pans are functional and are used for multiple water uses, mostly livestock and domestic use. The latter often happens without treatment as was observed during the visits. During the field visits it was observed that the pans are all relatively shallow due to siltation, the water depth varies from 0.5 to 1.5 meter. These pans dry up within weeks after the rains have stopped, field interviews indicated that none of the pans lasts throughout the dry season. These pans do not have functional silt-traps, and cattle can freely enter the water from all sides, which contribute to bank erosion and siltation and water quality degradation.

The water quality of the pans is generally poor, turbidity levels are high and EC levels of over 1500 µS/cm were measured. However, it should be noted that at Gudas where there are two water pans close together, the pan with the higher salinity level is preferred by herdsmen above the pan with a low salinity for livestock watering. The pans are expected to have a very high microbiological contamination, as livestock enters, and washing and bathing takes place directly in the water.

For the road construction a large sealed valley tank is being constructed, with a volume of approximately 40.000 m^3, uphill from Logologo at a kilometre distance, which will be available for Logologo later on. In addition several quarries are being excavated, which could provide water storage opportunities (see chapter 7).

To provide a higher water quality for domestic use from surface water reservoirs, infiltration galleries with a collection well and a handpump can be a feasible intervention. This technology has been applied at a number of pans in the District by CIFA, including Qilta Water Pan, which is located in the target area. This method can significantly improve the water quality, although it is not guaranteed to remove micro-biological pollution completely.

Wells and scoop holes

Shallow wells are mostly present along the seasonal rivers in Laisamis Sub-Location (near Kamatonyi and Lontolio). Previously the well in the riverbank of the Merille River nearby Kamatonyi provided water to the school and the surrounding community, unfortunately this well got washed away during the large floods of end 2012. A number of open wells are present in the riverbed. The water measured in a scoophole had an EC of 2300µS/cm, but is still used for domestic and livestock water supply. The larger part of the Kamatonyi community lives about 1 km north of the primary school along the Kamatonyi River. The community uses scoop holes to fetch water from the riverbed.

About 1 km from Lontolio primary school there is a larger river present, with similar characteristics as the Merille river at Kamatonyi primary school. There are two shallow wells present with handpumps and a number of open wells improved with concrete. Care rehabilitated the shallow wells in 2011, but they have been damaged by the 2012 floods and are currently not working. The concrete has large cracks and handpump is not functioning. The riverbed has course sand with many scoopholes, which is the only water supply for the community. The scooplholes contain clear water and on site measurements indicated an EC of 625µS/cm and a pH 7.5. The deep scoopholes(up to 4 m) have water throughout the year according to the community.

Additionally, shallow wells are found on the upper slopes and some at the middle slopes of Mount Marsabit, mostly along the streams (laggas). They are located within the area that remains much greener than the surrounding areas, which is partly related to the National Park Boundaries. The wells are mostly open hand-dug wells, with a depth of less than 6mbgl. Some of the improved wells have a depth of up to 10mbgl. The wells have yields varying from 1 to 20 m^3/h while the most yields are above 4 m^3/h. Most of the wells provide a perennial water source although the yield reduces during the dry season.

Rain water harvesting tanks

Rainwater harvesting (RWH) tanks are mostly present at schools, health centres and larger centres where roofs with iron sheets are present. Kamatonyi primary school currently only has a RWH tank as improved water source. Lontolio primary school currently only has RWH tanks as water source. The main one was a $200m^3$ ferrocement tank constructed by FH in 2009, which works well, besides there are a number of plastic tanks. At the time of the visit two 200m3 tanks were being constructed, one by Welt Hunger Hilfe in combination with a greenhouse and one by WVI.

Natural subsurface dam

Sanddams or sub-surface dams were not found in the area. However, some rivers have natural water storage in their beds, created by ridges of hardrock forming a natural barrier before which sand and water is stored. This situation was found at the Merille River at Kamatonyi and the Lontolio River. Just above these barriers open wells were found (see above), excavated in the riverbank by the community, up to 7 meters deep. These wells provide a perennial water source for the communities in the area since many years.

5.3 Management of water resources and water services

5.3.1 Balancing people, livelihood, environment and water

The Logologo area has to maintain a fragile balance between different interests, which are all centred on water availability. People in general are well aware of the importance of maintaining the balance between the use of the resources for livelihood on one hand and preserving the environment that provides for these resources. The pastoralist population moves with their herds of cattle and sheep and goats around in the area, using wet season grazing lands which can be as far as 40 km from their settlements and using the dry season grazing lands nearer to their homes. This strategy has an important security element as people are better able to protect themselves and their herds during the dry season when they are in their village. To be able to use these grazing lands 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.

This delicate balance can easily be disturbed and lead to conflicts between the different tribes over the use of water and/or the grazing lands. This means also that for the planning of the water sources, a careful assessment and consultation needs to take place. The people in Othola village (west of Logologo) for example expressed clearly that they didn't want a new water source, because it would attract herds form neighbouring tribes. The community that is now Kamboe moved to higher lands, primarily for protecting their settlement better against raids by rivalling tribes, even when at that time no water source at the Kamboe sub-location was available.

Another source of potential conflict is the creation of the Water User Association (WUA) at sub-location or location level. These WUAs have to be put in place following the sector reform of 2002 and in principle are responsible for all water sources in a certain area and should be the platform for coordination and management of water services for all communities in the area. This threatens the position of the Water Management Committees that in the past were created to manage a certain water source, in particular for the bore holes. In the Logologo area it is expected that Kamboe will become a new separate sub-location, which will free the way also to have separate WUA.

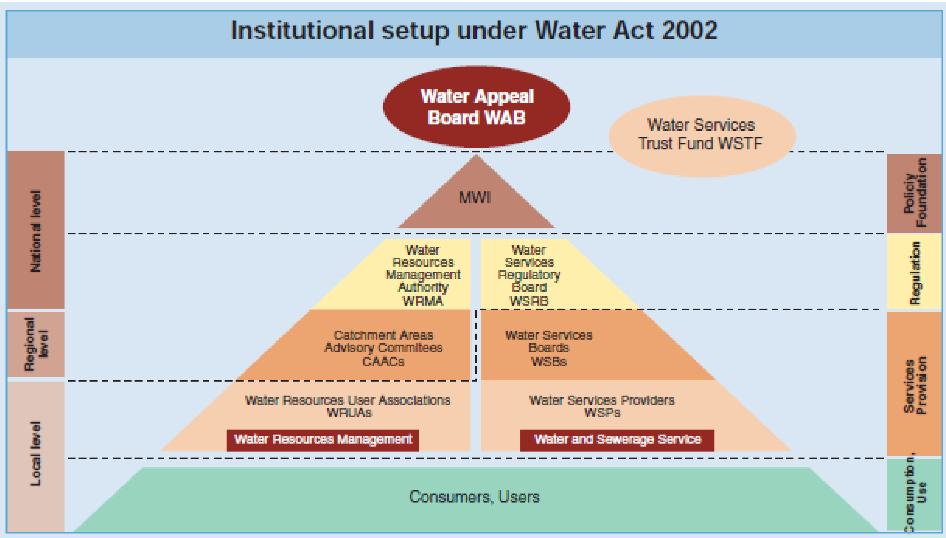


Figure 5-4: Institutional setup of the Kenyan water sector (Source: Kisima, May 2008)

5.3.2 Water Service Provision

The delivery of water services is according to the Water Act of 2002 the mandate of Water Service Providers (WSPs), which act as agents of the Water Services Boards, for Marsabit it is the Northern Water Services Board (NWSB). The Water Services Trust Fund (WSTF) is created to finance pro-poor investments through the NWSB. 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 the WUA. The WUA has all water users in an area as members and will establish the WSP that will be responsible for the actual water services. The WSBs contract Support Organisations (SO) that will support the WUA in the whole process of developing the water service and build the capacity of the WUA/WSP. The Water Management Committees (WMC) in Logologo and Kamboe at the moment have no formal agreements with the NSWB and are not formal WSPs as stipulated in the Water Act.

It is estimated that at the moment only 30% of all boreholes in the area are actually functioning. Main reasons for non-functioning are electro-mechanical problems, which in most cases would have been prevented when proper O&M had been carried out. There is therefore reason to believe that most WMCs if in place at all, are actually not doing very well. The WMC of the Logologo borehole functions mainly as a pump operator and in general is regarded as doing its job relatively well. It is, however, not clear how it carries out key tasks in terms of financial sustainability, accountability to both the community and to the District Water Office (DWO) and NWSB and transparency in governance issues. It is also not clear if the WMC has the required capacity to meet these tasks.

Stakeholders of Logologo feel that their borehole is put at risk during the dry seasons as it is overstretched, although there are no data to support this. They also think that in general the site of the borehole is not well maintained: slab is cracked, fence is damaged, surroundings not kept clean or trees planted.

Poor O&M is not only effecting the operation of boreholes, but many other examples can be found. At the school of Kamboe there are six tanks for Rain Water Harvesting of which only one seems functional. The tanks have been put there by different organisations. One problem mentioned is that ferro-cement tanks don’t last long as they develop cracks when they stand dry for a longer period. Instead of repairing a generator often a new one is bought and it is therefore not uncommon to find three generator sets in a pump house of which only one is working, and others are in different states of disrepair. A reason for this can also be that some organisations prefer to provide a new item instead of repairing the item that was provided by another organisation. People report that pipes are always leaking and the de-silting of water pans is often left to government or non-government organisations. The shortage of technicians and relative large distances contribute to the O&M challenge as well.

5.3.3 Water Resource and Service Authorities and support to service provision

As is mentioned above, according to the Water Act water service provision is through the WSPs, licensed by the WSBs. In this structure there is no formal role anymore for the DWOs, but they still exist directly under the Ministry of Water and Irrigation (MWI) with their own budgets independent from the WSBs. In fact most government post-construction support to the WSPs or WMC/WUAs comes in Marsabit via the DWO, not via the NWSB. It should also be noted that the office of the NWSB is in Garissa and they cover a very wide area with insufficient capacity. The consequences of the new constitution, which is vesting political power in the counties for the institutional set up are not yet clear. This may mean that the current DWOs will come under the new county governments, but will MWI devolve the budget they still hold presently to the counties? And what will the new counties mean for the existing WSBs?

The Water Resources Management Authority (WRMA) has 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. However, for the Marsabit area only 2 of the 113 WRUAs have factually been established, which is mainly a result of lack of resources. Logologo has no WRUA at the moment.

For coordination of WASH activities in the area, there are two coordinating bodies in Marsabit. The District Steering Group (DSG) meets monthly ad coordinates all development issues and interventions, including WASH. WESCOORD, in Marsabit chaired by Food for the Hungry (FH) also meets monthly and is solely addressing WASH issues and is regarded as a better forum for learning & sharing as the DSG.

On the ground in Marsabit district the strongest agencies to support communities in water services from government side is the DWO, next to the NGOs. For water resource management it is basically only the NGOs as WRMA has hardly any operational capacity. Both the DWO and WRMA have very limited data on water resources and water services.

The limited capacity and confusing roles of the water service and water resource authorities results in ad hoc support to the WSPs and WMCs only by government 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.

5.3.4 Local coordination

At district level coordination of activities by the different agencies takes place in the DSG and WESCOORD. However, 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. During the stakeholder meeting one of the issues that is mentioned is that already the water sources are too close together, resulting in too much pressure on a limited area.

5.3.5 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 water use, people want cleaner water or water nearer to their houses. They have the ambition to start small scale agriculture and ask for a water source near the wet season grazing lands in order to make better use of these pastures. At the same time, however, people seem to accept that 70% of the bore holes are non-functional or that they have to walk 8 km to a borehole, although the pipeline connecting their kiosk should have been put in place already seven years ago. There seems to be little belief that they are themselves the key to any solution in the area.

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 (will only be taken into account for more urban settings)*
- 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 look 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	**5.0**
Assumption 3:	Annual population growth rate considered is	**2.7%**

Figure 6-1: Assumptions on population and growth rate

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.

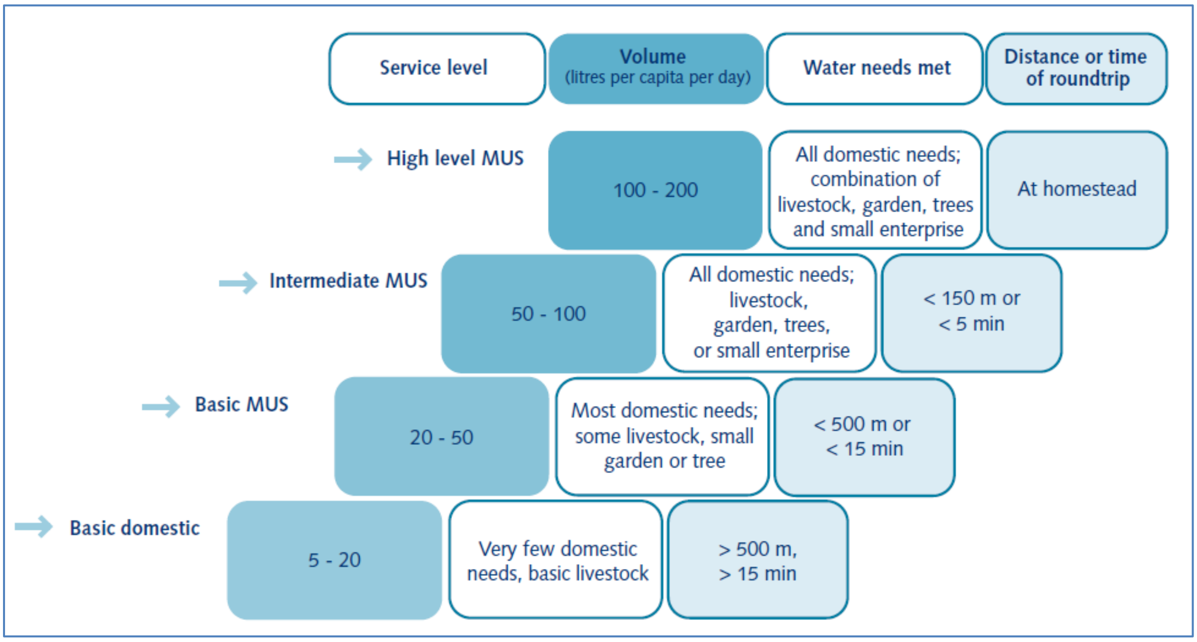


Figure 6-2: MUS ladder

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 200 l/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:

			Water demand (L /h /day)		
			Basic MUS	Intermediate MUS	High level MUS
			50	100	200
Year	Population	HH			
2013	3,709	742	185,446 L / d 185 m3/d	370,892 L / d 371 m3/d	741,784 L / d 742 m3/d
2023	4,841	968	242,059 L / d 242 m3/d	484,119 L / d 484 m3/d	968,237 L / d 968 m3/d
2033	6,319	1,264	315,956 L / d 316 m3/d	631,911 L / d 632 m3/d	1,263,823 L / d 1,264 m3/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 6-3: 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 (Logologo sub-locations), the domestic water demand is calculated using 20 l/h/d.

		Water demand (L /h/day)
		Basic domestic
		20
Year	**Population**	
2013	3,709	74,178 L / d 74 m3/d
2023	4,841	96,824 L / d 97 m3/d
2033	6,319	126,382 L / d 126 m3/d

Figure 6-4: 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 Logologo no census data on livestock have been found, and the focus group discussions in Ilbarok provide no sufficient information. Therefore only the methodology based on the FEWSNET data is used.

➔ As a result, Methodology 1, which uses the FEWS.NET estimates, was used to determine livestock water demand.

Methodology 1: Using FEWS.NET estimates

The following assumptions have been made for the calculations:

Assumption 1:

	FEWSNET estimate on livestock per HH	FAO LU
Cattle	7	0.5
Goats	23	0.1
Sheep	17	0.1
Camels	3	1.1
Donkey	0.5	0.6

Assumption 2:

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 6-5: Assumptions for livestock water demand calculations

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

	Number of livestock heads					
Year	**Cattle**	**Goats**	**Sheep**	**Camels**	**Donkey**	**Livestock Unit**
2013	5,192	17,061	12,610	2,225	371	3,431
2023	6,778	22,269	16,460	2,905	484	4,478
2033	8,847	29,068	21,485	3,791	632	5,845

Year	Water demand (L or m3/day) Livestock *Methodology 1: FEWSNET estimates*
2013	171,538 L / d 172 m3/d
2023	223,905 L / d 224 m3/d
2033	292,259 L / d 292 m3/d

Figure 6-6: Water demand projections for livestock use

Demand for agriculture

At present agriculture is very limited (only subsistence farming) and rain-fed only, for an average plot size of 0.5 acre (about 2,000 m^2). However, all communities have expressed their interest and willingness to get more engaged in agricultural activities and therefore the need for irrigation schemes. Communities have mentioned that greenhouses had been set-up in the area, and that they were willing to duplicate these examples.

Main crops are beans, sorghum and maize, 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:

Information are provided only for crops selected within the targeted area

Crop	Growing period (days)	Harvest 1	Harvest 2
Beans	60	June	December
Cabbage			
Groundnut			
Maize	90	July	January
Melon			
Millet			
Onion dry			
Sorghum	120	June	December
Spinach			
Tomato			

Assumption 3: Rainfal station used: Moyale

Assumption 4:

Surface of land per HH (acre): 0.5
% 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	10%	50%
Cabbage		
Groundnut		
Maize	50%	50%
Melon		
Millet		
Onion dry		
Sorghum	40%	50%
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 6-7: Water demand assumptions for agriculture use

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

		Irrigation water need (m3/month and average m3/day)											
		Agriculture											
		January	February	March	April	May	June	July	August	September	October	November	December
2013	month	351	0	523	236	607	999	351	0	580	426	774	385
	day	12	0	17	8	20	33	12	0	19	14	26	13
2023	month	459	0	683	309	793	1,304	459	0	757	557	1,011	503
	day	15	0	23	10	26	43	15	0	25	19	34	17
2033	month	599	0	892	403	1,035	1,702	599	0	989	726	1,319	656
	day	20	0	30	13	34	57	20	0	33	24	44	22

Figure 6-8: water demand projections for crop agriculture use

	Irrigation water need	
	Agriculture	
	Year	Average / day
2013	5,235 m3/year	14 m3/day
2023	6,833 m3/year	19 m3/day
2033	8,919 m3/year	24 m3/day

Figure 6-9: total water demand projections for crop agriculture use with small-scale irrigation

Demand for seasonal migration

During the training in Nairobi August 2013, the staff of FH mentioned that migrating herds is mainly happening during a period of three months in the area of the Laisamis seasonal river.

Demand for wildlife

During the MWA workshop of Nairobi August 2013 it was agreed to add a similar amount for wildlife demand as the seasonal water demand for use by the migrating lifestock.

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:

	Water demand					
	Basic domestic Based on 20 L/h/day	Livestock Based on FEWSNET estimates	Agriculture	Seasonal livestock + population	Wildlife	**Total**
Year						
2013	74 m3 / d	172 m3 / d	14 m3 / d	0 m3 / d	0 m3 / d	**260 m3 / d**
2023	97 m3 / d	224 m3 / d	19 m3 / d	0 m3 / d	0 m3 / d	**339 m3 / d**
2033	126 m3 / d	292 m3 / d	24 m3 / d	0 m3 / d	0 m3 / d	**443 m3 / d**

Figure 6-10: 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 6-10 are between 'basic level MUS' and 'intermediate 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 not included in table 6-10.

Disclaimer: a lot of assumptions were made to come-up with these results, and these tables are therefore indicative only. It is essential that the local partner – together with the stakeholders – validates these assumptions, or change them accordingly, to improve as much as possible the degree of accuracy.

6.2 Access

6.2.1 Availability of water points in the area

In general the communities in Marsabit are using different sources for water for different purposes, including seasonal management and therefore are already practicing MUS. In Ilbarok, they presently rely solely on the borehole for domestic and livestock during the dry season and practice some small agriculture as well from this source. For the wet seasons their herds go some 30km. to west for grazing in Gudas. In Kamboe they rely for domestic use during the rainy season first on the open water pan, where after they use a closed reservoir that captures water from the run off from the hills. When also this source has dried up they use the Kamboe borehole, which is 8 km away. For water fetching from this borehole the people use often donkeys. The grazing lands used by the Kamboe village are mainly in to the West (Gudas), up to 30-40 km from the village. In addition water is sometimes brought by water tankers. The critical factors that are mentioned to be determining for actual use are: (1) accessibility (distance), (2) costs (price of water), (3) storage at home. For domestic use people are supposed to pay 2 Ksh for a jerry can of 20 litres. Poor people are allowed to take water for free form the water pans (Kamboe).

In the focus group discussions with the stakeholders, the following information was shared:

Date: 14 May 2013

Place: Ilbarok, Marsabit

Organisation: FH

Livelihood	Well-off	Medium	Worst-off
Livestock and small businesses	> 80 livestock **20**	5-80 livestock Milk selling	
Livestock	> 80 livestock **44**	5-80 livestock	0-5 livestock
Labours		Watchman at school **6**	
Relief – food aid		5-80 livestock **20**	0-5 livestock **50**
Social security (pension)	> 80 livestock **16**	5-80 livestock **20**	0-5 livestock **4**
Totals	**80**	**46**	**54**

Total number of households: 180 (in **bolt** number of households)

Figure 6-11: Livelihood and wealth matrix

Date: 15 May 2013

Place: Kamboe

Organisation: FH

Main water source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Borehole	x	x	x		x	x	x	x	x	x		
Water pan				x							x	x

	Unit	Borehole	Water pan/closed reservoir
Time return trip	hours	8	1
Frequency		alternated day	daily
Quantity/household	litres	15-20	60

Figure 6-12: Seasonal calendar water fetching time

Date: 15 May 2013

Place: Kamboe

Organisation: FH

Activities	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Watering of animals	x	x	x		x	x	x	x				
Right of pasage by agegroup (Lilmuset)							x	x				
Milk selling			x	x								
Preparation shallow wells	x				x							
Social event (Sorio)						x	x					
Farming			x	x								
Livestock rearing	x	x	x		x	x	x	x	x	x		

Figure 6-13: Seasonal calendar activities

Date:	15 May 2013
Place:	Kamboe
Organisation:	FH

Diseases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Typhoid			x						x			
Amoebia			x						x			
Diarrhoea			x	x					x			
Pneumonia				x	x		x		x			
Trachoma					x			x				
Malaria						x	x					x

Figure 6-14: Seasonal calendar diseases

6.2.2 Quantity

The experience of FH in the ASAL lands is that people often don't use more than 7-10 l/h/d when they have to carry the water from some distance. In Ilbarok where the borehole is 2 km, people said they collected about 4 -5 jerry cans every 2 days, which is 40-60 l/hh/d, which is also in the range of the 7-10 l/h/d. The households that have a higher storage capacity, for example the 200 liters PE tanks that have been distributed to some households in Ilbarok claim that they use more water. In the advantage of increased storage at the household in cases the borehole has broken down is mentioned.

Although the water pans in principle are being designed for bridging the dry periods, in practice most water pans last only for 2-3 months. Of course this varies with the rainfall, but also depends strongly if the pan is used for domestic only, or used for livestock as well and in what numbers. The management of the use of the water pan plays a crucial role for the actual access to the water.

6.2.3 Quality

It is very common that people use the water from the water pans for their domestic use. Only few people mention that they treat the water before drinking. The treatment that is most frequently mentioned is PuR, which is a combined coagulation/settlement and disinfection treatment and the correct type of treatment for the highly turbid water (estimated >300 NTU with highly colloidal matter) of the water pan. Some households also mention that they boil the water for drinking. Women in Kamboe explained that "they are aware of the health risks but that it is difficult to change habits". Diarrheal diseases occur mainly in March/April and September according to the seasonal calendar (see annex) that was drawn by the villagers of Kamboe, which coincides with the beginning of the wet season and the use of water from the water pans.

The Public Health Officer of Marsabit emphasises the importance of sufficient water for the household for improving the hygiene situation of the households

6.2.4 Reliability

Reliability of both the water sources and the systems is erratic. 70% of the boreholes is presently non-functional due to different electro-mechanical problems. The kiosk of Kamboe has never worked because it was never connected to the bore hole. Water pans often have only water for 2-3 months after the rains and depend heavily on the quantity of precipitation of the season. But in addition many water pans suffer from siltation, which can be mitigated by proper O&M and environmental measures of the catchment area of the water pan.

6.2.5 Accessibility

Box 2: Assumptions used for distances by humans and livestock for Marsabit district (Rural Focus Ltd, 2003)

- 5 km is the maximum distance for humans to fetch water from a source
- 10 km reflects a distance used by cattle with normal stress in terms of travel distance to water
- 15 km is the maximum distance for cattle to access a water source
- 30 km is the maximum distance for camels and goats to access a water source

Discussions with district resource persons confirmed that these figures were relatively accurate. However, for Marsabit district it was stated that the following figures should be considered or used for comparison purposes.

- 20 km is the maximum distance for settled agro-pastoralists to access a water source
- 20km is the maximum distance for cattle and cattle herders to access a water source
- 30km is the maximum distance for shoats and shoat herders to access a water source
- 65km is the maximum distance for camels and camel herders to access a water source

In Ilbarok the population of 140 households is served by one water point (bore hole) 2 km from the settlement. In Kamboe 745 households depend on one water point (borehole), which is 8 km away, however work on the pipeline that will connect one (!) kiosk in the village is under way. During dry seasons water is also brought in by water tankers, supported by government and NGOs.

For the livestock balance between the availability of grazing land and water is sought. In general the wet season grazing lands can be found further away from the village and around seasonal rivers and natural wet lands or depressions where water collects. But also the use of wet season grazing lands depend often functional bore holes. (e.g. Gudas) The dry season grazing lands are found more closely to the settlements and livestock is watered with water from both the water pans and boreholes. In Ilbarok the livestock uses Logologo borehole for approximately 2 months during the dry season.

In general the women manage the herds of small animal, the sheep and goats (‘shoats’), the men the bigger animals: cattle and camels.

6.2.6 Additional barriers

A key additional barrier for water access and use in this area are conflicts around the grazing lands and water sources. The fragile balance to have the right amount of pastures with sufficient water for animals and people in the areas varies from season to season and herds from far away come look for both vital resources when they are too scarce in their own areas. This means that both supply and demand on the two key resources is changing all the time and requires continuous management and negotiation. This leads for example the population of Ilbarok to say that they don't want another water source because it will attract more people and in particular more livestock.

6.2.7 Current coping strategies

The harsh and challenging environment of the Logologo and Kamboe area has already led to quite a number of strategies that try to deal with the situation.

- FH helps in implementing zoning strategies for the grazing lands in order to prevent conflicts about grazing lands by reserving pastures.
- People use wet season grazing lands far away from the village and dry season grazing lands near the villages to increase security. Also the goats and cows that are milked and the smaller and weaker animals are kept near the village.
- FH is trying to address key issues by including different strategic elements in their interventions:
    - Take into account water quality for domestic use
    - When dimensioning infrastructure aim at bridging the gap of the dry season
    - Increase water storage capacity
    - Conflict mitigation
- In Kamboe they have started rain fed agriculture, but they plan to start small scale irrigation (with jerry cans) when the water from the borehole is reaching the kiosk.
- The Public Health Office and NGOs are promoting treatment of the water of the water pans when for domestic use.
- Water storage capacity at household level has been increased for some families by agencies donating 200 l. PE storage tanks in Ilbarok.
- Recently a number of agencies have started to promote the use of greenhouses for small scale agricultural production

6.2.8 Seasonality

The figures mentioned for seasonal demand of the migrating herds varies considerable. Some reports suggest that the total water demand may be up to 10 times higher during the wet seasons when there is a high influx of livestock from surrounding area. Because the many uncertainties surrounding the migration, this requires more research and may also need a separate coping strategy.

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

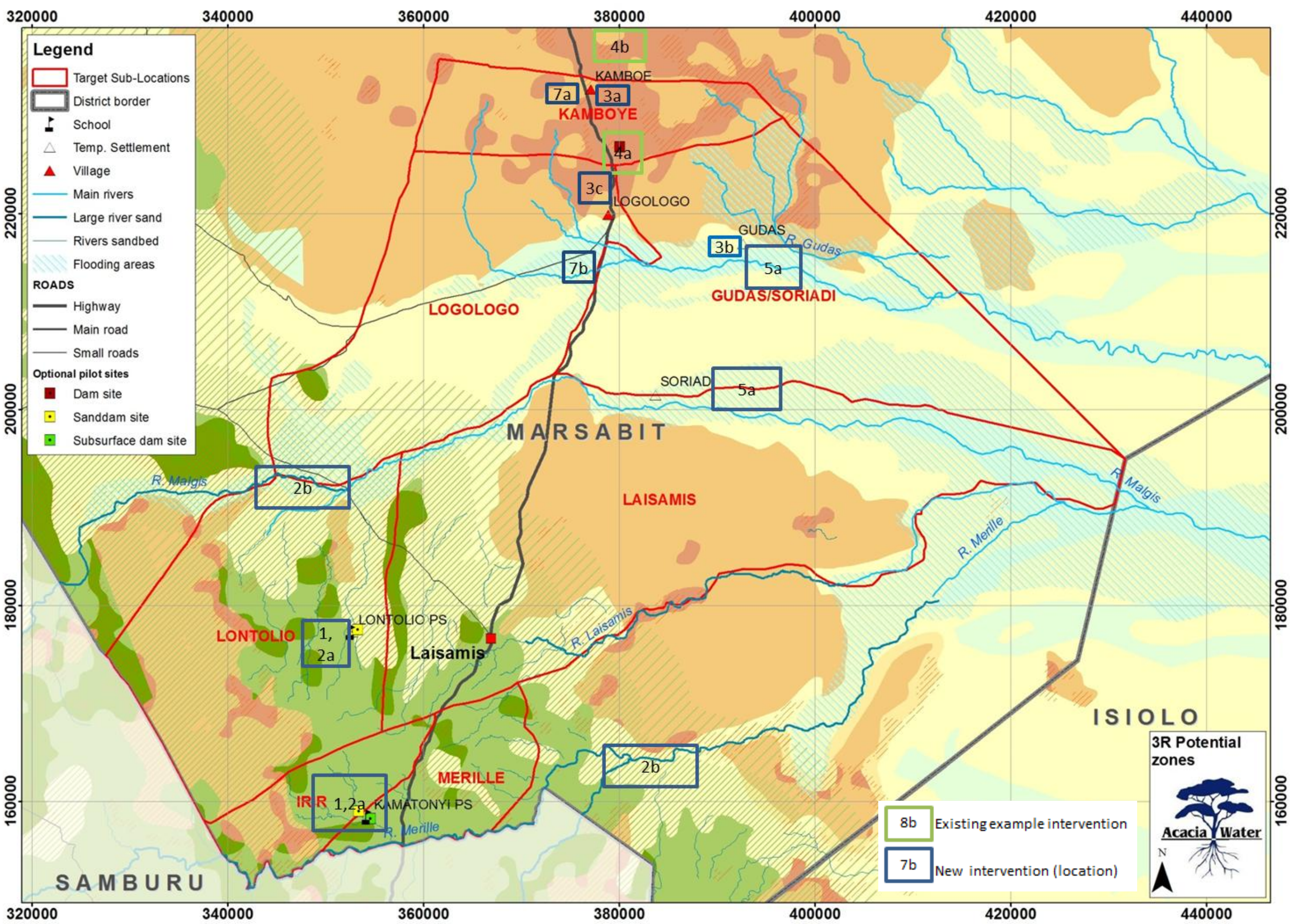
In the Marsabit target region the following 3R potential zones are present:

- Zone 1A: Basement, mountains, low porosity, weathering products suitable for storage
- Zone 1B: Basement, plane areas, low porosity, weathering products suitable for storage
- Zone 2: Buffer zone around basement rock area (5 and 10 km)
- Zone 3E: Volcanic, mountains, high porosity, weathering products unsuitable for storage
- Zone 3F: Volcanic, plane areas, high porosity, weathering products unsuitable for storage

- Zone 4A: Alluvial sediments with variable permeability, often clayey sediments / layers present & shallow groundwater potential
- Zone 4C: Variable sediments with mostly moderate permeability, and low vertical resistance when clayey sediments / layers are present & possibly shallow groundwater potential
- Zone 5: Areas with slopes steeper than 10 degree

	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, contour bunds, and other run-off reduction /infiltration options	H Closed tanks	G Deeper, confined aquifer groundwater: wells / boreholes
Zone 1A	x[1]	**X**	x	x		x	x	x
Zone 1B	x[1]	**x**	**x**	x	x	?	x	x
Zone 2	x[1]	x[2]	**x**[2]	x	x	x	x	x
Zone 3E	**x**			x		x	x	x
Zone 3F	x			(x)		x	x	x
Zone 4A	x			x	x	?	x	x
Zone 4C	x			x	x	?	x	x
Zone 5	x	(x)		x		x	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.



3R potential zones

Zone 1: Basement rocks

- 1A, mountains, low porosity, weathering products suitable for storage
- 1B, plane areas, low porosity, weathering products suitable for storage

Zone 2: Lowlands near basement areas

- 2, buffer from basement (5 and 10 km) plane areas

Zone 3: Volcanic rocks

- 3A, mountains, low porosity, weathering products suitable for storage
- 3C, mountains, porosity and weathering products variable
- 3D, mountains, high porosity, weathering products unsuitable for storage
- 3B, plane areas, low porosity, weathering products suitable for storage
- 3D, plane areas, porosity and weathering products variable
- 3F, plane areas, high porosity, weathering products unsuitable for storage

Zone 4: Sedimentary formations

- 4A, alluvium along rivers, variable permeability, potential for shallow groundwater
- 4B, sands and sandstones, high porosity and storage potential
- 4C, variable sedimentary formations, varialbe permeability and storage potential

Zone 5: Areas with steep slopes

- 5, steep slopes (>10°)

Examples:

1. Rivers with sandbeds and shallow hardrock (Zone 1A)
2. Wide river bed with sandy sediments
   a. Underlain by hardrock and with rock barriers (zone 1A, 1B)
   b. In the sedimentary areas, within the buffer zone (zone 2)
3. Water pans preserved for specfic use
   a. Mainly for domestic use
   b. Mainly for livestock watering
   c. For road construction, in the future available for other uses
4. Open water storage opportunity's
   a. Volcanic craters
   b. Valley dams in pronounced valleys
5. Flooding areas
   a. River floodplains, with good grass
   b. Floodwater used for irrigation
6. Erosion reduction
   a. Gulley's present on steep slopes
   b. Gulleys eroding the road
7. Road water harvesting
   a. Water storage created by former road quarry
   b. Road causing floodwater spreading

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 1 Basement rocks & Zone 5 Steep slopes

Appearance of the zone in the target area

In the Marsabit target area basement rocks are found in the southern part of the area, mainly in the Laisamis Sub-Location. These areas are mostly relative plane (zone 1A), only a few steep basement zones are found within the target area. More towards the West in Samburu District, there is a large basement mountain range, from where rivers discharge into the target area. In the southern part of the area sand rivers of large and intermediate sizes were found. Both near the villages of Lontolio and Kamatonyi rivers were found with the potential to store water in the riverbed (Figure 7-2, example 1). At locations this potential is already utilized, as water is extracted through scoopholes and open wells, especially at locations were rock banks form natural sub-surface dams.

The use of groundwater storage in sand rivers can be extended to store more water with good quality. Also the subtraction structures to retrieve the water from the subsurface storage can be improved, to increase both the water quality and the sustainability against large floods. Below a number of interventions are described.

Riverbank infiltration

In the riverbeds of the seasonal rivers the groundwater table is relatively shallow. The water here is currently harvested with scoop holes. Also riverbank subtraction systems were already implemented in the area (Figure 7-2, example 1 and 2a), some of which work correctly. However, during the large floods some of these systems were destroyed, due to erosion of the river bank in which they were located. Additionally, in many locations it was found that the cattle walked directly on top of the aquifer, this can pollute the water in the aquifer. To improve the quality of the stored water it should be prevented that the cattle enters the area on top of a sandy aquifer.

Future shallow wells should be sited outside the streambed on the riverbank, preferably on the inner side of the bends in the river, to prevent erosion at the location of the well. Locating wells outside the riverbank has a number of benefits: (1) the water quality can be improved by the filtration when the water is transported through the ground from the river to the well, (2) when the watering points are next to the riverbeds, instead of in the riverbeds, pollution of the aquifers because cattle walks on top of the aquifer can be prevented -for this a fence has to be constructed between the watering point and the riverbed, (3) the constructions are more resilient to large floods.

The siting of the riverbank infiltration wells should be done in cooperation with the community, ensuring that it will receive recharge from the riverbed, but that the site is not in the flood bed of the river. Optionally an infiltration gallery can be constructed to increase the yield.

Natural sand dams

In the southern sub-locations in the target areas, some rivers have a natural water storage in their beds, created by ridges of hardrock forming a natural barrier before which sand and water is stored (Figure 7-2, example 2a). This situation was found at the Merille River at Kamatonyi and the Lontolio River. These natural dams are already used by the population as a reliable source of water. At these locations, only the manner of water subtraction can use improvement. A feasible intervention in this situation is riverbed infiltration (see previous section).

Potential for new sand- and subsurface dams

Many of the rivers in the southern part of the target area have potential for riverbed storage, especially the western part, where the Kamatonyi and Lontolio villages are located (Figure 7-2, example 2a). For the construction of sand dams consist a number of success factors. These include a sediment load in the river that consist of sand which will create an aquifer with sufficient porosity to store enough water, hard rock or clayish layers on which the sand dam can be constructed, and relative narrow locations in the rivers (e.g. 5-20m width) so that the required dam does not become too large. These requirements are all met at several locations in the target area. At the visited locations the sand was estimated to have a storage capacity of between 25 and 30%.

Near Kamatonyi village there are several options nearby for sanddams and/or subsurface dams of variable size (Figure 7-3). The large part of the Kamatonyi community lives about 1 km north of the primary school along the Kamatonyi River. There is no existing water source in this area. As a pilot intervention a sanddam could be constructed in the side river near the settlement, at the end of the canyon. A feasible site for a sanddam was found in a narrow stretch with hard rock surrounding the riverbed, close to the village. This site requires a relative small intervention, and is located upstream from most other potential sites. If required, additional cascading sand/subsurface dams could be added downstream, so the combined effect will be increased. Table 7-1 provides an estimation of the storage capacity of a sanddam constructed at the proposed location, based on observations of the cross-section of the river, a proposed dam height of 3 m, and an rough estimate of the gradient of the riverbed.

Table 7-1: Estimation of storage capacity and households supplied with the proposed sanddam

Site	Effective depth of sand bed (m)	Average width (m)	Length stretch (m)	Porosity sand	Water storage capacity (m3)
Kamatonyi village	2.5	15	350	25%	1640.625

In the target area, the large rivers with a catchment area larger than 50 km^2 have high turbulent discharges, and wide riverbeds, for example the Merille River (Figure 7-3). These rivers are less feasible for sand dams, but subsurface dams could be an alternative. Subsurface dams are constructed within the sandy sediment in the riverbed, thus preventing the sub-surface run-off of the water that is stored in the riverbed. A large advantage of sub-surface dams is that they are constructed within the existing soil layer, and no parts of the dam stick out above the soil layer. In this way the required strength of the subsurface dam is smaller than the strength of an intervention that has to dam the water during the flashfloods, and may thus be easier implemented in large rivers. Also for the subsurface dams it the presence of a hard rock or clayish layer is required. In the fieldwork at several locations the depth of this layer is determined (Annex 7). Annex 8 provides some general guidelines for siting and design of sanddams and subsurface dams.

Figure 7-3: Locations of the proposed sanddam site, the natural rock barriers in the sandrivers near Kamatonyi (for location reference see Figure 7-2 , Kamatonyi Village)

7.4 Zone 2 Buffer zone of the basement rock sedimentation area

Appearance of the zone in the target area

The buffer zone of the basement rocks in Laisamis area overlays the sedimentary formations as well as some plane volcanic areas and lava plateaus. In this zone indeed rivers with sandy sediments were found (Figure 7-2, example 2b). Observations of the sediments showed that it had a porosity that was suitable for water storage. The large rivers with sand beds, like the Merille, Laisamis and Malgis Rivers, extended even beyond the 10 km buffer zone. These rivers originate from the large mountain region over the border on the Western side of Laisamis Sub-Location. Within zone 2 these Rivers and the surrounding riverbanks might have shallow groundwater potential. However, this potential depends on the presence of an impermeable (clay) layer, as is further described in the next paragraph.

Sanddams and Subsurface dams

The potential for sanddams or subsurface dams depends largely on the characteristics of the underlying formation. The potential for subsurface dams in sedimentary and plane volcanic areas within the buffer zone of the mountains (zone 2) is difficult to assess. The sediment in the rivers in this area was found to be appropriate for the implementation of such a dam. However, because in the current fieldwork we could not verify the existence of an impermeable layer which could serve as a base for the subsurface dam, subsurface dams cannot be recommended at this stage for the plane areas. Without impermeable layer the water stored behind the dam can easily be lost to deeper groundwater and will be difficult to retrieve. When an impermeable layer is found subsurface dams could provide a sound option for water storage (e.g. Figure 7-2, example 2b). Further research to find layers with low permeability is required for this. The floodplains along the rivers appear greener and some locations were indicated by the community to be remarkable green during the dry season, which may indicate shallow groundwater. However no existing wells or other evidence for shallow groundwater was found. This could be explored by test drilling for shallow groundwater at some promising locations.

7.5 Zone 3E Volcanic, mountains, high porosity, weathering products unsuitable for storage

Appearance of the zone in the target area

The northern part of the target area contains the slopes of Mount Marsabit, which fall under zone 3E volcanic rocks with high porosity (trachytes, basalts and pyroclastics), with weathering products that are mostly unsuitable for storage, in mountainous areas. The volcanic slopes in the target area have loamy soils which still have a moderate infiltration capacity. The underlying volcanic rocks are often porous and ground water is expected to infiltrate to the deep aquifer, as no evidence for presence of shallow groundwater was found.

On the upper slopes the beds have large stones and boulders and little sediments, while on the middle and lower slopes many of the beds contain loamy material. Some streams on the middle and lower slopes contain course sand and cobbles, but the depth to the bedrock is unknown. At the lower slopes especially, water is expected to be lost to deep infiltration due to porosity of the bedrock. The following paragraphs describe the identified 3R possibilities in the area.

Water Pans

Various water pans are found throughout the zone 3, a relative large amount is present at the slopes, but also at the plane volcanic areas. Some pans are mainly used for domestic supply, while most pans are mainly for livestock (see Figure 7-2, example 3a and 3b). Water pans at the slopes mostly collect runoff water from gullies or small streams. When the pans are sited well, natural lining may be sufficient. At more sandy locations a lining may be required to prevent loss of the water due to leakage. This must be examined based on the soil characteristics. Annex 8 provides some general guidelines for siting and design.

Valley dams to create water reservoirs on the slopes

When valley dams are located at smart places in the landscape, large reservoirs can be created with relative small interventions. The slopes of Mount Marsabit provide good opportunities for valley dams, using landscape elements. The pronounced valleys (see Figure 5-2) provide good possibilities for the construction of valley dams. Currently FH is creating a valley dam at the slopes of Mount Marsabit, at Dirib Gombo village. Such a valley dam is in principle a good 3R option to store more water. In the construction of the dam it is recommended to keep the siltation notions (Annex 8) in mind. When siting such a valley dam is recommended to perform a catchment analysis to estimate the amount of water that can be captured, and to select a location with natural narrowing in the valley, so that a relative small dam can be sufficient.

An example of a landscape feature, which with a limited investment can be used to create a large reservoir is located 6 km south of Kamboe (see Figure 7-2, example 4a). Here a volcanic crater was observed through remote sensing and visited during the field assessment. This crater has a seasonal stream flowing through a narrow valley on the south-eastern side, with a catchment of about 6 km^2. A small valley dam, of about 30 m wide and 8 m high at this location, could store an estimated volume of 2,000,000 m^3, while an embankment with an height of 10 m could store over 5,000,000 m^3. Next to storing surface water, a reservoir may also recharge groundwater and increase the yield of boreholes and springs lower in the catchment if water infiltrates from the reservoir. To establish this additional advantage, the subsurface characteristics should be further investigated.

Gully plugs or check-dams to prevent flash floods and increase infiltration

The gullies and valleys with seasonal streams found on the south and eastern side of Mount Marsabit currently have high seasonal runoff. In these valleys water can be stored through check dams, and gully plugs in the smaller gullies. This prevents the fast run off of water by flash floods, and increases the infiltration. However, in the steep gullies no large water reservoir can be created, because the area behind the gully plugs is not flat enough, and the turbulence behind the dam is expected to be too high to create a natural clayish lining. Therefore, gully plugs in steep gullies will not create substantial open water reservoirs. They may, due to the increased infiltration, strengthen the (deep) groundwater recharge, and may increase the baseflow. To fully understand the benefits of increasing infiltration of flash floods at the slopes, more research is needed. Since no abundance of springs were found at the food of the mountains, the options for direct recovery of the infiltrated water seem limited.

7.6 Zone 3F Volcanic, plane areas high porosity, weathering products unsuitable for storage

Appearance of the zone in the target area

In the target area several areas are covered by zone 3F are present. These are the lower parts of Mount Marsabit with gentle or no slopes and the volcanic plateaus in the Laisamis and Lontolio Sub-Locations. On the flat basalt plateaus with loamy to clayey soils infiltration is reasonably to low, the infiltration capacity measured in the field was within the range of 5-6 cm/h. Infiltration on clayey soils is influenced by macro pores. The underlying volcanic rocks are often porous and no evidence for presence of shallow groundwater was found. These areas might have deep groundwater potential, but siting and drilling is often challenging while the water quality might also be a concern. The porous rock, absence of slopes and sandy weathering products, make that this zone has a limited potential for 3R-interventions. Open water storage like water pans could be constructed in topographic depressions, but lining may be required to reduce the infiltration rate. Clay for dam construction may in parts of this area, but probably not everywhere be available locally.

Water Pans

Pans are currently the main water source in these areas, there are examples of pans used for different purposes in the pilot area (see Figure 7-2, example 3c). They are a feasible option in this area. The clayish weathering products of these volcanic rock may locally provide an option for the natural lining of the pans, although the sensitivity to cracks might be a concern. For the use for drinking water extra measures (e.g. separate pans for different uses, filtration and purification) are required. Annex 8 provides some general guidelines for siting and design of pans and dams.

7.7 Zone 4C Variable sedimentary formations – plane areas

Appearance of the zone in the target area

Within the target area the sedimentary area is known as the Kaisut Dessert, and is mainly found in the Logologo and Guda sub-locations. This area consists of younger (quaternary) sediments on top of volcanic formations. The depth to the volcanic rocks varies, interviews and borehole data indicate that at some places the sediments are over 50 meter thick, while at other places parasitic cones are present forming small hills in the sediments. In the western part of Logologo there are inselbergs of basement outcrops present within the sedimentary formations.

Water Pans

In this area various pans are found (see Figure 7-2, example 3b). When the pans are sited well, natural lining may be sufficient. At more sandy locations a lining may be required to prevent loss of the water due to leakage. This must be examined based on the soil characteristics.

Pans are most feasible within the flooding areas of the streams. Here the water has reduced velocity and has lost sediment due to the vegetation buffer. Stagnant water remains often available in puddles and small pools. Traditionally, all water available outside the dry season water reservoirs is utilized for watering of livestock, before the water pans and other dry season sources are used. By increasing the availability of small temporary water sources, water stored in the larger water pans will remain available for longer.

Rangeland improvement

Next to water for drinking and cattle, 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. Therefore, in the planning of new 3R interventions, the grazing patterns should be taken into account. Many small decentralized interventions can spread the grazing pressure compared to a limited number of large scale interventions, this should become part of the 3R-MUS strategy. Additionally, 3R measures can be applied to strengthen an enlarge the grazing areas, as described below, and pans could be combined with floodwater spreading.

Floodwater spreading to enlarge the green floodplains

Naturally, within the 3R target area the water of the rivers in the sedimentary areas have wide floodplains. These current floodplains are found south of Logologo, in Gudas and the Malgis floodplains in Soriadi (see Figure 7-2, example 5a). At these locations the effect of floodwater in the dessert areas are clearly visible, they are remarkably green compared to other areas (Figure 7-4).

Figure 7-4: Contrast in vegetation in the Kaisut Dessert in Soriadi, left 'normal' situation, right floodplain of Malgis River

Application of more flood water spreading interventions may enlarge this green area. Floodwater spreading is a good example of turning a menace – silt-laden floods- into an asset. The floodwater carries high volumes of sediment – up to 5%, which is not unusual for ephemeral rivers (Transforming Landscapes). Through floodwater spreading the silt is used to build up fertile land in a sandy desert that is under the constant threat of wind erosion. It could be appropriate in the lowlands near Logologo and Gudas, where it can be used to transform the dessert into grazing lands. It can be used to increase the soil moisture, and to contribute to groundwater recharge, as most soils outside the usual flooding areas are loamy and relatively high infiltration rates were found. The risk of floodwater spreading is an increased loss of water due to evaporation, and a reduction of downstream discharge. When considering these interventions, this should be further investigated.

In addition to floodwater spreading, the water within the floodplains can be buffered to increase infiltration and soil moisture storage. Possible 3R techniques to achieve this include contour bunds, trenching and eyebrows.

7.8 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.

Improvement of existing water pans

Most of the visited pans are not managed nor maintained in an optimal manner. Only the Kamboe water pans had a local agreement on the water use, where the smaller pan is used first, then the large pan and the underground masonry tank as last. None of the pans or dams had a working fence and livestock could enter any time. The quality of the water in the pans therefore was strongly reduced. Moreover, the observed pans were filled with a relative thick layer of sediment, and had therefore become rather shallow. Most observed pans were not deeper than 50cm to maximal 1m.

The existing water pans can thus 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 (Figure 7-2, example 7a and 7b). Therefore, it is recommended to reinforce these quarries into full functioning pans, including proper water management.

During the construction of the road a lined water basin with a storage capacity of approximately 36,000 m^3 (Figure 7-2, example 3c) and several boreholes were created for the water supply. After the road construction is completed, these are donated to the local people to provide in their water use. In addition, potential water storage can be created using the opportunities offered by the presence of the road, as extra recharge can be created by discharging road runoff water through turn-outs. Also, the quarries that were created during the construction can be made available as large water reservoirs, when they are combined with smartly placed interventions. This is illustrated by the following example.

Near Kamboe a road quarry is located, which is currently not yet optimally used for water storage. To make it available as a reservoir, a small check dam should be implemented to store the water. However, at the current location, the catchment behind the quarry is too small to provide enough run-off water to fully fill the potential reservoir. Therefore, the reservoir should be connected with the discharge from an adjoining catchment. This can be accomplished by the construction of a culvert, which captures the runoff coming from the Kamboe Hill and transfers it to the quarry. Also here the design of the construction should be made in such a manner that first a natural clay lining can be deposited, and that after that a too large sediment deposition is prevented.

With the implementation of two relative modest interventions the amount of water storage capacity can in this example thus be strongly increased, making using a depression that was made for the road construction. To optimize this multiple use of road quarries, the location choice for future quarries may also be guided by the possibility to later use it as a water pan.

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 realize 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 summarizes the key problems. After that, chapter 8.3 presents a summary of the building blocks of a vision for the pilot area as being developed by the stakeholders during a first meeting on 31 May 2013. Finally, chapter 8.4 provides as number of recommendations, based on the analyses presented in this report, 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.

Poor water management

Another main area of problems is that the organizations responsible for direct management and provision of the water services and the water resources are weak. 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 and there is the impression that people from within the communities hardly pay for water services, in contrast with people from other area using the water sources. The fact that people report that their traditional management structures (water pans) work much better 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 are 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.

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 use, people want cleaner water or water nearer to their houses. They have the ambition to start small scale agriculture and ask for a water source near the wet season grazing lands in order to make better use of these pastures. At the same time, however, people seem to accept that their water points are poorly managed by a WUA which they have elected themselves, or that they have to walk a long distance to a neighbouring borehole because no initiative is taken to solve internal political problem which stops the repairing of the community borehole. As mentioned by FH staff during the focus group discussion to one of the communities, people shall lower their expectations towards external aid and become pro-active in the provision of safe reliable water for their community. Years of external aid have surely disturbed the fragile balance and coping mechanisms which were put in place by communities in the past, are not used anymore. There seems to be little belief that they are themselves the key to any solution in the area.

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). The visioning discussion provided the first building blocks for a vision and longer-term plan for the area. In summary the visioning contain the following points: People want to see all boreholes and main pipelines functional so everyone can reach water easily. The overall access to water is used to improve public health and hygiene. More run off is caught and seasonal rivers are used better for the different water uses. The planning of the water infrastructure is taking into account the impact it has on the environment (grazing lands) and risk of depletion of the water sources. The size of the livestock herds is managed by selling and re-purchasing, balancing it with dry and wet seasons. Communities are capable to develop small scale agriculture in the area, building on the first experiences with drip irrigation, green houses and kitchen gardening. The water infrastructure is managed by competent water committees that are supported by government and civil society organisations.

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 en the actual use in the future with 3R information on the water resource development potential in the area (see chapter 3.4 and annex 10). The potential for 3R interventions is discussed in detail in chapter 7.

8.4.1 Pilot interventions

During the workshop in Nairobi, the pilot interventions were discussed which have to be implemented before the end of 2014. The high potential 3R options are described in Chapter 7. Out of these options the preferred options were discussed amongst the IP and Dutch partners. The newly planned 3R interventions for the pilot will take place in Laisamis at Kamatonyi Village, and not in Logologo because of the many existing water sources and ongoing projects. For the Marsabit 3R/MUS pilot area the following preliminary selections were made:

- Construction of a new sanddam at Kamatonyi Village. A large part of the Kamatonyi community lives about 1 km north of the primary school along the Kamatonyi River. There is no existing (improved) water source in this area. The Kamatonyi River has a riverbed with course sand. A feasible site for a sanddam, was found in a narrow stretch with hard rock surrounding the riverbed, close to the village.

- Riverbank infiltration through a shallow well at Kamatonyi PS. Previously a well in the riverbank provided water to the school and the surrounding community, but this well got washed away during a severe flood. Future shallow wells should be sited outside the streambed on the riverbank at a straight stretch or at the inner bend of the river. This should be done in cooperation with the community, ensuring the site is not flooded, but will still receive recharge from the riverbed. Optionally an infiltration gallery can be constructed to increase the yield.

These options will have to be further discussed with the stakeholders. The exact location, the dimensions and specifications will have to be determined through a process of stakeholder consultation and siting. The exact siting and design of the interventions will be executed by a third party (consultant). During this process backstopping will be provided by the Dutch partners.

8.4.2 The Local Integrated Water Resource and Service Management master plan

- Make a water master plan for the Bori/Kate 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.
- These gaps are identified by with the RIDA analysis and strategic interventions are selected using the provided tools including the 3R potential map and MUS demand analysis tools.
- 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.

8.4.3 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 analyzing 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.
- To make sure that the WMCs/WUAs/WSPs/traditional water supervisors can do their job, the support to these organizations need to be committed and integrated in the MoU.
- For rural domestic water supply the most feasible water supply techniques in the 3R/MUS target area include: sanddams, subsurface dams, shallow wells, rooftop harvesting, closed tanks, and alternatively deep boreholes.
- 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 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.
    - Find out if increasing household water storage is increasing the domestic water use.

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.
- Optimize 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.
- Water sources can be specifically developed for this purpose, or combined with water sources for other demands. Water pans are commonly used for small scale irrigation of vegetables in the dry season, while maize is often grown in flooding areas. The latter could be enhanced through floodwater spreading and buffering with bunds and eyebrows.
- Find out the potential for food production for the local market.

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

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. FAO Livestock Unit table

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

Population

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%]

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

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

Water demand for domestic use for the sub-location

[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

Water demand for livelihood: livestock

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.

Water demand for livelihood: agriculture

[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).

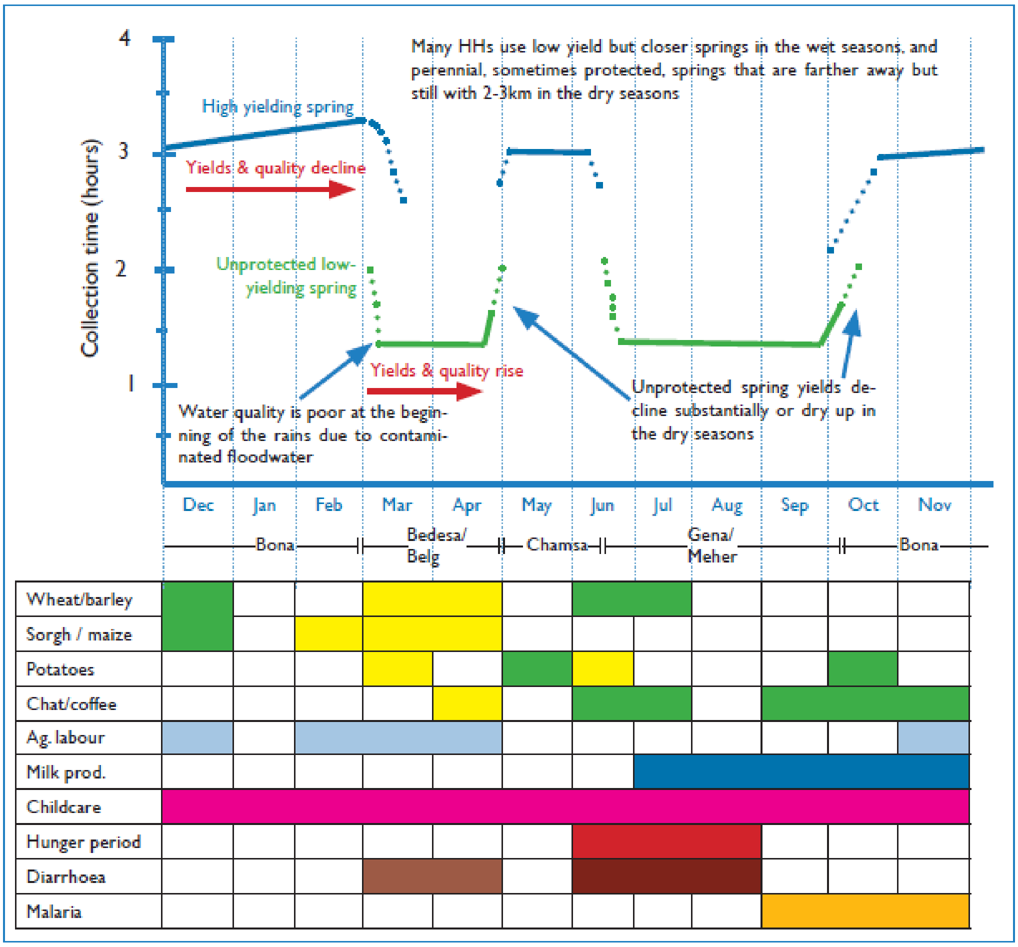
Periods of vulnerability are those where both assignments (seasonal labour and water collection) are high – where HH may struggle to obtain enough safe water for survival or livelihood protection.

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.

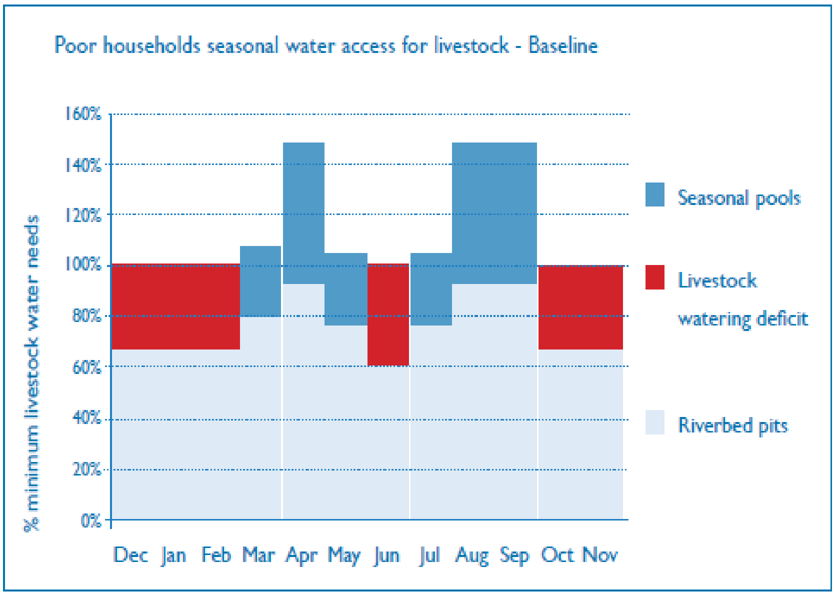


② – Based on the calendar, periods where households cannot obtain enough water to meet survival (drinking, cooking, hygiene and sanitation) or livelihood protection (livestock rearing, irrigation) can be identified. This seasonal water access and deficits can be quantified more precisely by defining 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

① Before 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.

② Checking the logistic - for the map, make sure:

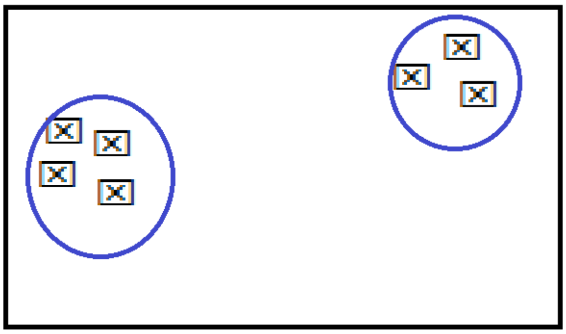
- That a good diversity of pens and pencils in different colors are available to the participants,
- As for the font used, the overall map of the area can be either drawn by the community on a simple blank A3 paper, or provided by the facilitator (Google map printing, map of the village, map of the area 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.

③ Once 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 Logologo and Kamboe

County	Sub location	Water source		Coordinates WGS84 37N UTM				
		Type	Name	X	Y	Elevation	Functional?	Remarks
Marsabit	Logologo	Borehole	Lesitima	379291	219494	461	Yes	3 gensets present, only emergency genset from Laisamis is working, borehole is not properly covered, pipes leak and water meter exposed on the ground
Marsabit	Logologo	Borehole	Lansangir	N/A	N/A		Yes	
Marsabit	Logologo	Borehole	Kijito	N/A	N/A		No	
Marsabit	Logologo	Borehole	Sanjir	380202	220050	472	Yes	4 gensets + windmill present, one genset working. Borehole next to fenced plot with drip irrigation lines and 2 greenhouses from Welt Hunger Hilfe. System under construction, not working currently. People tried to grow crops on fields outside greenhouses, but failed due to insects and diseases.
Marsabit	Logologo	Borehole	GUDAS	393524	218372	423.0	No	In very bad state of maintanance, raiser main has a problem according to community
Marsabit	Logologo	Borehole	Soriadi	395904	202832	424.0	YES	
Marsabit	Logologo	Borehole	CH windmill	379140	219091	456.0	No	Abandoned
Marsabit	Logologo	Borehole	Road Construction 1	377150	230694	742.1	N/A	Under construction
Marsabit	Logologo	Borehole	Road Construction 2	373573	203043	486.3	N/A	Under construction
Marsabit	Logologo	Borehole	Road Construction 3	379012	219080	456	N/A	Under construction
Marsabit	Logologo	Water pan	KOHTE	383253	209608	457	YES	The pan has water but will likely dry up within a month, silted. EC 1480, T36.5 deg. pH 7.8
Marsabit	Logologo	Water pan	GUDAS 1	391941	218211	433	YES	Water used for livestock, but also directly for drinking (observed during visit). Water has a high turbidity, gray color. EC 1300 mS/cm, temp 27.5 deg. Water lasts for up to 3-4 months in the dry season.

Marsabit	Logologo	Water pan	GUDAS 2	393460	218223	426	YES	Water has high turbidity, reddish color. EC 200 mS/cm. The water lasts for about 3 months in the dry season. Dam no. 1 is preferred by herdsman because the cattle need the salty water.
Marsabit	Logologo	Valley tank	LOGLOGO Road	379171	221192	486	N/A	New tank for road construction, sealed with plastic sheets. Storage capacity 36.000 m3. After road construction the tank becomes available to the community.
Marsabit	Logologo	Water pan	Lekorela	379058	221669	490	NO	
Marsabit	Logologo	Water pan	TORNASIRA-2	378882	216736	453	YES	
Marsabit	Logologo	Water pan	TORNASIRA-1	377400	215997	454	NO	Silted
Marsabit	Kamboe	Borehole	KAMBOE/Furmarsen	378999	227330	623	No	
Marsabit	Kamboe	Water pan	KAMBOE	377686	232241	796	YES	2 reservoirs. High turbidity, red color. Lasts 1-3 months. Used for domestic and livestock. First the little tank is used, after that the large one.
Marsabit	Kamboe	Water pan	Kamboe Silanga Road Quarry	376475	232722	807	YES	
Marsabit	Kamboe	Water pan	Rete WP	379145	232959	737	?	
Marsabit	Kamboe	Water pan	Niogor Ancare	N/A	N/A		?	
Marsabit	Kamboe	Closed tank	Kamboe Tank	377111	233265	819	Yes	Uses runoff coming from the hill slopes. Silttrap filled, inlet silted, handpump clogged with silt. Rervoir full of water, but likely also contains silt.

ANNEX 7: Field observations

Double ringinfiltrometer

No.	Location	WGS 84, 37N			Area description	Soil description	Plot description	Infiltr. cap. (cm/hr)
		UTM-X	UTM-Y	Z				
1	Central, Karare	374906	239145	978	Marsabit volcanic upper slopes, grassland and shrubs	Dark red loamy soil	Gentle slope, bare soil some grass	5
2	Laisamis	352677	176455	615	Basement rocks, plain area 4km from large granite ridge	Red loamy soil with silt/sand	very gentle slope, almost bare soil	5
3	Laisamis	370012	189889	580	Volcanic plateau, flat area with basalt outcrops	Brown-red loamy soil/silt loam	Bare soil	6
4	Logologo	386241	201391	450	Malgis River floodplain	Brown clay-loam	Cracked clay, some grass	3
5	Central, Kamboe	379411	224557	576	Marsabit volcanic lower slopes (Kamboe), scarse grassland and shrubs	Brow silty clay	Bare soil, many basalt outcrops present	10

Open hole infiltration test

6	Laisamis	353712	158713	629	Riverbank Kamatonyi river (depth 50cm)	Brown red loam	Riverbank with large trees	300
7	Logologo	383441	209770	445	Kaisut Dessert, near Kothe Water Pan (20 cm)	Yellow-grey silt-loam	Bare soil	70

Riverbed probing

				Bedwith	Test 1		Test 2		Test 3		Test 4		Remarks
No.	Location	UTM-X	UTM-Y		Distance	DTBR	Distance	DTBR	Distance	DTBR	Distance	DTBR	
1	Merille River, natural barrier	354610	158251	33	10	0	15	0.4	23	0	28	0.5	Area with rocks close to surface, sand bed before is deep at places, over 3 m according to community, also observed in scoopholes
2	Kamatonyi River1, proposed sanddam site	353445	158989	20	1	0.5	2	1	10	1.5	15	0.5	
3	Kamatonyi River2	353707	158686	25	10	1.5							400 m downstream proposed sanddam site Kamatonyi, wider riverbed, and banks are loamy

Auger profiles

Profile 1				
Location	Gudas flood plain			
UTM-X	395693	**UTM-y**	218989	
Depth	**Color**	**Texture**	**Remarks**	
0	dark brown	Loamy clay	Cracked	
20	dark brown	Loamy clay	Moisture	
80	dark brown	Loamy clay	Moisture	
100	dark brown	Loamy clay	Moisture	
Profile 2				
Location	Double ring 1			
UTM-X	374908	UTM-y	239134	
Depth	**Color**	**Texture**	**Remarks**	
0-20	dark red	silty clay		
20-80	brown red	silty clay		
80-120	orange red	silt		
Profile 3				
Location	Double ring 2			
UTM-X	352679	UTM-y	176454	
Depth	**Color**	**Texture**	**Remarks**	
0-2	Light brown	Sand		
2-50	browns red	Loam		
Profile 4				
Location	Double ring 3			
UTM-X	370012	UTM-y	189887	
Depth	**Color**	**Texture**	**Remarks**	
0-20	brown red	silt loam		
20-30	grey	weathered rock	stones	
30-100	brown red	silt loam		
Profile 5				
Location	Double ring 4	Malgis River flood plain		
UTM-X	386239	UTM-y	201392	
Depth	**Color**	**Texture**	**Remarks**	
0-5	brown	clay	cracked	
20-50	brown	clay loam	moisture	
50-65	brown	clay loam	moisture, mica	
65-120	dark brown	silty clay	moisture, silt	

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 A7-2 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

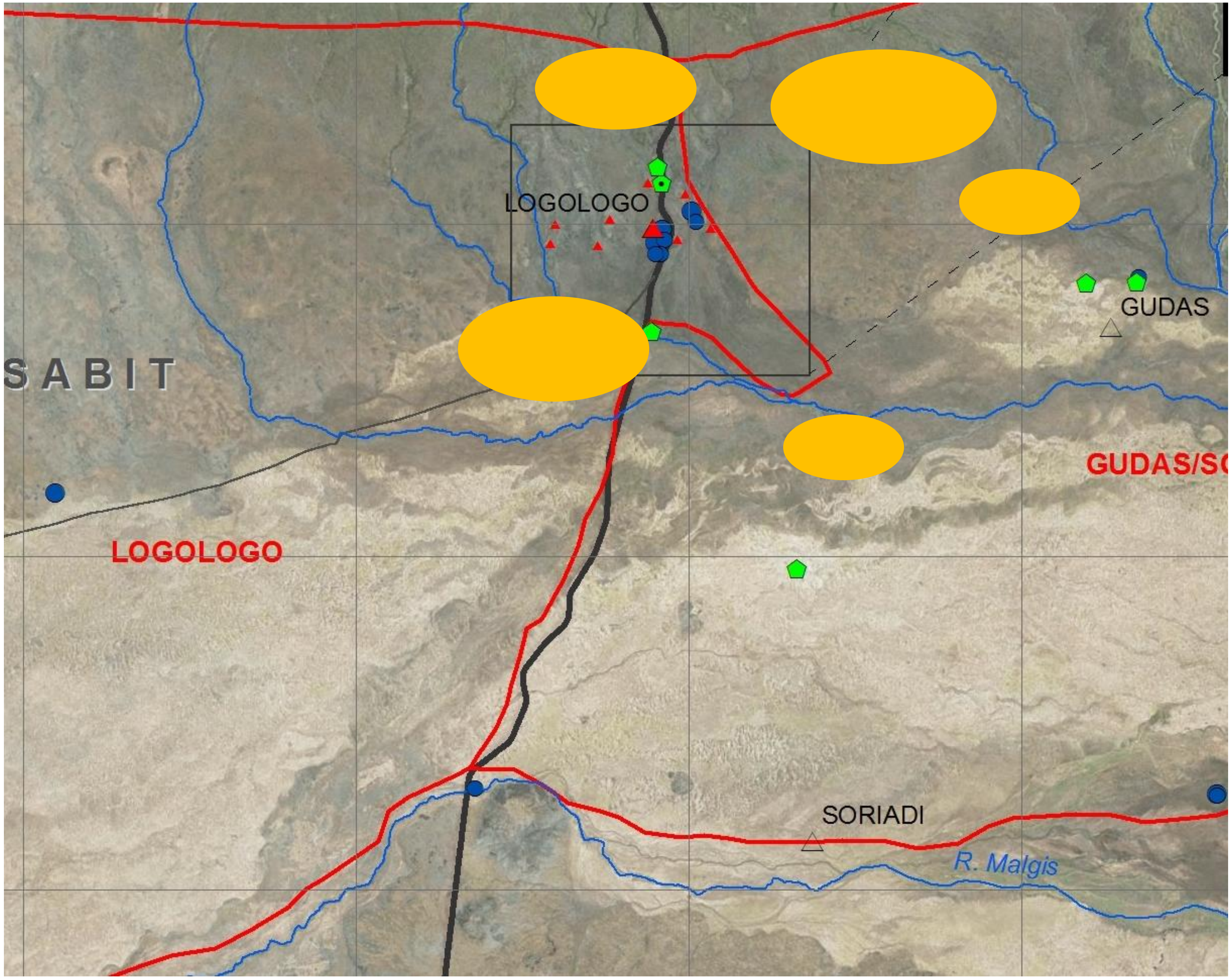
1. Using the estimate methodology of chapter 6, provides the values for the demand in 2023. In the case of Logologo, wildlife is assumed to make use of the same infrastructure (remote water pans), during the same periods as the migrating herds for a period of 3 months only
2. Infrastructure has been 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

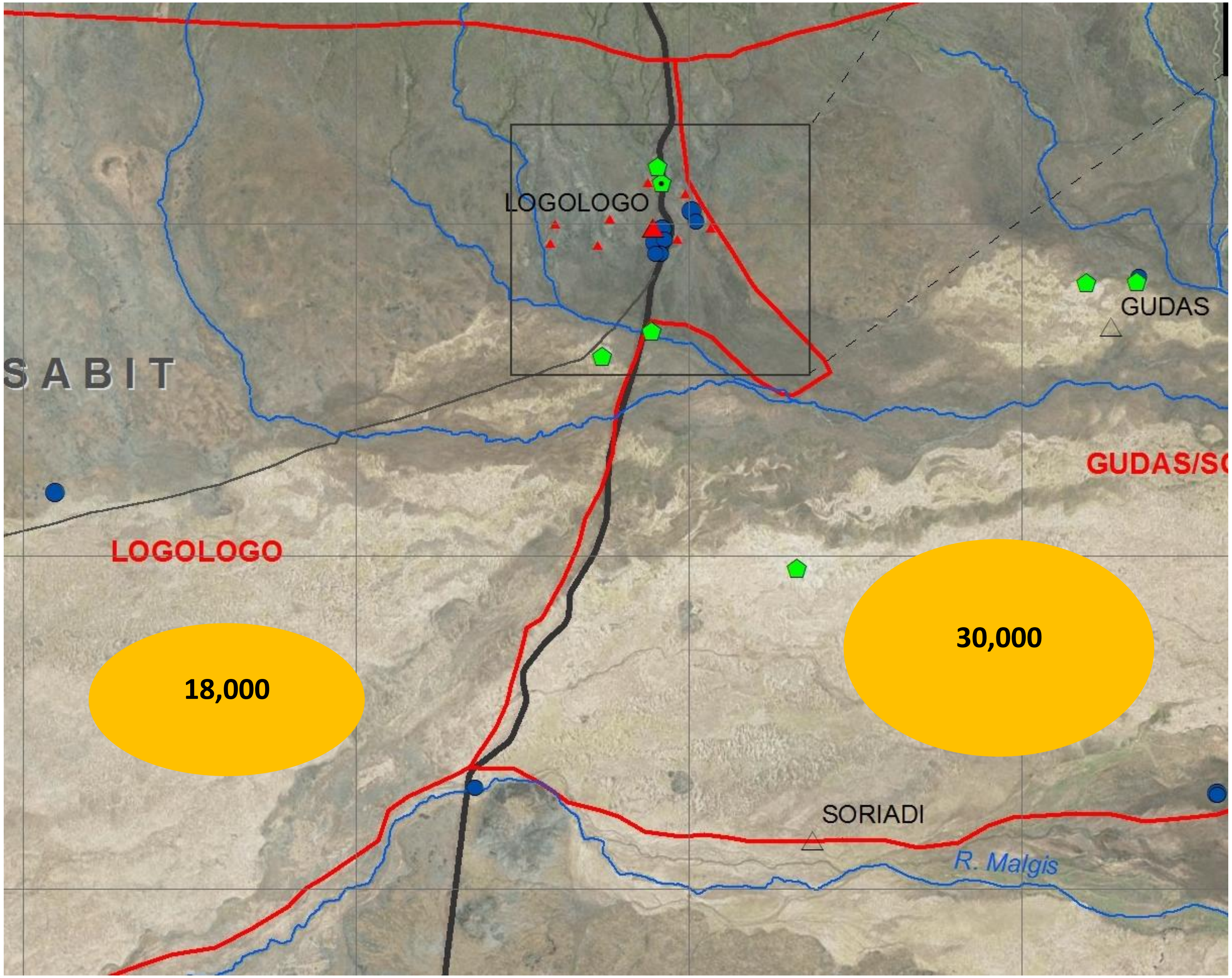
[1]: in m^3 covering an agreed dry period

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

Gap domestic water demand Logologo 2023 (m^3)

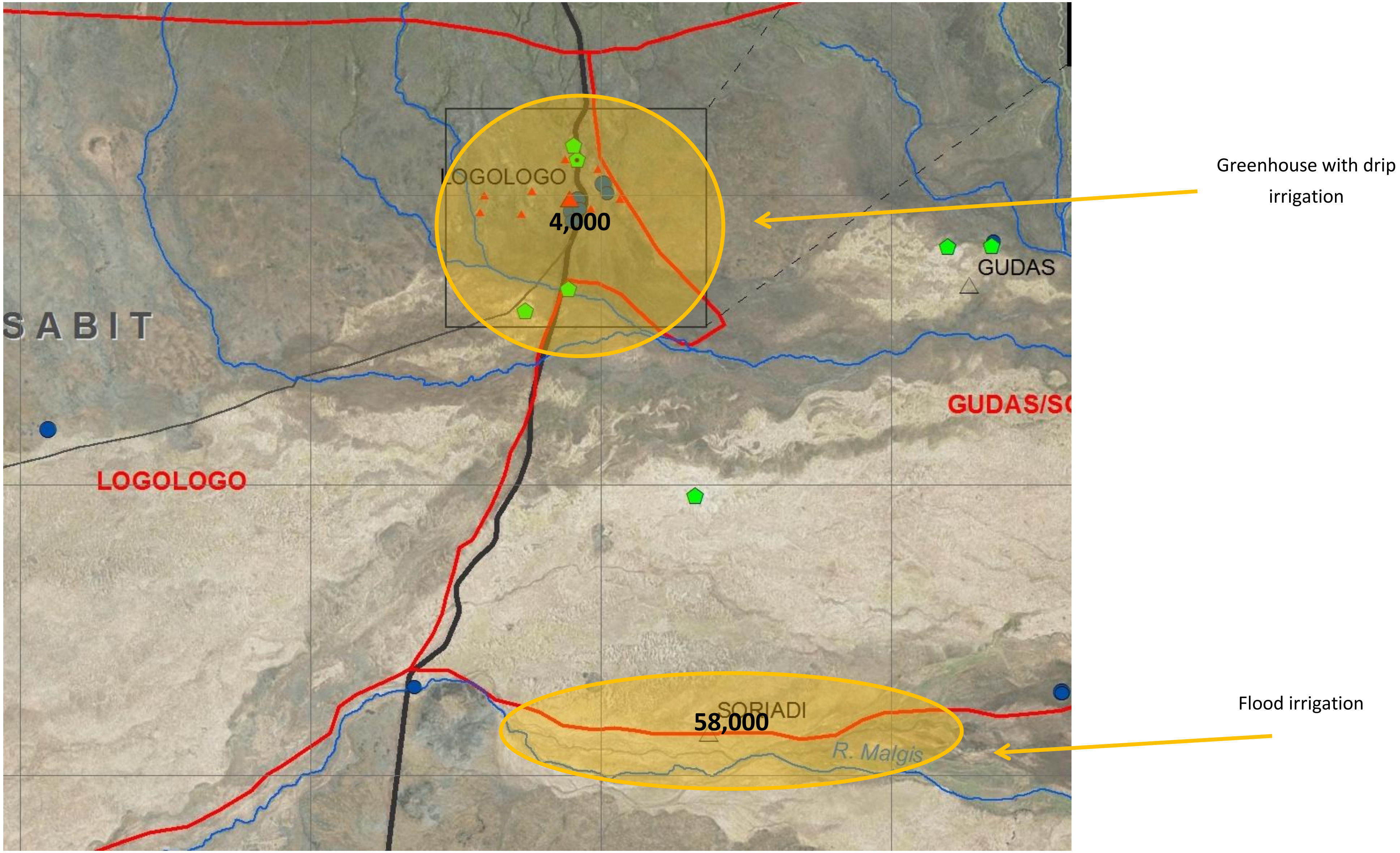


Gap livestock water demand Logologo 2023 (m^3)

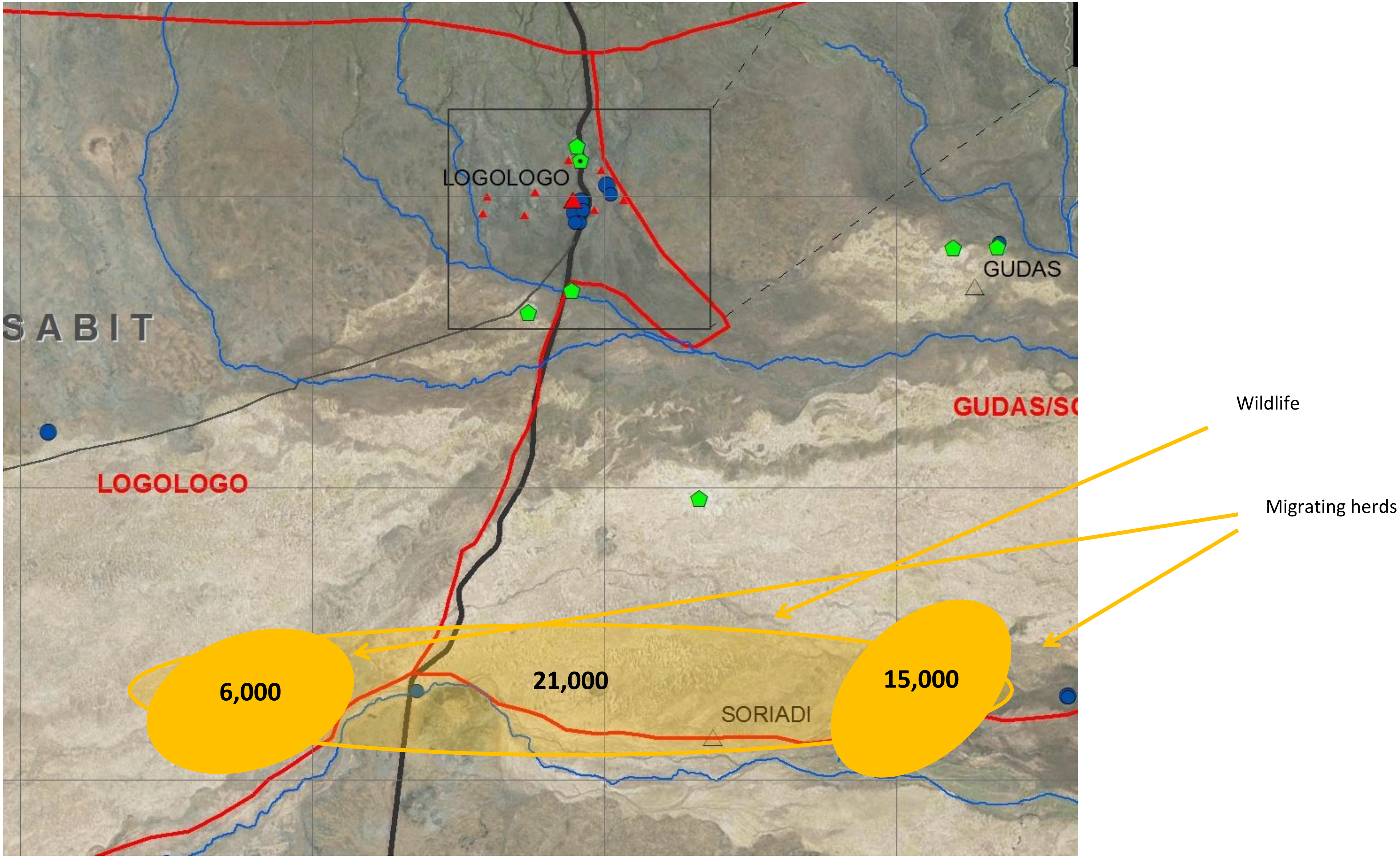


Kenya Arid Land Disaster Risk Reduction (KALDRR -WASH)

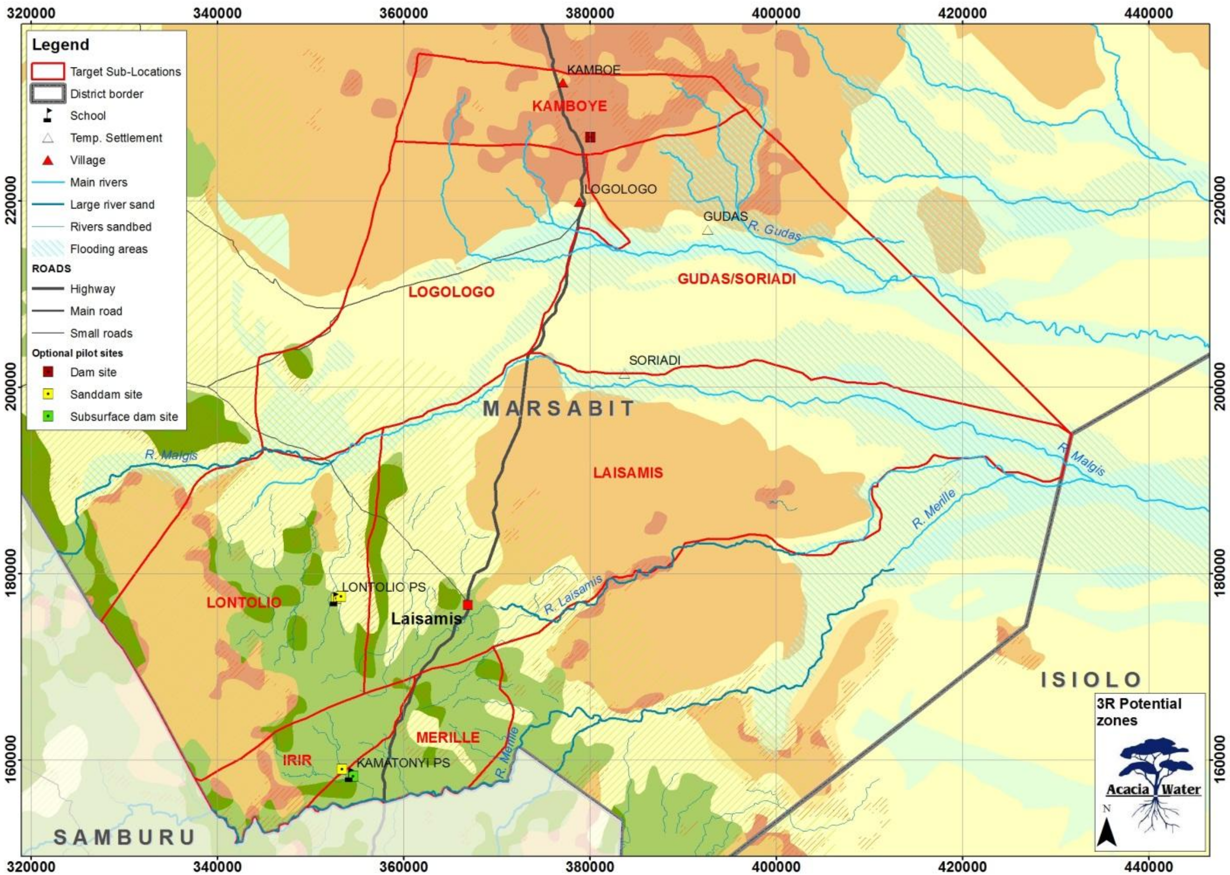
Gap agriculture water demand Logologo 2023 (m^3)

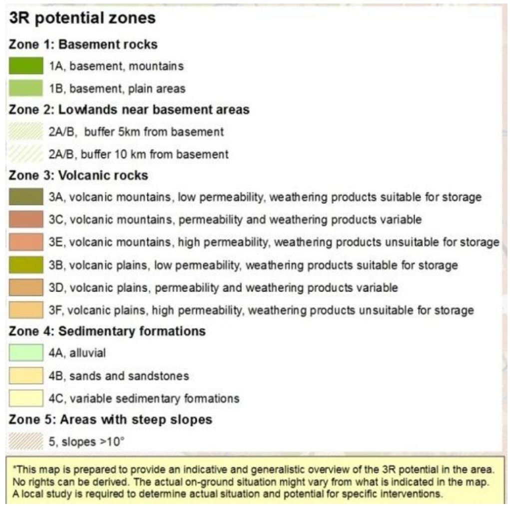


Gap migrating herds and wildlife water demand Logologo 2023 (m^3)



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.