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 Kalemngorok-Katilu in Turkana

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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.

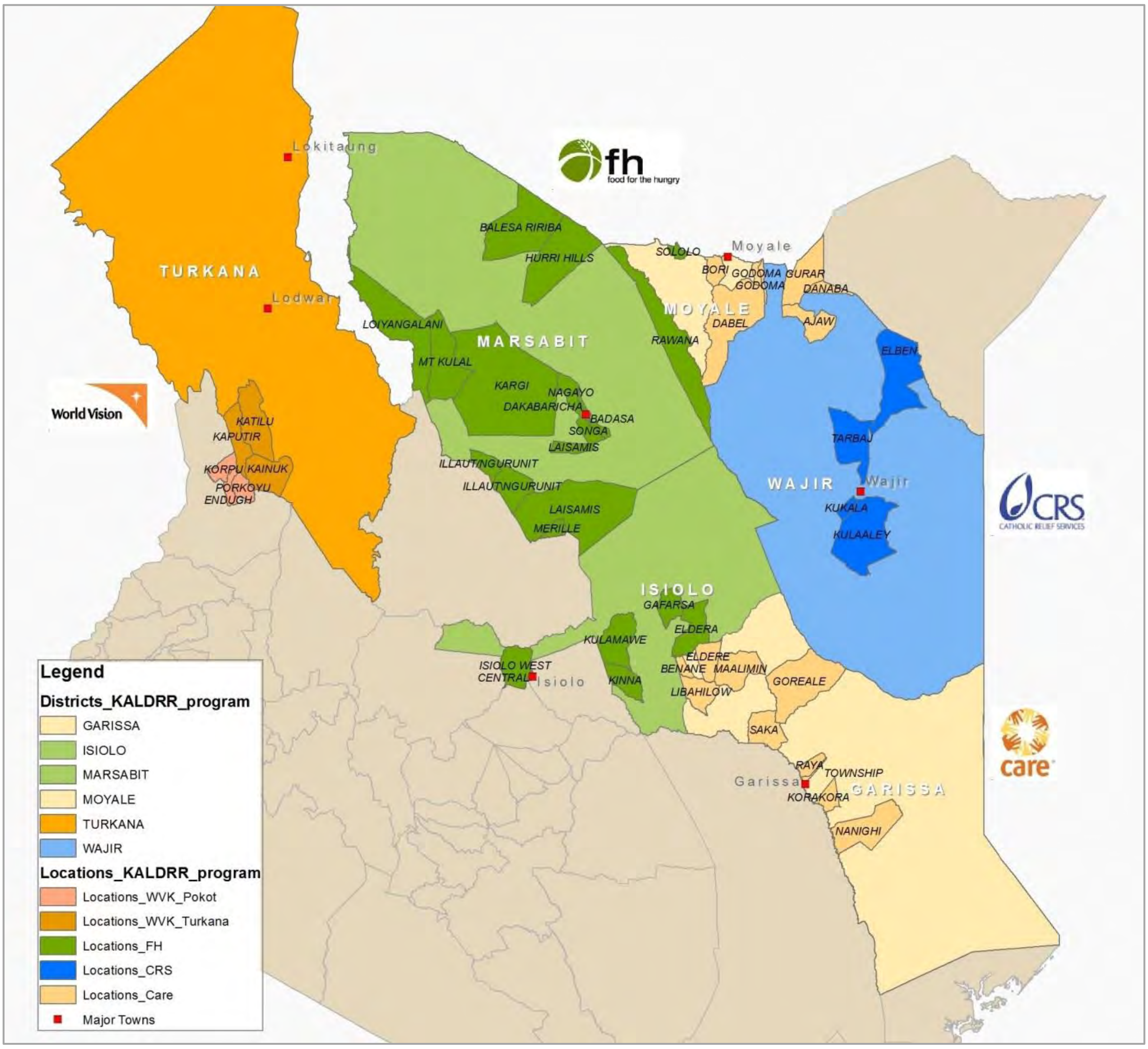

Figure 1-1: KALDRR project areas

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 methodologies: for maximising 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

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

[2] For more on 3R, see: http://www.bebuffered.com/

[3] For more on MUS, see: http://www.musgroup.net/

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 WVI, which is located in Turkana 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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[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).

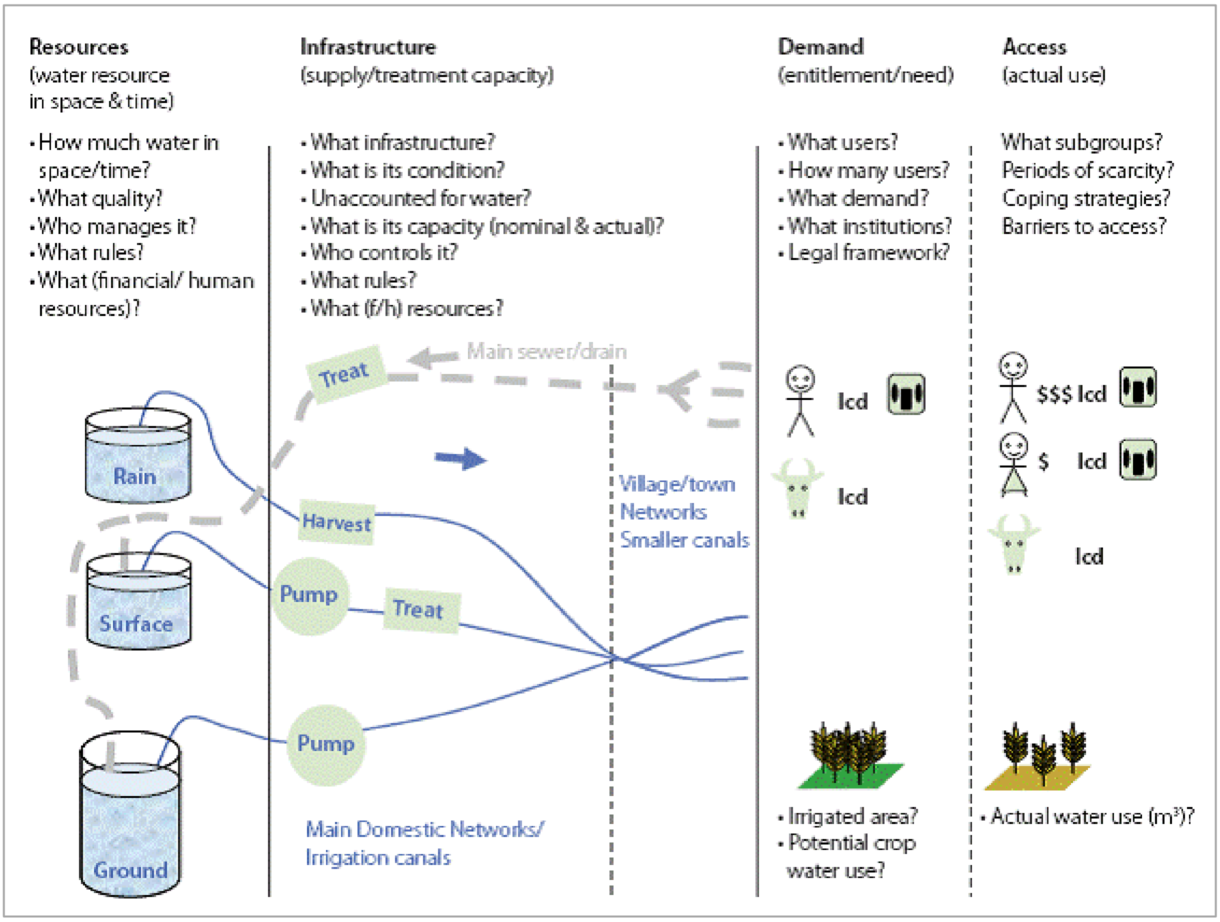


Figure 2-1: Example of RIDA (Empowers 2007)

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.

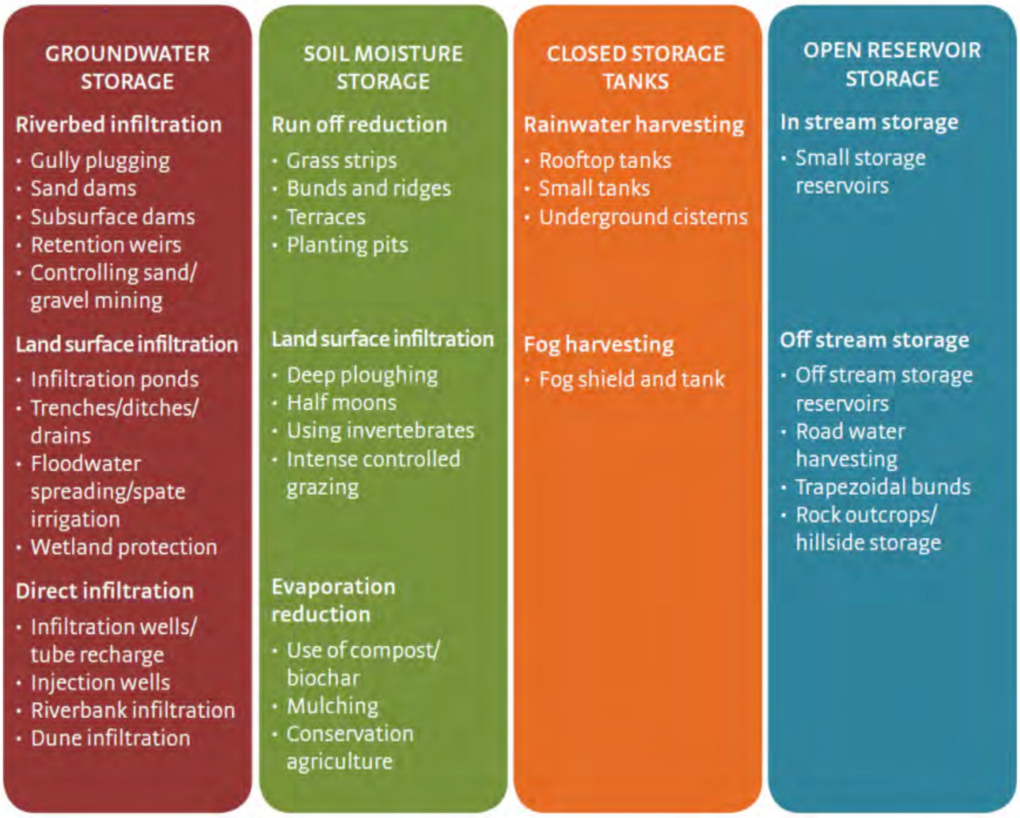
The resource determines the amount of water that is potentially available, while the infrastructure makes it accessible. In many areas that currently suffer from droughts the resources are in total enough to fulfil the demand. However, the moments that water is naturally available are limited in time, 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.



GROUNDWATER STORAGE

Riverbed infiltration
- Gully plugging
- Sand dams
- Subsurface dams
- Retention weirs
- Controlling sand/ gravel mining

Land surface infiltration
- Infiltration ponds
- Trenches/ditches/ drains
- Floodwater spreading/spate irrigation
- Wetland protection

Direct infiltration
- Infiltration wells/ tube recharge
- Injection wells
- Riverbank infiltration
- Dune infiltration

SOIL MOISTURE STORAGE

Run off reduction
- Grass strips
- Bunds and ridges
- Terraces
- Planting pits

Land surface infiltration
- Deep ploughing
- Half moons
- Using invertebrates
- Intense controlled grazing

Evaporation reduction
- Use of compost/ biochar
- Mulching
- Conservation agriculture

CLOSED STORAGE TANKS

Rainwater harvesting
- Rooftop tanks
- Small tanks
- Underground cisterns

Fog harvesting
- Fog shield and tank

OPEN RESERVOIR STORAGE

In stream storage
- Small storage reservoirs

Off stream storage
- Off stream storage reservoirs
- Road water harvesting
- Trapezoidal bunds
- Rock outcrops/ hillside storage

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, like 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 helps to create 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:

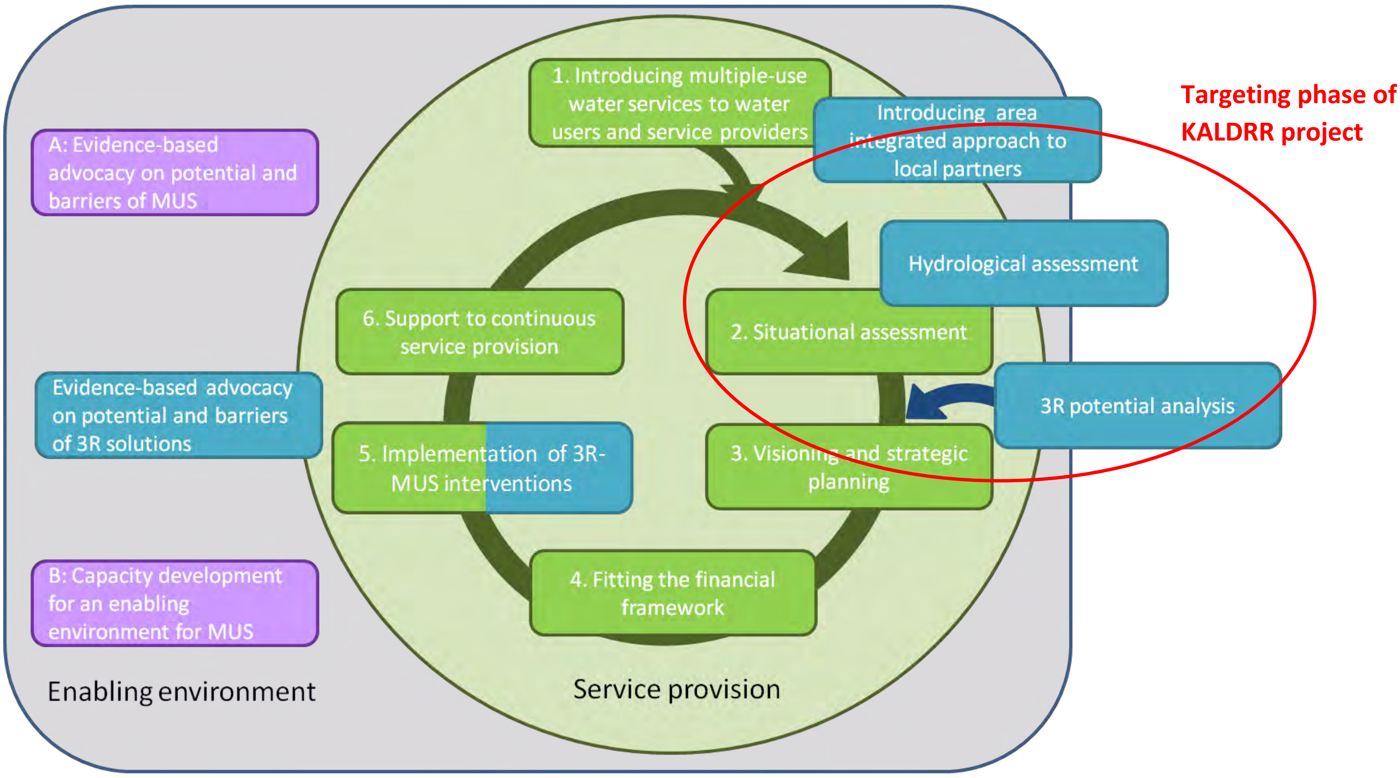


Figure 3-1: Process cycle, combining the MUS components (in green) with the 3R components (in blue)

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 recognises 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.

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[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 Turkana county

The following is based on FEWSNET "Livelihoods zoning "plus" activity in Kenya", 2011.

The North-Western pastoral zone has a hot climate, with temperatures of between 240C and 380C and an annual average of 300C. Rainfall is bimodal, erratic and unreliable. The short rains (April-July) and the long rain season (October-November) average 300mm-400mm of rainfall yearly. The rain falls in brief, violent storms resulting in floods. The surface runoff and potential evaporation rates are high.

The inhabitants of this zone are generally from the Turkana ethnic group. The majority of the residents (95%) are nomads, while 3% are internally displaced persons and 2% fully settled. The households mainly engage in livestock husbandry, trade, hunting and gathering for food and cash income. The overall pastoralist population can be broken down into the following wealth groups:

	Rich	Middle	Poor	Very poor	Sedentary
% of population	10-20	25-40	30-40	5-25	<5
Shoats/HH	80-150	50-80	25-40	15-25	8-15
Camels/HH	10-20	1-5	0-1	0	0
Cattle/HH	50-100	`0-10	0	0	0

On the other hand, communities along the Turkwell river have a different lifestyle although surrounded by the Northwest Pastoral livelihood zone. About half of the inhabitants are fully settled, 40% are nomadic and 10% migrant labourers. The majority of the inhabitants engage in food crop production, livestock production and firewood collection and/or charcoal production for income.

An average household keeps up to 5 cattle, 10-20 goats, 10-20 sheep, chickens, ducks, a donkey and a camel. Goats, sheep and cattle are the highest contributors to cash income and goats are the highest contributors to food from household livestock production. Livestock, including poultry production contribute to up to a third of household income. Households consume their own produce including sorghum, maize, vegetables and dairy products. Crops are cultivated under rain-fed and irrigated conditions during both rainy seasons. Maize and sorghum, which account for about 80% of crops are the most important crops grown under irrigation. Sorghum is the highest contributor to cash income from household crop production, followed by tomatoes, maize and pulses. Food crop production contributes to up to 40% of household income. However, local production is not adequate for all year consumption and households have to rely on markets for food purchases which are poorly distributed and often difficult to access. Livestock production contributes about 25% of household income, followed by firewood collection/charcoal production, small businesses and other self-employment activities.

For the pastoralists, most of the food commodities consumed by the households are sourced from the markets. The most common food purchased is maize. Livestock and livestock products are the main source of income for the better off. The middle and poorer households sell bush products (charcoal, poles, etc.) and rely on social support for income. CFW (Cash for Work) contributes to mainly the middle and poor income and ensures that these households protect their asset base. Middle and better off households have similar expenditure patterns: purchasing mostly food, as well as trading goats for clothes and beads, health care and household goods.

Aid dependency is very high and most households cannot cope without aid, even during a non-crisis year. Poorer households cannot depend on pastoralism for their livelihoods. Coping mechanisms, such as increasing charcoal sales, are not sufficient to compensate, since the market is so limited. Markets function inefficiently. Maize prices are twice the national average, and goat prices are low.

There is high insecurity and conflict incidences with neighbouring communities occur frequently: herds are stolen and people killed. Essential dry season grazing lands in the north are inaccessible. There are no alternative livelihoods. Education and skill levels are very low for employment.

4.2 Area selection in Turkana

For the area analysis within the program area of WVI, an area is selected in Turkana 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 selected 3R/MUS pilot area for the local inventory consists of Kalemngorok and Katilu Sub-Location, in Turkana South District, Turkana County (Figure 4-1). The area is located between Kainuk and Lochichar, along the Turkwel River.

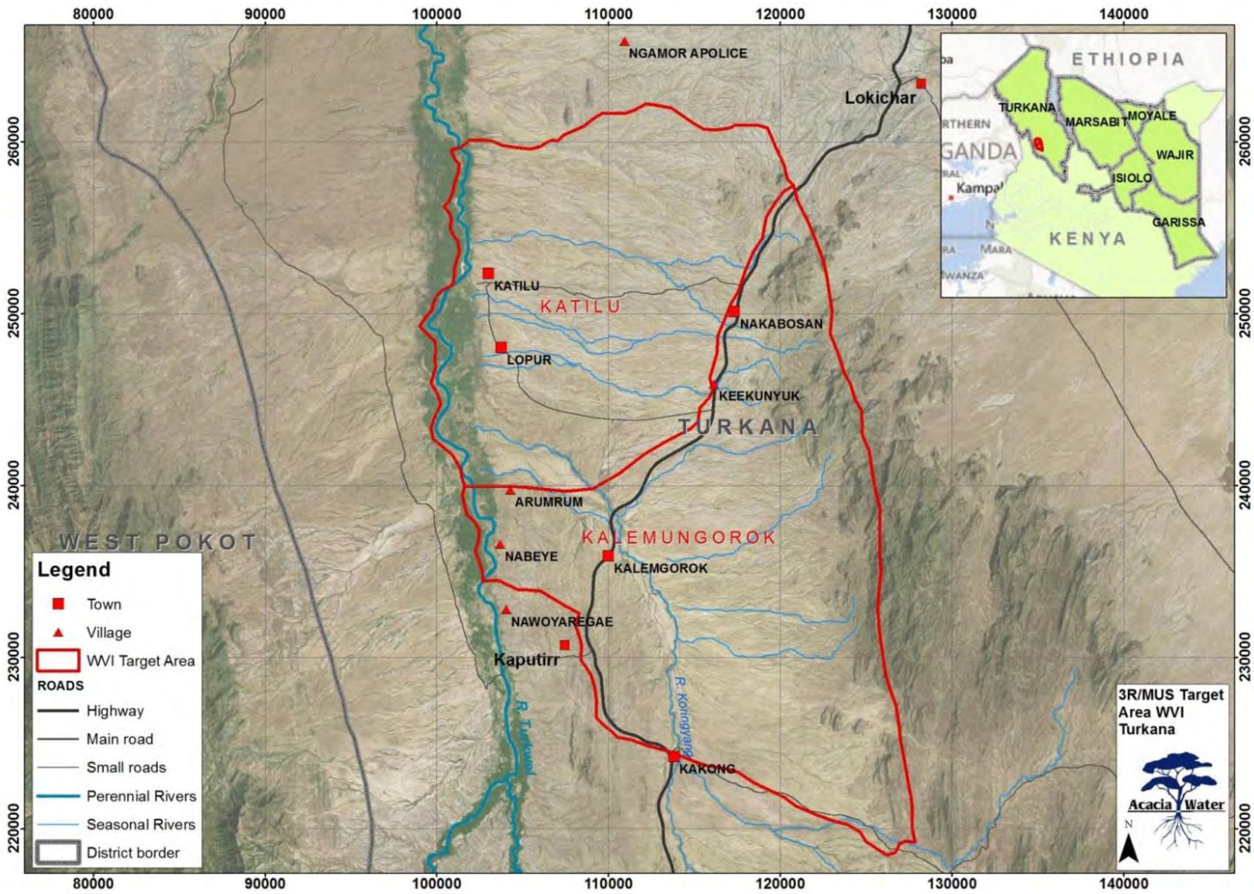


Figure 4-1: Selected area for the RIDA analysis. In red the 3R target area where the resources and infrastructure are evaluated, and in orange the area in which the MUS management, demand and access analysis focus

The 3R/MUS target area is located in a relatively flat sedimentary area, between the Turkwel River on the West and the mountain range on the East. Turkana South National Reserve covers part of the south-east of the target area. The sedimentary area consists of colluvial deposits, pebble sheets, red soils, old surface (Garissa) (Sedimentary continental Holocene). The mountains in the east are part of the basement rocks of the Mozambique belt, consisting of quartzites, micaschists, biotite and hornblende gneiss, granitoïd gneiss, amphibolites, migmatites, syntectonic granites.

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-, overlandflow, gully flow, seasonal rivers, groundwater and springs (Figure 5-1). These components their characteristics in relation to the different landscapes classes are described in this chapter.

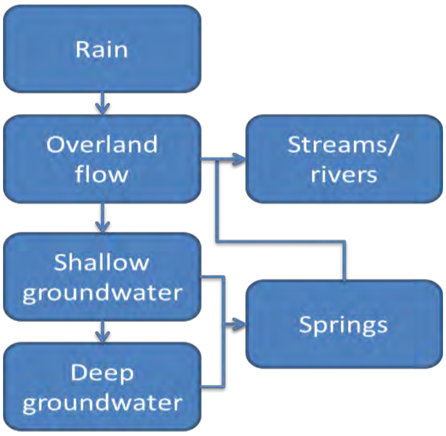


Figure 5-1: Water resources and their relation

Rain

The rainfall in Turkana is seasonal, generally divided over a main rainy season between March and May and a smaller rain period in October and November. Within the district there is a high variety in total annual rainfall, which is mainly influenced by altitude. Generally, the northern parts, south Turkana and areas bordering Uganda receive more rain than the other parts of the county and especially the central-eastern part surrounding Lodwar, receives low rainfall (Food Security Master Plan for Turkana County, 2013).

The average annual rainfall ranges between 170 mm in the dry areas up to 1000 mm per year in the upper parts of the mountainous areas in the North. The rainfall is erratic in distribution and timing, the drier the area, the more unreliable the rain is. The intra-year coefficient of variation is more than 50% throughout the District, with peaks of 75% and more in the driest western areas (Hijmans et al., 2004).

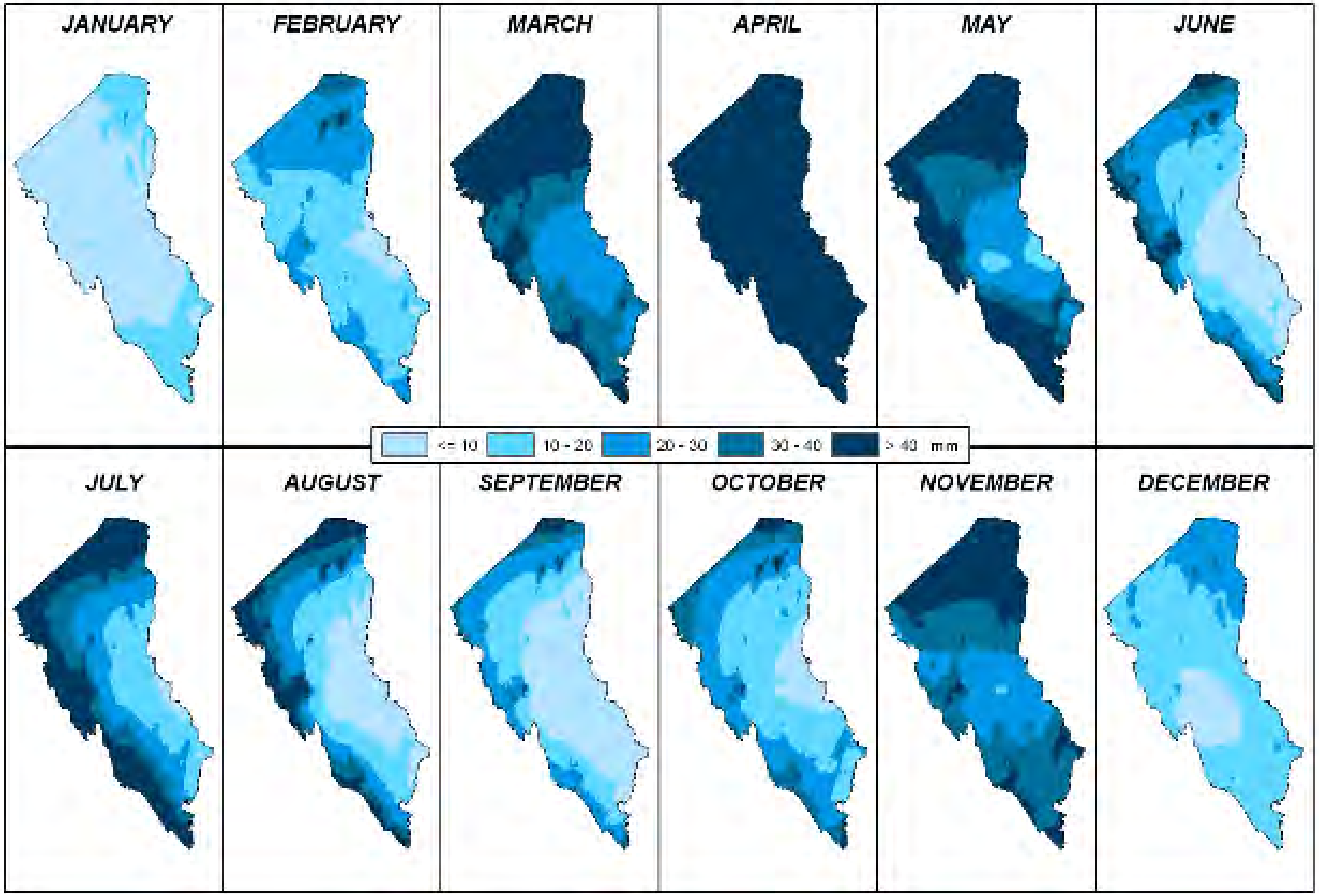


Figure 5-2: Average monthly Rainfall for Turkana (ILRI, 2005)

Overland flow

The mountains east of the sedimentary plains have mostly steep slopes and rocky catchments. Therefore, the intense rainfall events will generate high surface runoff, discharged through the seasonal streams in the valleys present on the slopes. The field observations and interviews indicated that the overland flow at the slopes is quickly lost from the area, unless it is captured with interventions like pans or checkdams.

The sedimentary areas have generally gentle slopes and the runoff coefficient is expected to be much lower. However, runoff will occur when the rainfall intensity exceeds the infiltration capacity of the soil. Infiltration test carried out on different soil types in these areas indicated an infiltration capacity between 6 and 12 cm/h.

Additionally, overland flow in the plane sedimentary areas occurs in the floodplains of some of the streams and rivers that discharge the runoff from the mountains. Especially along the Turkwel River, floodplains are found, but also near Kalemngorok a large flooding area is present. This was observed in the field from alluvial deposits, dense vegetation cover and flow patterns. The overland flow in the floodplains will have a lower velocity, sediment is likely to deposit and the clayish sediments fertilize the soil. 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

Turkana County has three perennial rivers i.e. Turkwel, Kerio and Omo as well as one dependable intermittent river, the Tarach River (Food Security Master Plan for Turkana County, 2013). The Turkwel River is located in the target area and forms a perennial water source, and is used for many purposes, including irrigation. Many seasonal river and streams are present in the target area. The largest of these rivers, the Koringyang River has its catchment in the mountains south-east of the target area, flows along Kakong and Kalemngorok towards the Turkwel south of Lopur. Most other seasonal rivers have a catchment in the mountains and discharge west, towards the Turkwel or Koringyang River. These streams fan-out some kilometers before joining the Turkwel River. Figure 5-3 provides an overview of some of the larger streams and rivers in the area.

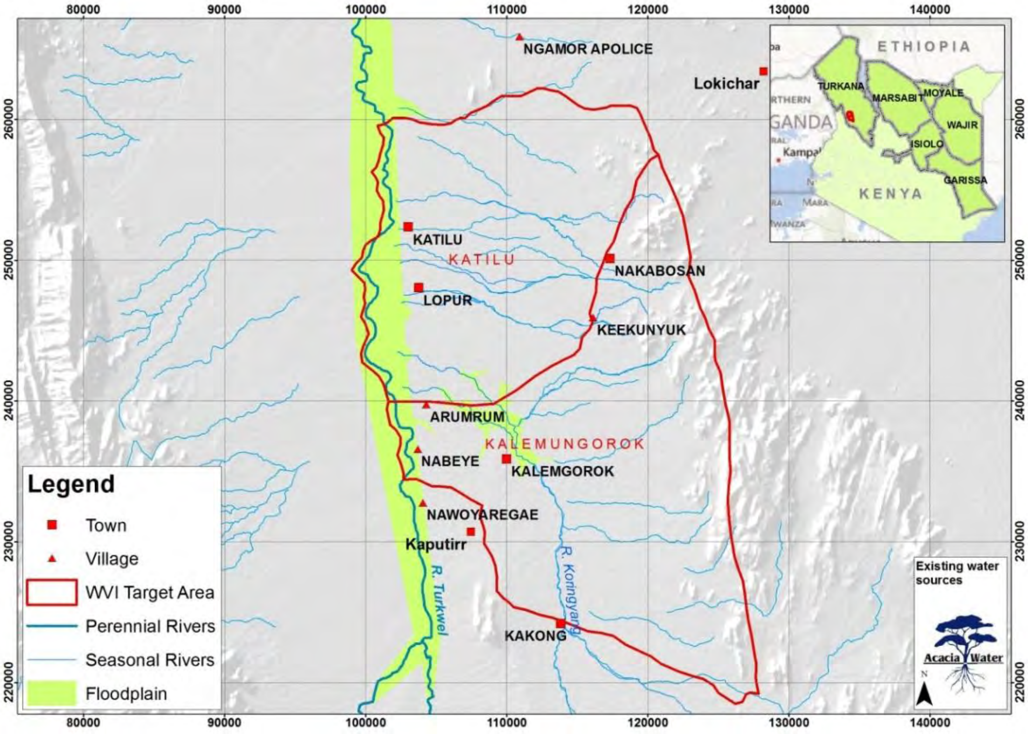


Figure 5-3: Rivers and streams in the project area

Field interviews indicated the seasonal rivers are dry for most of the year. These rivers only flow after heavy rainfall, which creates a periodical discharge and sometimes flash floods. For the smaller rivers close to the mountains, the discharge start within a few hours, while for the Korinyang River it normally takes several days. When the rains stop, most of the rivers dry up within a day, although water remains available in the riverbed for much longer, where communities use scoopholes to extract water during the dry season.

Most 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. The sediment in most streams consist of medium to coarse sand particles, reasonable well sorted and sub-angular. The porosity of the sand was tested at a number of rivers with the bucket method, and the water storage capacity varied from 25 to 30%. The rivers in and near the mountains (basement rocks) have stony riverbeds with hard rock shallow to the surface. The hard rock in the sedimentary areas varies strongly, it can be as deep as 100 mbgl or more, while at other places a ridge of hard rock crops out. However, although the hard rock is generally deep, at least some of the rivers have a clay layer within 2 to 6 m below the bed. During the field visit the depth of the riverbed was measured using a probe and obtained through field interviews. At the River near Keekunyuk (see Figure 5-4), a thick clay layer with some boulders was found at a depth of 2.2 meter. Interviews indicated that the Koringyang River at Kalemngorok has a clay layer at a depth of about 6 m. Upstream at Kakong the interviews indicated that the river has a clay layer at about 5 m depth. At the river 1 km south of Nakabosan the riverbed had a depth of over 3 m at some places, while at two sites a hardr ock layer came up to the riverbed, forming a natural barrier before which water is likely to be stored. Local interviews prevailed that large scoopholes were dug in this area, supplying several communities, before other water sources like boreholes were available. Comparable hard rock layers are also present in some of the smaller streams near Nakabosan.

Figure 5-4: Test pit in Keekunyuk River, the dark layer at the bottom is a clay layer (left). Riverbed with sand near Nakabosan (right)

The streams in most of the area have a clear streambed that does not seem to change its coarse regularly or flow outside the riverbanks. This is indicated amongst others by the large trees covering the riverbanks and the limited signs of erosion in the banks. In some areas, especially near the Turkwel River, the rivers become wider and split up in several streams or large flooding areas. This is most likely related to the slope, as these areas are more flat.

Shallow groundwater

Shallow groundwater is found throughout the area, especially along the (seasonal) rivers, where many existing shallow wells are present. In the sedimentary areas the hard rock is mostly found at greater depths, often below 50 m, and the measured infiltration capacity at the surface was reasonable (6 to 12 cm/h). This indicates the presence of layers that stop the water from infiltrating to the deep groundwater. The field tests and interviews confirmed this assumption, as clay layers with cobbles were encountered.

Shallow groundwater is found directly in the riverbed, where water is extracted through scoopholes, and shallow wells, as well as in layers below the riverbed and in the riverbanks. The riverbanks are characterized by trees and other dense vegetation, compared to the surroundings, which can be clearly distinguished from an aerial view (see Figure 5-5). This might be an indication for the presence of shallow groundwater.

Figure 5-5: Picture taken from the mountain near Nakabosan, looking towards the Turkwel River. Streams are clearly distinguished by trees. The main road crosses from left to right; while in the upper left corner a river with a sand bed can be observed

The depth of shallow wells is mostly between 4 to 10 mbgl (MIS database and field observations). The water level in the river bed varies during the dry season. During the field visit (end of July) at the start of the dry season, the water level was still near the surface. Local interviews indicated that at the end of the dry season scoopholes or open wells in the riverbed are dug up to 5 to 8 meters.

Many boreholes and shallow wells in the project area have a salinity problem, which often increases in the dry season. Figure 5-6 provides an overview of the depth and salinity of shallow wells in the target area. The data is based on some field electrical conductivity measurements and the MIS databases. The latter only provides secondary data of the users based on taste; fresh, slightly saline (use for drinking), saline (used for livestock), and very saline (too saline for livestock). From the field measurements the EC above 1000 µS/cm was indicated as slightly saline, above 3000 µS/cm as saline.

There seems to be a relation with the depth of shallow wells and the salinity, as the shallowest wells of less than 5 mbgl have lowest salinity. However this does not always apply, some of the deep boreholes also have low salinity and some of the shallow wells, are slightly saline. Water directly extracted from the riverbeds generally has a low salinity, as all EC measurements carried out in scoopholes had an EC below 1000 µS/cm.

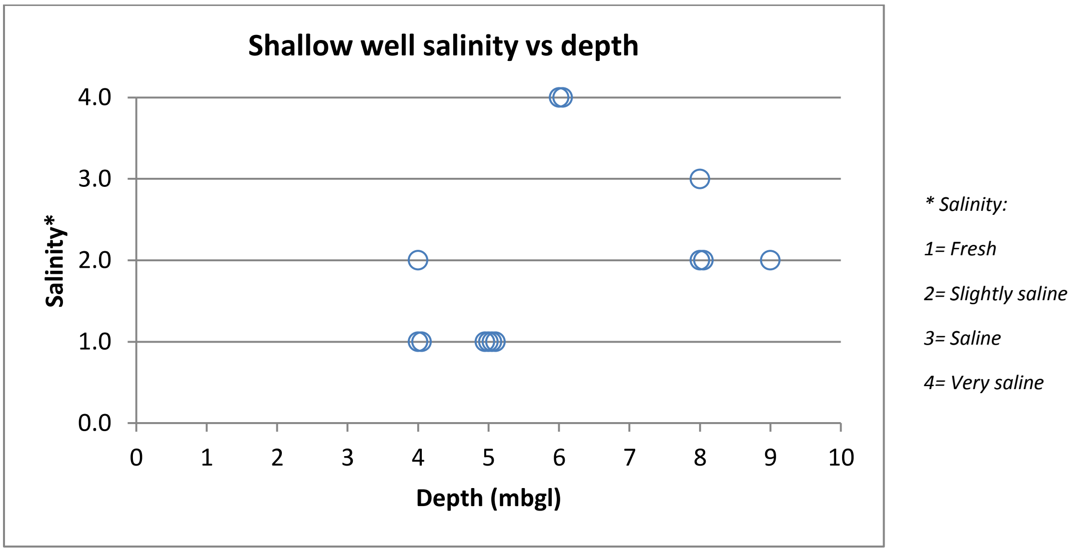


Figure 5-6: Shallow well salinity vs depth, from shallow wells in the target area (source: field data and MIS database)

Especially shallow wells along the Turkwel river seem to have salinity problems, while the River itself has a low salinity; the EC measured during the time of visit was 196 µS/cm. When looking at the elevation profile of the area, the Turkwell River lies in the lowest part of the valley with sediments, more than 100 m lower than the sedimentary area near the mountains (Figure 5-7). This might explain why the saline groundwater comes close to the surface near the river.

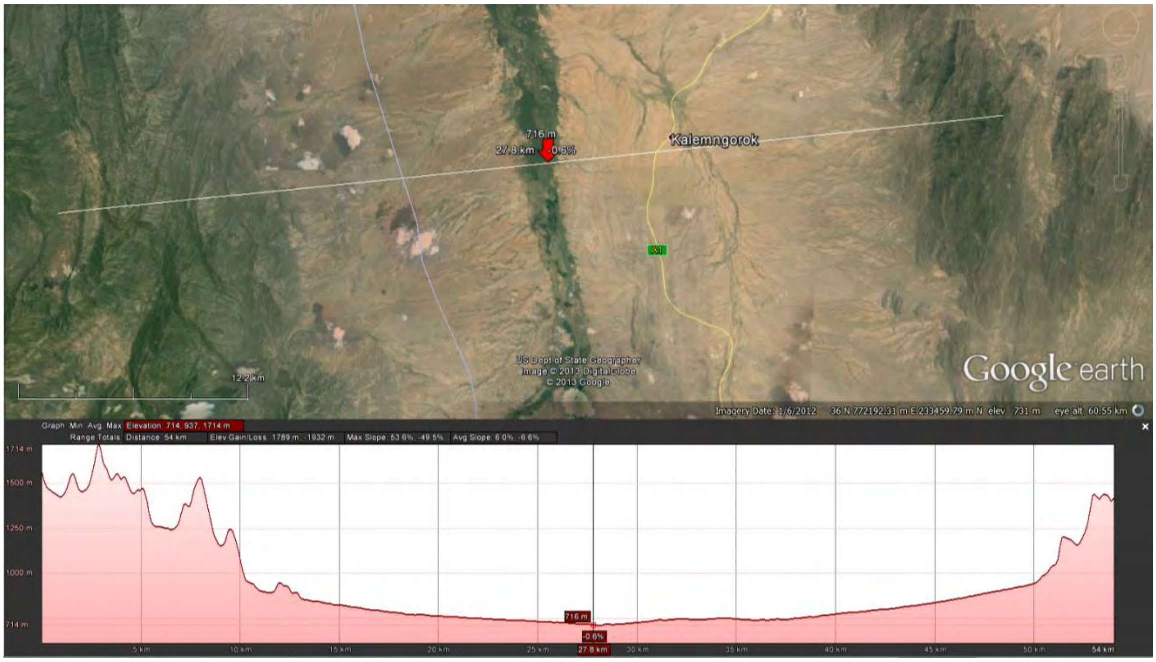


Figure 5-7: Eeast-west elevation profile of the project area at Kalemngorok (source: Google Earth)

(Deep) groundwater

The main deep aquifers are found in the sedimentary formations. Aquifers vary highly in depth and yield, water strike levels are found from 5 to 100 mbgl and yields vary from 1 to 20 m^3/h. The depth to bedrock also varies, at some places hard rock is surfacing while at other places the bedrock is found at a depth of 120 mbgl (BH data WVI Kainuk). Quite a number of boreholes have a salinity problem. Based on the MIS database, more than half of the boreholes have a salinity problem, which increases during the dry season.

5.2 Existing infrastructure

Different types of existing water infrastructure is found in the area, including motorized deep boreholes with piped schemes, shallow (open) wells, pans and closed water storage tanks. Figure 5-8 provides an overview of the existing water sources the target area, based on the data available in the MIS 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.

Boreholes and wells are mostly found along the (seasonal) rivers, while pans are mostly off-stream. The difference between the 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.

Most of the water infrastructure is located in or near the towns or larger centres and the main road, while villages and settlements further away from the main roads do often not have any improved water source in the vicinity.

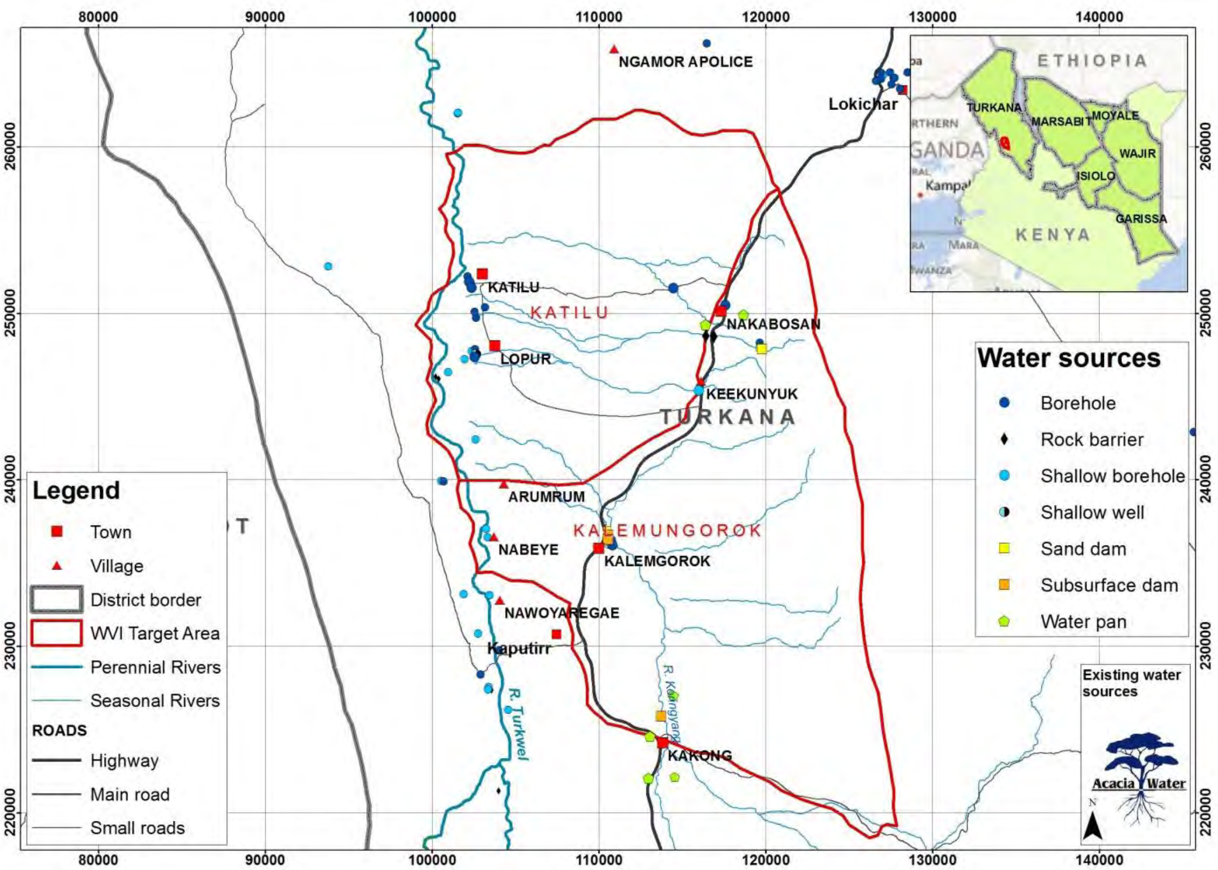


Figure 5-8: Existing water sources

Boreholes

Boreholes are the most common water supply technique in the area, and are present throughout the project area. Generally they provide a reliable water supply in terms of quantity, while about half of the boreholes have a salinity problem.

Water from most of the boreholes is extracted with submersible pumps, of which the larger part is powered with a solar system, and some with a generator. Some of the boreholes and most shallow wells are equipped with hand pumps.

Water pans and valley tanks

Open water storage in water pans is widely used in the region. Most of the water pans are used for multiple water uses, mostly livestock and domestic use. The latter often happens without treatment as was observed during the visits. The water pans vary largely in size, functionality and state of maintenance. Most of the pans that were visited are shallow and are likely to dry up within weeks after the rains have stopped, while others were already completely dry at the time of visit. These pans do not have functional silt-traps, and cattle can freely enter the water from all sides, which contributes to bank erosion and siltation and water quality degradation.

The water quality of the pans is generally poor and turbidity levels are high. Some of the pans are expected to have a very high microbiological contamination, as livestock enters, and washing and bathing takes place directly in the water.

To provide a higher water quality for domestic use from existing and new surface water reservoirs, infiltration galleries with a collection well and a handpump can be a feasible intervention. This method can significantly improve the water quality, although it is not guaranteed to remove micro-biological pollution completely.

Wells and scoop holes

Shallow groundwater is found throughout the area, especially along the (seasonal) rivers, where many existing shallow wells are present. The depth of shallow wells is mostly between 4 to 10 mbgl (MIS database and field observations). Most wells have a perennial yield, but the water levels reduce during the dry season and some completely dry up.

Scoopholes and open wells are dug in the sandy riverbeds throughout the project area, although the number has reduced in areas where improved water sources have been constructed. In some cases scoopholes are dug up to many meters during the dry period, sometimes causing dangerous situations because of instable walls. Field interviews indicated that at Kalokoda river, near Nakamor A Police Village the surrounding communities excavate a large scoophole in the riverbed every dry season, up to 8 m deep (Figure 5-9). The nearest improved water source is located at a distance of 6 kilometre from the village according to the community.

Figure 5-9: Scoophole at Kodakoda River, water was present just below the surface at the time of visit, but the water quality is obviously a concern

Rain water harvesting tanks

Rainwater harvesting and storage in closed tanks is mostly applied in the larger centres where roofs with iron sheets are present or at schools or health-centres. WVI has constructed many masonry storage tanks in the area and two were under construction at the time of visit.

Sand- and subsurface dams

Although unknown by most organisations, the area has a number of sand- and sub-surface dams in the 3R/MUS target area. In the Koringyang River at Kakong and Kalemngorok, sub-surface dams are present.

The surbsurface dam at Kalemngorok is constructed by Arid Lands (NDMA) in 2007. Currently the dam is not visible at the surface, but local informants who were involved in the construction were interviewed. The interviews indicated that the dam was excavated up to 6 m below the riverbed, and raised up to up to about a meter below the surface. Ever since the dam is there water is available, the water level in the riverbed remains available within some meters of the surface, even in dry season.

In June 2012 a second dam was constructed 250 m upstream, funded by UNICEF. This dam was based on the same layer as the first dam, but only one meter high. Before this wall a collector drain was laid, leading to a collection well located on the riverbank. The well is equipped with a handpump, but the pump broke after one month and is non-functional ever since. According to the community the well provided water with a good quality. Currently scoopholes are used to extract water from the riverbed. However, 500 m upstream from the dam constructed by Arid Lands, a shallow well with a handpump is present in the middle of the riverbed. This well was constructed in 2011, is about 4.5 m deep and has a perennial yield. It is likely that the yield of the well is increased by the subsurface dam 500 downstream.

In the river near Nakabosan, on the edge of the basement formations, a sanddam was constructed in 2011 (Figure 5-10). The sanddam is constructed on top of hardrock, and has a wall height of 5 m and a width of 25 m. During the field visit the storage area before the dam was filled up with sand. Local interviews indicated that within two years the dam was filled. So far the dam is not used, no well is present and the community does not dig scoopholes in this area, since it is relative far from the nearest village.

Figure 5-10: Sanddam near Nakabosan

It was observed that some dams constructed where the road crosses the riverbed, formed a sand – or subsurface dam, before which sand filled the riverbed (Figure 5-11). It is unknown if these dams are constructed up to an impermeable layer or not and whether they currently provide water storage or not. Local interviews indicated that at some rivers, the community digs scoopholes upstream of these road crossings.

Figure 5-11: Concrete road-crossing through a riverbed, creating a sanddam

5.3 Management of water resources and water services

Balancing people, livelihood, environment and water

The Kalemngorok and Katilu sub-locations areas have to maintain a fragile balance between different interests, which are all centred on water availability. People in generally 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 in the different seasons, in the research for the best grazing lands and source of water for their livestock; in some cases, security is also the motive to look for further grazing lands. Regarding the communities living along the Turkwel river, water is primarily used (in quantity) for irrigating their crops and thus ensuring their main source of incomes. Turkwel river being one of Turkana county only 3 perennial rivers (Food Security Master Plan for Turkana County, 2013), it means it is also the only fully reliable source of water for livestock in the dry season. This was verified through the different FGD in the communities, where Turkwel river was always mentioned as source of water in the dry season, even for communities who had to walk several kilometres.

Finally, regarding domestic, and as in many others areas, the burden of water fetching is under the responsibility of women, who have to walk (1) to get water for the household and (2) to move around goats and sheep (and cattle if no men in the household) to the different water points according to availability of water in the different seasons. In areas where agro-pastoralism is present, it is also mainly the role of the women to (3) undertake agricultural activities.

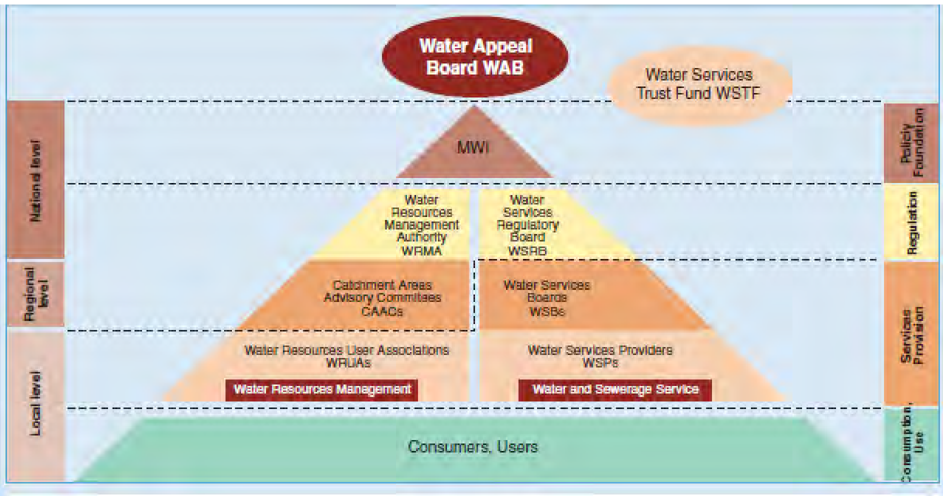
Movements of population in the area – as mentioned before, mainly by pastoralist communities with their livestock - is very common and largely practised, although exact proportion of community members moving around is not known. Water scarcity in the dry season lead to extensive queuing at the main water points, but is usually well accepted by the community, as people migrating are actually from the same community (FDG Keekunyuk). As a general rule, payment of water for people external to the community is at a higher fee than for the community members. Some communities (FDG Keekunyuk) are well aware of problems of over-grazing and try to make sure that livestock use different areas throughout the year.

This delicate balance can easily be disturbed and lead to tensions between the different communities over the use of water and/or grazing lands. In the area, the main conflict oppose Turkana and Pokot people, which very frequently leads to theft of livestock and sometime killing of people.

This means also that for the planning of the water sources, a careful assessment and consultation needs to take place. In accordance with Do not Harm principles, assistance brought in conflict-prone areas shall not worsen conflict among groups which the project is helping. This goes through conducting an in-depth analysis of the way water points are managed, and beyond the rules set by the authorities, how they are managed traditionally.

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 (WSBs). WSPs located in Turkana district depend in from the Rift Valley Water Service Board (WSB). 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 (SPA). The communities can access funding via the WSTF by registering as a Community Based Organisation to form a Water User Association (WUA). All water users from a given area become de facto members, and together they establish the WSP that will be responsible for the actual water services. The WSBs contract Support Organisations (SO) that will support the WUA in the whole process of developing the water service and build the capacity of the WUA/WSP.



Source: Kisima, May 2008

Figure 5-12: Institutional setup under the Water Act 2002

The Water Act was implemented in this area with the setting-up of the Rift Valley Water Service Board in 2004. According to their website, the rift Valley WSB has appointed 10 water companies and 23 water societies through Service Provision Agreements. As part of their objective to meet the MDG, a Ten year strategic plan was also developed which covers the period 2006 till 2015.

However, on the ground, and among the associations met within the target area (Kalemngorok water committee for example), water committee seem to operate independently from the Board as well as independently from each other, each of them being usually in charge of a set of water points within a given location. If the Water Committees officially have the role of Water Service Provider since the Water Act, and are officially reporting to the WSB, in the facts, they have not signed yet a SPA and Water committees tend to report primarily to the DWO (District Water Office) and WRMA office located in Lodwar.

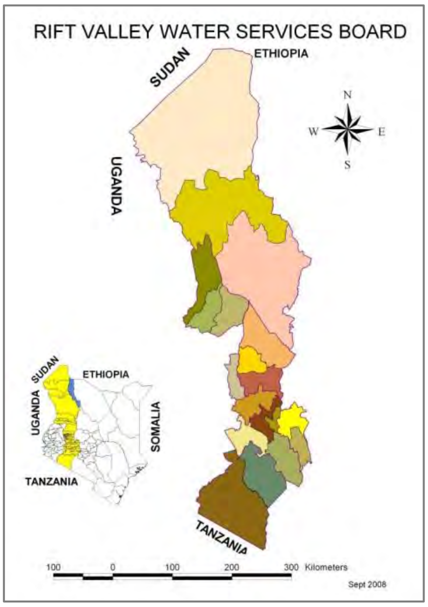


Figure 5-13: Rift Valley Water Service Board

One Water Committee in Kalemngorok mentioned however being registered with the Department of Social work. Water Committees organise the O&M of the water points they are in charge of (with support of the DWO and NGOs), pay salaries for guards (for solar panel equipment) and operators (water kiosks) when necessary, and fix the price of water.

This shows also that although the WaterAct has set-up a pyramidal line of responsibility to ensure proper O&M of existing infrastructure, traditional management rules over the water system management.

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 District Water Offices (DWOs), but they still exist directly under the Ministry of Water and Irrigation (MWI) with their own budgets independent from the WSBs (for both new investments and operational costs). However, DWO and NWSB work in parallel and in the fact there is no support from the NWSB to the DWO, or coordination in regards to money allocated for which projects. 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.

Both DWO and WRMA are present in Lodwar, but it was not possible to meet them.

Local coordination

For coordination of WASH activities in the area, monthly meetings are organized in Lodwar monthly (WESCOORD), where about 20 NGOs (Acted, World Renew, Merlin, …) meet and update each other on their current activities and scope of interventions.

The limited capacity and confusing roles of the water service and water resource authorities results in ad hoc support to the WSPs and WMCs, done mostly by NGOs in the target area. 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.

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 (if applicable),
- 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 **8.0**

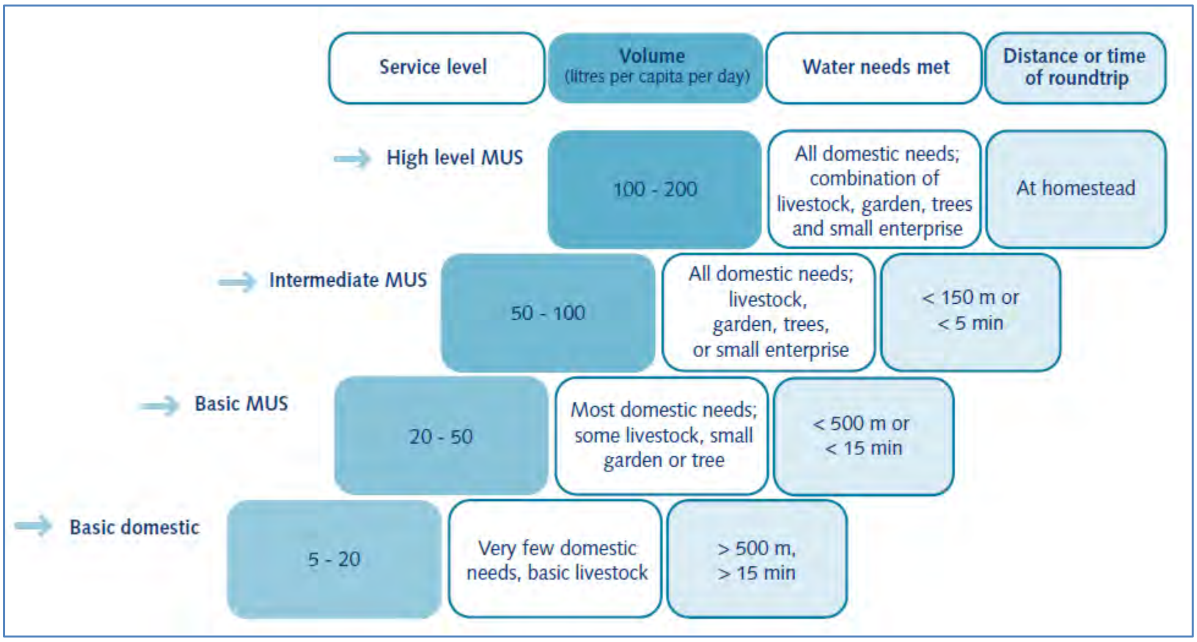
Assumption 3: Annual population growth rate considered is **3.0%**

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.

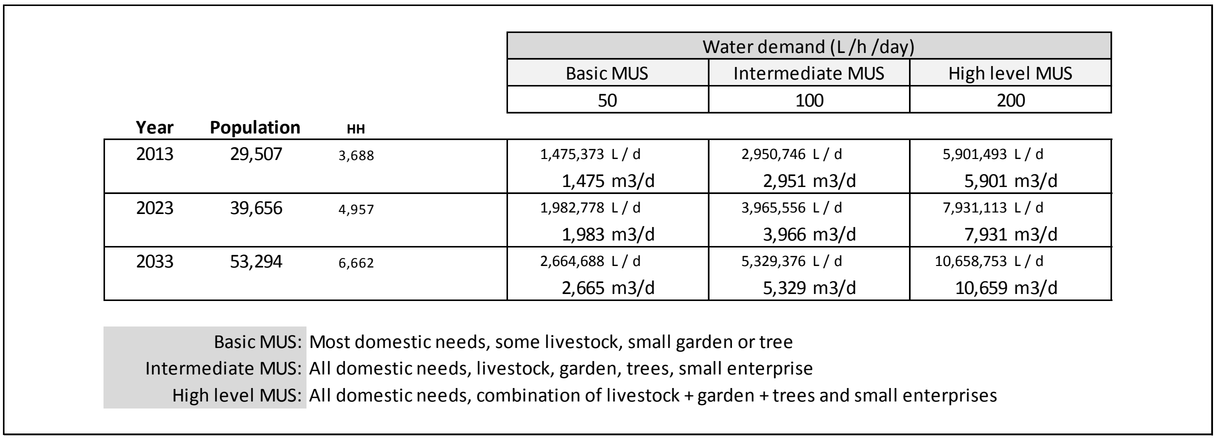


Service level	Volume (litres per capita per day)	Water needs met	Distance or time of roundtrip
High level MUS	100 - 200	All domestic needs; combination of livestock, garden, trees and small enterprise	At homestead
Intermediate MUS	50 - 100	All domestic needs; livestock, garden, trees, or small enterprise	< 150 m or < 5 min
Basic MUS	20 - 50	Most domestic needs; some livestock, small garden or tree	< 500 m or < 15 min
Basic domestic	5 - 20	Very few domestic needs, basic livestock	> 500 m, > 15 min

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
Year	**Population**	**HH**	50	100	200
2013	29,507	3,688	1,475,373 L / d 1,475 m3/d	2,950,746 L / d 2,951 m3/d	5,901,493 L / d 5,901 m3/d
2023	39,656	4,957	1,982,778 L / d 1,983 m3/d	3,965,556 L / d 3,966 m3/d	7,931,113 L / d 7,931 m3/d
2033	53,294	6,662	2,664,688 L / d 2,665 m3/d	5,329,376 L / d 5,329 m3/d	10,658,753 L / d 10,659 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

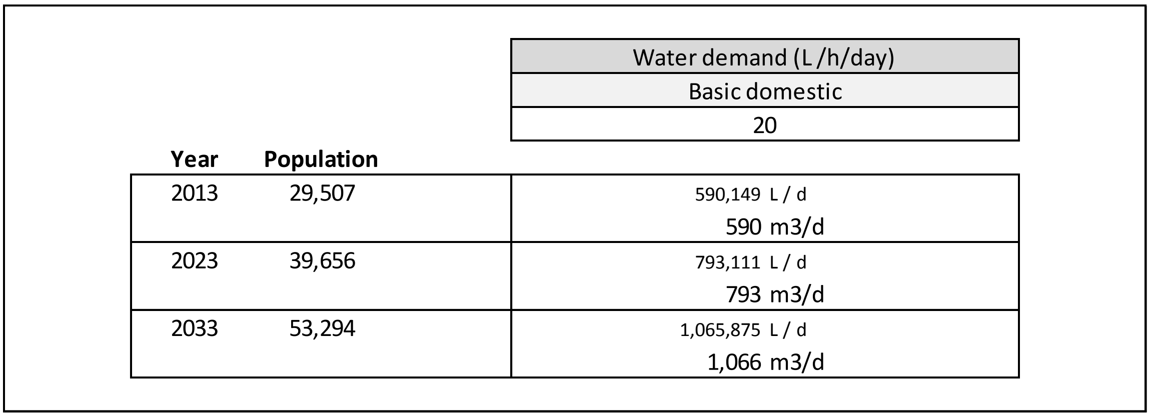
6.1.2 Demand per type of use

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, details 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 (Katilu and Kalemngorok sub-locations), the domestic water demand is calculated using 20 l/h/d.



		Water demand (L /h/day)
		Basic domestic
		20
Year	**Population**	
2013	29,507	590,149 L / d 590 m3/d
2023	39,656	793,111 L / d 793 m3/d
2033	53,294	1,065,875 L / d 1,066 m3/d

Figure 6-4: Water demand projections for domestic use

Demand for livestock

Different calculations made can be applied regarding the livestock water demand, 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.

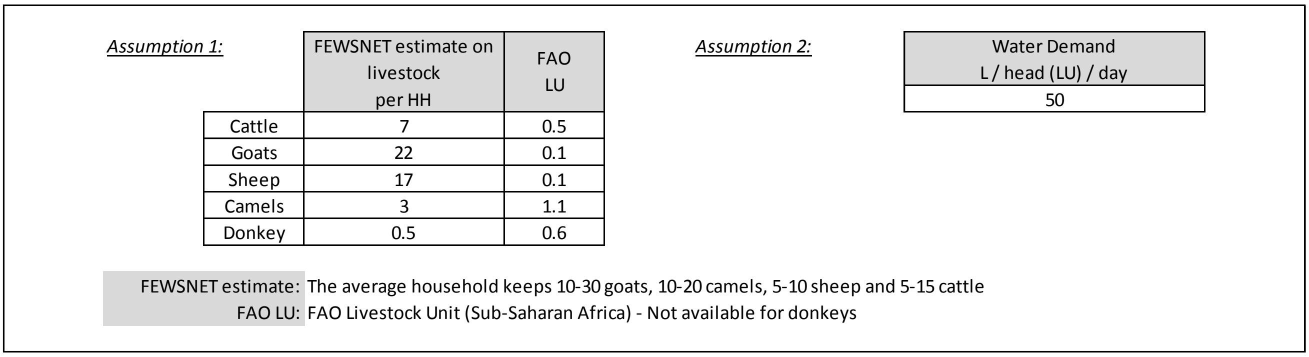
In the case of Turkana:

- Methodology 2: no census data were available
- Methodology 3: although many questions of the FDG conducted in the communities were about number of livestock, it was almost impossible to get data from the communities. In this area, counting and speaking heads of animals is a taboo, and it is socially not accepted to release this numbers.

➔ 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	22	0.1
Sheep	17	0.1
Camels	3	1.1
Donkey	0.5	0.6

Assumption 2:

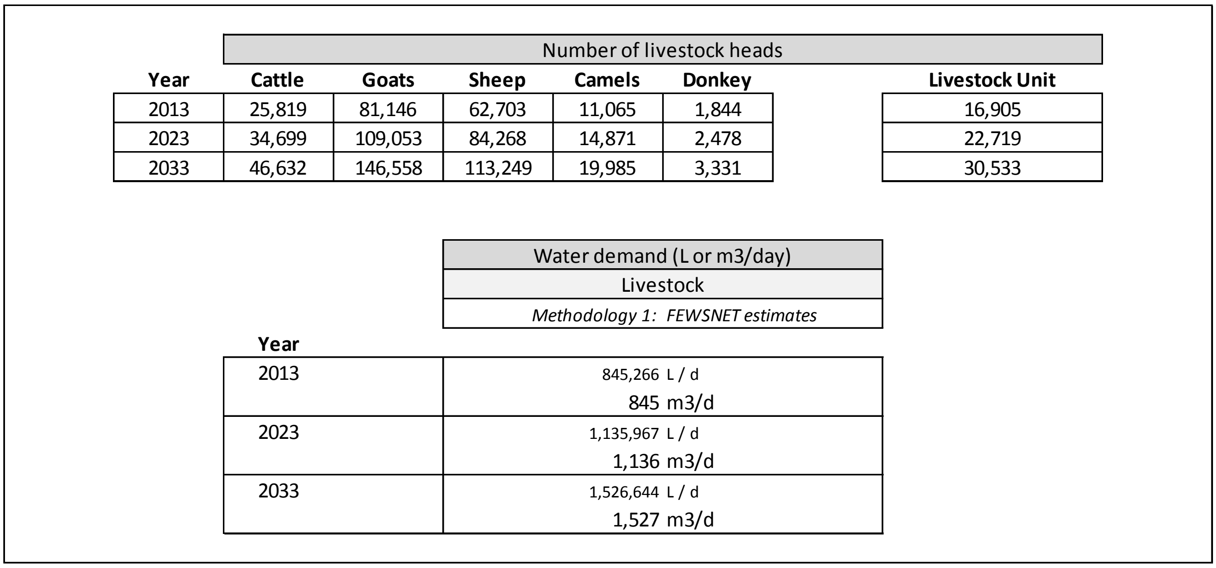
Water Demand L / head (LU) / day
50

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	25,819	81,146	62,703	11,065	1,844	16,905
2023	34,699	109,053	84,268	14,871	2,478	22,719
2033	46,632	146,558	113,249	19,985	3,331	30,533

	Water demand (L or m3/day) Livestock *Methodology 1: FEWSNET estimates*
Year	
2013	845,266 L / d 845 m3/d
2023	1,135,967 L / d 1,136 m3/d
2033	1,526,644 L / d 1,527 m3/d

Figure 6-6: Water demand projections for livestock use

Demand for agriculture

The area experiences to very distinctive type of communities in regards to their geographical area and main livelihood activity:

- Communities living next to the Turkwel river, which main source of activities is farming,
- Communities living further away from the Turkwel river, and which are mainly if not exclusively pastoralists.

However, some initiatives (for subsistence farming) have been launched and were witnesses in some of the communities visited during the study, as for example:

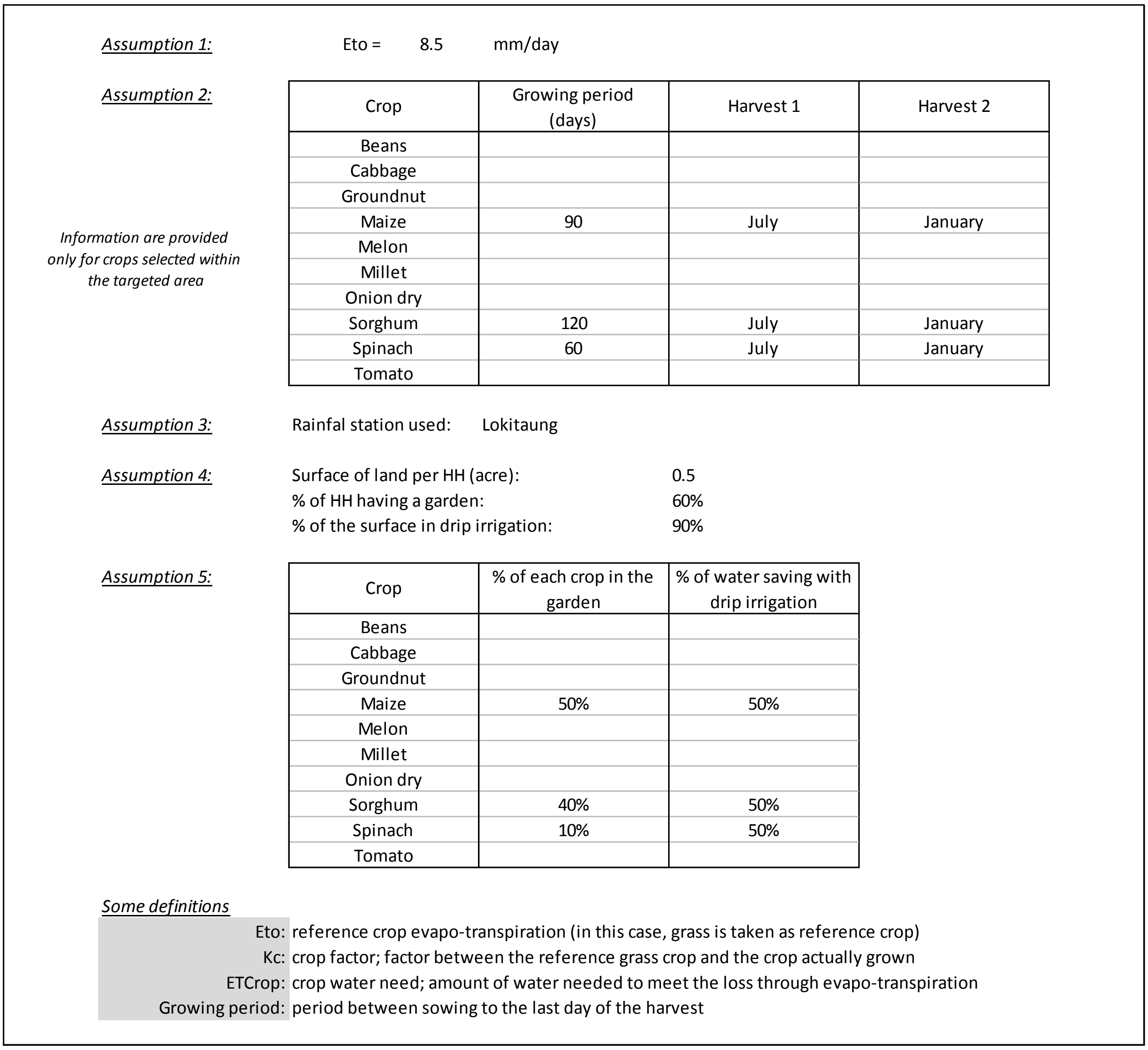
- In Kalemngorok, where a water pan has been constructed especially for irrigating trees, under the supervision of Kalemngorok “associations of farmers”,
- In Keekunyuk, were a community garden has been set in place by 60 families, and being irrigated using the community BH.

And in most of the villages visited, some villages were trying farming at very small scale, and rain fed, most often pushed by NGO’s food security programmes or initiatives.

Due to the recurrent food insecurity crisis and drought faced in the region, aid dependency has become a barrier to development. To encourage a change of the situation, initiative were launched by the government where lands were distributed to the most vulnerable families for agriculture use (such as in Kainuk). Even pastoralist communities have engaged in farming as a coping mechanism to food insecurity. During the FGD, most of the communities have expressed their interest and willingness to get more engaged in agricultural activities and therefore the need for small-scale irrigation schemes.

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.

For the assessment of the agricultural water demand in the 3R/MUS pilot area, the following assumptions have been made; among other, and since it is not possible with current data to precisely differentiate pastoralist population from agro-pastoralist or farmers; as a consequence, an average surface of land per HH for the entire target area was applied. Irrigation water needs are calculated using the methodology detailed in the **Annex 3**.



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			
Cabbage			
Groundnut			
Maize	90	July	January
Melon			
Millet			
Onion dry			
Sorghum	120	July	January
Spinach	60	July	January
Tomato			

Assumption 3: Rainfall station used: Lokitaung

Assumption 4:

Surface of land per HH (acre):	0.5
% of HH having a garden:	60%
% of the surface in drip irrigation:	90%

Assumption 5:

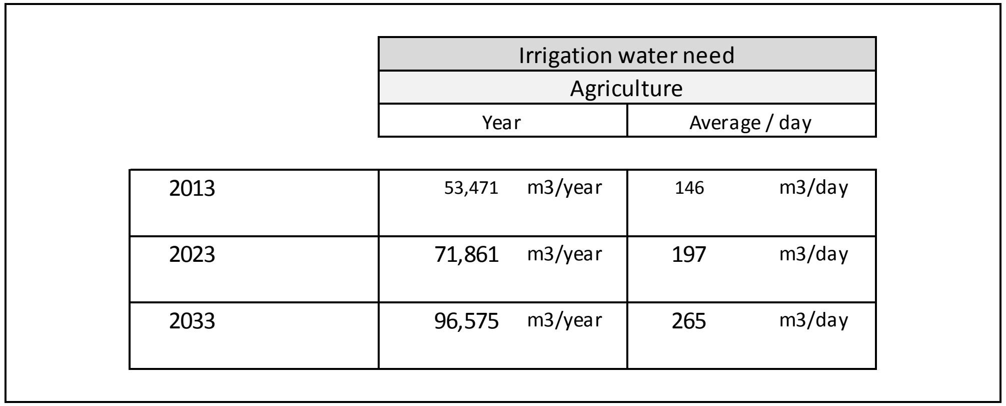
Crop	% of each crop in the garden	% of water saving with drip irrigation
Beans		
Cabbage		
Groundnut		
Maize	50%	50%
Melon		
Millet		
Onion dry		
Sorghum	40%	50%
Spinach	10%	50%
Tomato		

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 projections for crop agriculture use

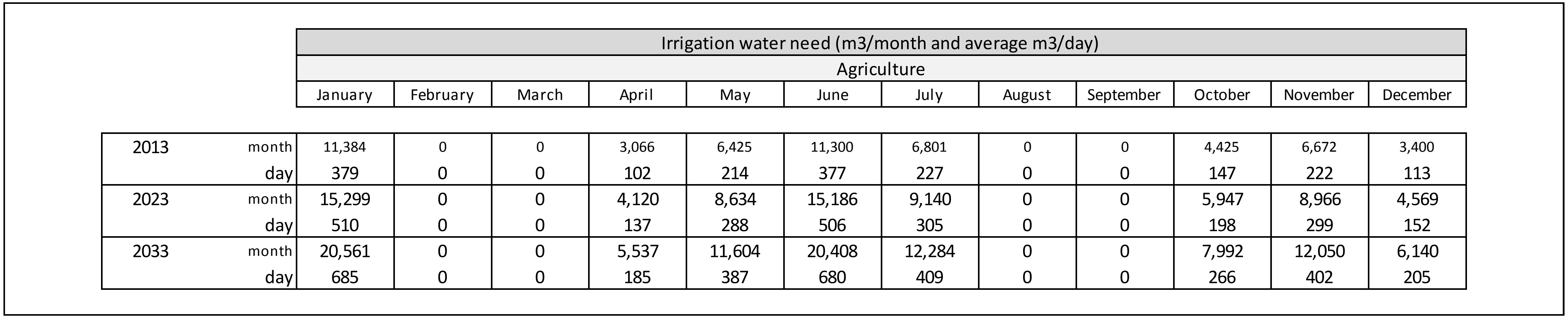
Based on these assumptions, the water demand for agriculture is evaluated to be:



	Irrigation water need			
	Agriculture			
	Year		Average / day	
2013	53,471	m3/year	146	m3/day
2023	71,861	m3/year	197	m3/day
2033	96,575	m3/year	265	m3/day

Figure 6-8: Water demand projections for agriculture use

As detailed in the “assumptions”, crop harvestings are planned according to the water seasons, in order to minimize the amount of water to be provided from the irrigation scheme, and optimize the rain water as primary source. As a consequence, water need for agriculture activities is very seasonal, as detailed in the following table:



		Irrigation water need (m3/month and average m3/day)											
		Agriculture											
		January	February	March	April	May	June	July	August	September	October	November	December
2013	month	11,384	0	0	3,066	6,425	11,300	6,801	0	0	4,425	6,672	3,400
	day	379	0	0	102	214	377	227	0	0	147	222	113
2023	month	15,299	0	0	4,120	8,634	15,186	9,140	0	0	5,947	8,966	4,569
	day	510	0	0	137	288	506	305	0	0	198	299	152
2033	month	20,561	0	0	5,537	11,604	20,408	12,284	0	0	7,992	12,050	6,140
	day	685	0	0	185	387	680	409	0	0	266	402	205

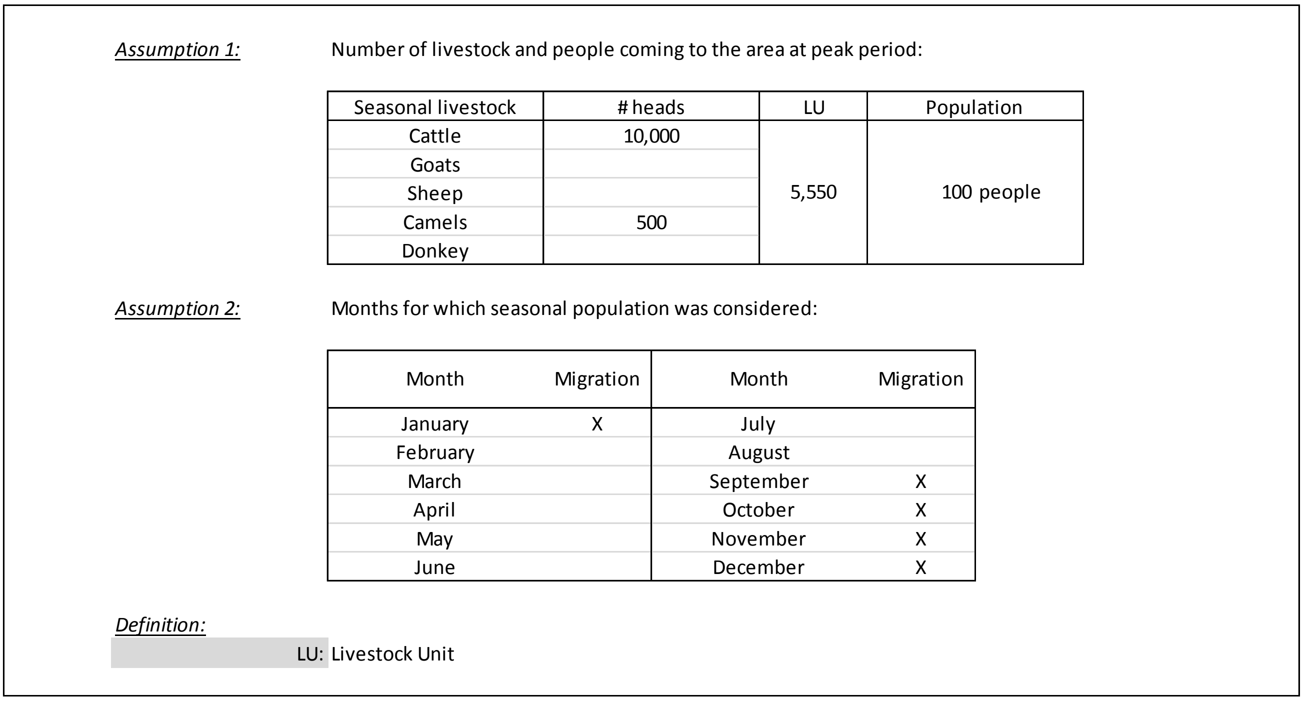
Figure 6-9: Water demand projections for agriculture use per month

Demand for seasonal migration

In all the communities visited, seasonal variation of the water demand was always mentioned. Indeed, as most of the population in the area are pastoralists, fulfilling their livestock 'water demand often comes as a priority (and is part of their life style), and therefore population tend to move around to get enough grazing lands and water for their animals.
However as mentioned before, these movements of population are very difficult to evaluate:

- It was not possible to find official census data or population flow map which would show theses migrations of population and livestock, and
- Discussions conducted in the communities did not help to get additional information, at least in terms of precise numbers (or only for some of the communities). Some communities such as Keekunyuk mentioned for instance that it was "their own people" that were coming back in the dry season. In other communities on the other hand, such as in Kakong, external pastoralist communities also come to the communal water point.

As a result, the following assumptions were made based on WVI staff inputs during the workshop in Nairobi in August 2013:



Assumption 1: Number of livestock and people coming to the area at peak period:

Seasonal livestock	# heads	LU	Population
Cattle	10,000	5,550	100 people
Goats			
Sheep			
Camels	500		
Donkey			

Assumption 2: Months for which seasonal population was considered:

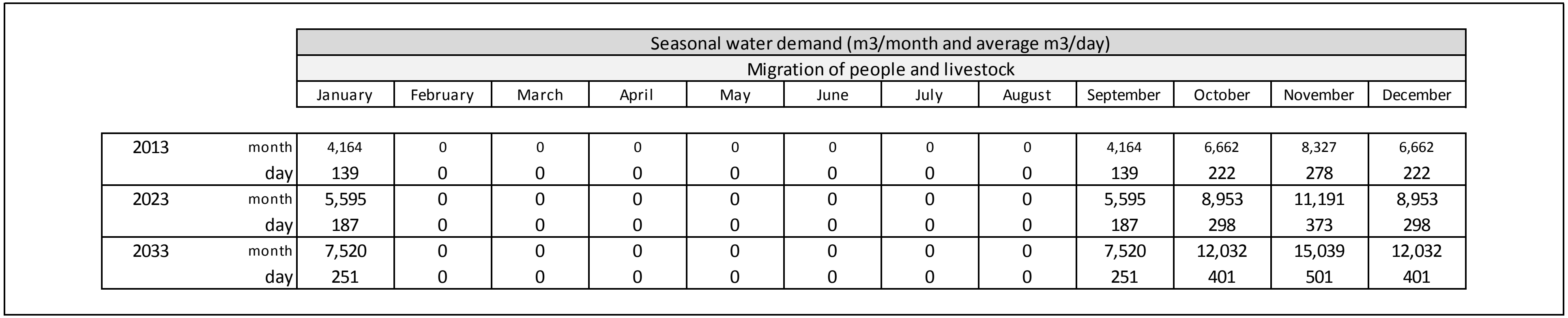
Month	Migration	Month	Migration
January	X	July	
February		August	
March		September	X
April		October	X
May		November	X
June		December	X

Definition:

LU: Livestock Unit

Figure 6-10: Water demand assumptions for seasonal population and livestock

Based on these assumptions, the monthly water need linked to seasonal migration of livestock and population is the following:



		Seasonal water demand (m3/month and average m3/day)											
		Migration of people and livestock											
		January	February	March	April	May	June	July	August	September	October	November	December
2013	month	4,164	0	0	0	0	0	0	0	4,164	6,662	8,327	6,662
	day	139	0	0	0	0	0	0	0	139	222	278	222
2023	month	5,595	0	0	0	0	0	0	0	5,595	8,953	11,191	8,953
	day	187	0	0	0	0	0	0	0	187	298	373	298
2033	month	7,520	0	0	0	0	0	0	0	7,520	12,032	15,039	12,032
	day	251	0	0	0	0	0	0	0	251	401	501	401

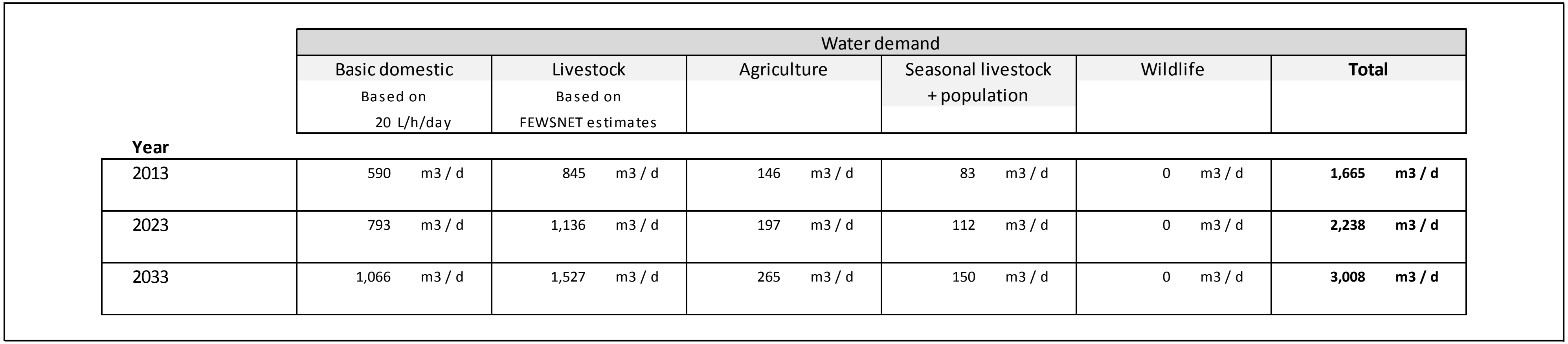
Figure 6-11: Water demand projections for seasonal population and livestock per month

Demand for wildlife

During the MWA workshop of Nairobi in August 2013, it was agreed to take into account the water demand of wildlife into the overall pictures.
However, there is up to date no clear agreement on how to evaluate this water demand. This point shall be further clarified during the up-coming stakeholder meeting to be hold towards end of 2013.

6.1.3 Total water demand of the target area

The total water demand for the whole area and for all the different uses 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	590 m3 / d	845 m3 / d	146 m3 / d	83 m3 / d	0 m3 / d	**1,665 m3 / d**
2023	793 m3 / d	1,136 m3 / d	197 m3 / d	112 m3 / d	0 m3 / d	**2,238 m3 / d**
2033	1,066 m3 / d	1,527 m3 / d	265 m3 / d	150 m3 / d	0 m3 / d	**3,008 m3 / d**

Figure 6-12: Total water demand projections based on multiple uses

The total water demand for the whole area is specified per month in the following table:

		Water demand (m3/month and average m3/day for each month)													
		January	February	March	April	May	June	July	August	September	October	November	December	**Total**	
2013	month	58,610	43,062	43,062	46,128	49,487	54,362	49,864	43,062	47,226	54,149	58,061	53,124	600,198	m3/year
	day	1,954	1,435	1,435	1,538	1,650	1,812	1,662	1,435	1,574	1,805	1,935	1,771	1,667	m3/day
2023	month	78,767	57,872	57,872	61,992	66,507	73,058	67,013	57,872	63,468	72,772	78,029	71,394	806,616	m3/year
	day	2,626	1,929	1,929	2,066	2,217	2,435	2,234	1,929	2,116	2,426	2,601	2,380	2,241	m3/day
2033	month	105,856	77,776	77,776	83,312	89,380	98,184	90,059	77,776	85,295	97,799	104,865	95,947	1,084,024	m3/year
	day	3,529	2,593	2,593	2,777	2,979	3,273	3,002	2,593	2,843	3,260	3,495	3,198	3,011	m3/day

Figure 6-13: Total water demand projections based on multiple uses per month

All details on water demand calculation are obtained by using a Water Demand Excel sheet, specially developed for the KALDRR-WASH program. Slight differences of total volumes between the 2 summary tables are due to round-up formulas.

Based on the results presented in both summary tables, it can be noted that:

- figures of table 6-13 are between the “basic” and “intermediate” values of the MUS ladder values of table 6-3,
- as expected in a pastoralist context, water demand for livestock counts for more than half of the total water demand.

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

See chapter 5 for a more detailed description

In Katilu sub-location, the communities of Katilu, Lopur and Tongolodi were visited. All 3 communities are located near the Turkwel river, which is perennial. In Katilu, a solar-powered borehole serves the health centre and the police station, and another borehole located at the primary school deserves both students and surrounding population. In Tongolodi, a shallow well along the river (rehabilitated by Tearfund in 2011) is connected to two 10m^3 water tanks which serve two water tap stands. The water point is used for domestic use only, and livestock of the area are brought to the Turkwel river in the dry season. In Lopur, the community benefits from 3 boreholes, but one of them is not yet connected to the town centre; distribution of water is done through water kiosks. All 3 boreholes are solar-powered.

In Kalemngorok sub-locations, the communities of Nakabosan, Keekunyuk and Kalemngorok were visited. Kalemngorok community has access to two boreholes, but one of them (constructed by WVI) is salty; as mentioned earlier, salinity is one of the biggest issues in the area for underground resource management. As a result, the borehole showing high salinity is not used for drinking and water demand is also fulfil by using the river, digging of scoop holes in the nearby river or using one big area of stagnant water along the main road. A shallow well was also dug in the river bed (equipped with hand-pump) by NDMA. Nakabosan has currently no water point in the community, and women have to walk all the way to the borehole in Napusinyan (7 km) to get water for domestic use; however, WVI has recently drilled a borehole which is to be equipped in the coming months. A water pan is also used by the community for the livestock. Finally in Keekunyuk, the borehole is used as primary source of water for domestic use, but also for the livestock at the peak of the dry season. The nearby river is used for scoop holes in some specific areas.

6.2.2 Accessibility

Well-being of the livestock comes as a priority in pastoralism communities, and people move around or settle down according to the availability of grazing land or reliable sources of water for their cattle and camels. Wet season grazing lands are found around seasonal rivers and natural wet lands or depressions where water collects. 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.

Focus group discussions have shown that population usually use a set of different water sources for different purposes, including seasonal management. All communities mentioned that water pans were for example not used for domestic use; one criteria contributing to this safe hygiene practice is that in all communities visited, borehole usually have water all year through, even during the dry season, even with the presence of migrating population and even of the water point is used for the livestock. Water quantity per household then becomes less, but is nevertheless always available. In the rainy season however, it can be assumed that more water points are used for domestic use. As for the livestock, and even for communities located far from the Turkwel river, Turkwel river is often mentioned as the main source of water for animals in the dry season.

6.2.3 Quantity

It is very common that people use the water from the water pans for their domestic use, and there is little knowledge on whether people actually treat the water before drinking on a regular base or not. Water pans in the area are not protected and cattle and other animals can easily access it. From the field investigation undertaken on the water pans, turbidity is high; together with the water point's poor management when it comes to hygiene, it surely indicates high probability for contaminated and unsafe drinking water. When boreholes are used as the primary source of water, no regular water quality monitoring is undertaken neither by the authorities nor by the local NGOs.

However, as widely accepted within the sector, safe water at water point level does not mean safe water at household level, and recipients used for fetching water usually show poor protection against contamination (open jerricanes).

Figure 6-14: Containers at different water points

It will be interesting to further investigate household habits towards the storage and treatment of drinking water.

6.2.4 Quality

It is very common that people use the water from the water pans for their domestic use. Also household water treatment products such as “Pur” or “Waterguard” were mentioned, there is little knowledge on whether people actually treat the water before drinking on a regular base or not. “Pur” 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. In Antuta for example, where people rely on the water pan including for their domestic use, the community indicated that there are no health problems and no frequent diarrhoea. It will be interesting to further investigate household habits towards the storage and treatment of drinking water. However, in Kate, diarrheal diseases occur mainly in March/April and October/November according to the seasonal calendar that was drawn by the villagers. This coincides with the two rainy seasons and the exclusive use of water from the water pans for domestic use.

6.2.5 Reliability

Reliability of both the water sources and the systems is erratic. In the study area, water pans often have only water for 2-3 months after the rains and depend heavily on the quantity of precipitation of the season. As mentioned earlier, un-proper management of the water pan also jeopardized their longevity and sustainability.

As for the boreholes, for the majority of the communities visited, boreholes had been rehabilitated recently and for many of them, equipped with a solar panel unit. Although switching the power supply equipment of the borehole from fuel to solar brings some evident advantages such as reduction of cost and lower operational time, it comes with the following drawback:

- Given the price of such equipment, Water committee are obliged to employ a full-time guard (often 2) to supervise the equipment at all time; the salaries push additional pressure on the water committee and can (1) decrease the money available for eventual maintenance to be done and (2) impact on the water price, as in Keekunyuk, where the monthly fee was increased from 20 to 200 KES/month/HH,
- Compared to the repair of a generator, maintenance of a solar panel equipment requires technical knowledge and experience which is not necessarily available locally; as a result, and in case of serious break-down, the community might experience longer shortage of water than with a more simplistic system where local mechanics could intervene.

Finally, within the communities visited, there were evidence of projects which were poorly implemented or follow-up after construction; before even being put into service, some water supply equipment are already non-functioning, which highlighted the lack of planning and/or coordination locally. This has been seen for example in Katilu Health Center, where an entire water storage units (20 m^3) has never been put into service, or Lopur, where a new water tank of $10m^3$ is already leaking.

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).

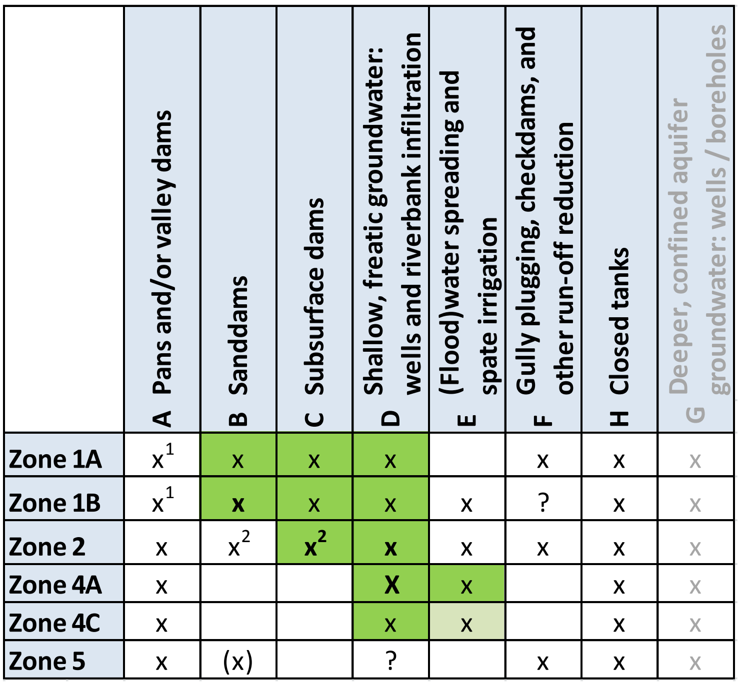
The zones are grouped in five categories, and several subcategories. The first category (zone 1) contains basement rocks, these rocks have generally a low porosity and weathering products suited for storage. The second category (zone 2) are the lowlands that receive the weathering products through the 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 plains. Finally zone 5 indicates the mountainous areas with steep slopes.

7.2 3R zones present in the target area

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

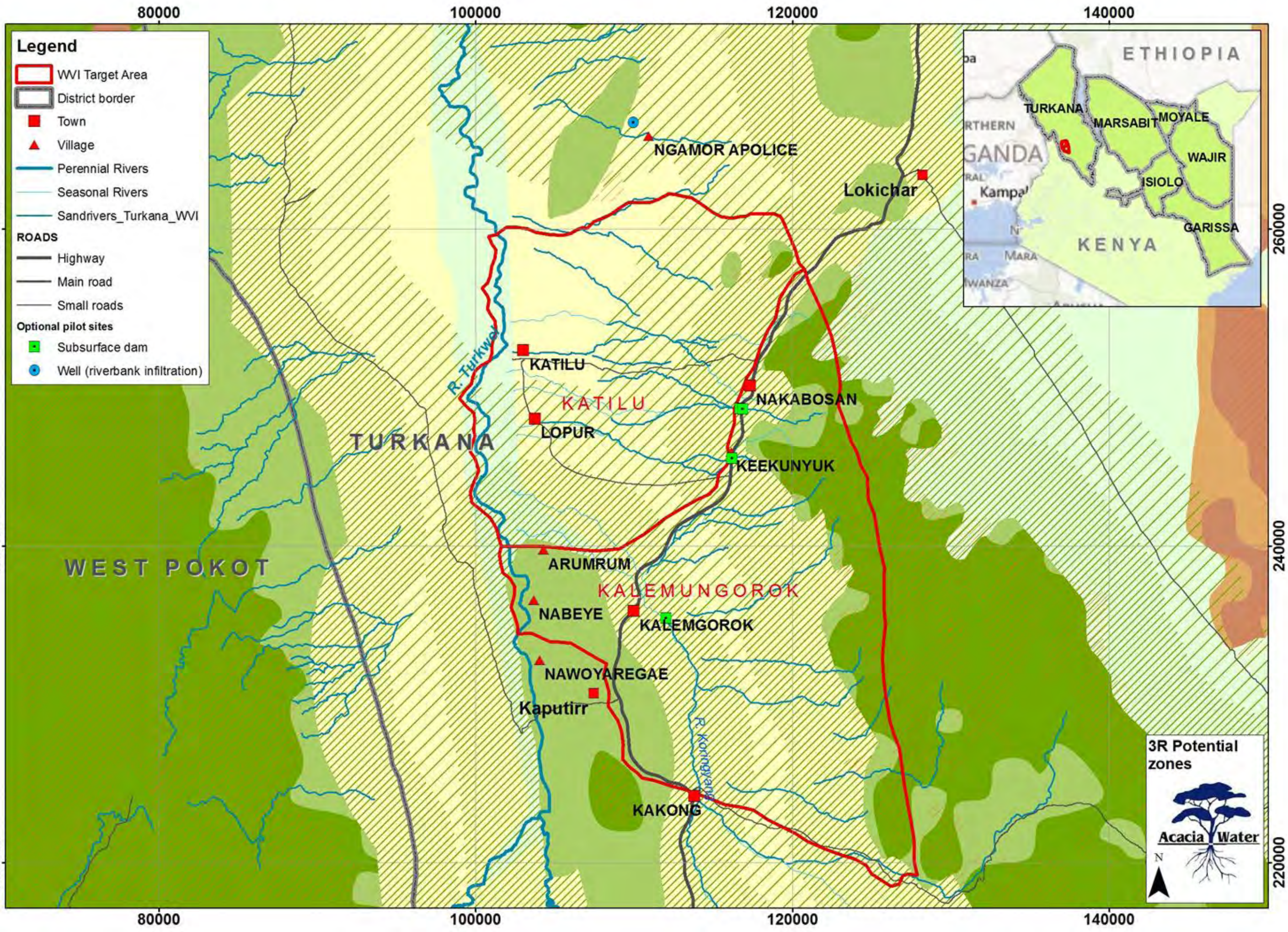
- Zone 1A: Basement, mountains, low porosity, weathering products suitable for storage
- Zone 1A: Basement, plane areas, low porosity, weathering products suitable for storage
- Zone 2: Buffer zone around basement rock area (5 and 10 km)
- Zone 4A: Alluvial sediments with variable permeability, often clayey sediments / layers present & shallow groundwater potential
- Zone 4C: Variable sediments with mostly moderate permeability, and high vertical resistance when clayey sediments / layers are present & possibly shallow groundwater potential
- Zone 5: Areas with slopes steeper than 10 degree

In Figure 7-1 an overview of the kind of 3R interventions which may generally be possible in these zones are indicated, and the interventions which appeared to have potential in this target region are highlighted (in green). Figure 7-2 provides the map of the 3R potential zones in Turkana target area. In the next section the interventions that appeared to have potential in this target region are described, with the locations of examples as indicated in figure 7-2.



	A Pans and/or valley dams	**B Sanddams**	**C Subsurface dams**	**D Shallow, freatic groundwater: wells and riverbank infiltration**	**E (Flood)water spreading and spate irrigation**	**F Gully plugging, checkdams, and other run-off reduction**	**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	x^2	$\mathbf{x}^2$	**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

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. River with sand bed, underlain by basement rock (Zone 1B)
2. Wide river bed with sandy sediments in sedimentary areas and buffer (zone 4c and 2)
   a. With natural rock barrier
   b. With clay layer under the bedding
3. Riverbank infiltration (shallow well)
4. Water pans preserved for specific use
   a. Mainly for domestic use
   b. Mainly for livestock
5. Flood irrigation
   a. Floodwater spreading and buffering, for agriculture
   b. Irrigation from perennial river
6. Road water harvesting
   a. Road crossing, creating sanddam / gulley-plug
   b. Road causing floodwater spreading

Figure 7-2: 3R potential zones in the Turkana 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 Turkana target region basement rocks are found at two locations (see Figure 7-2). At the eastern site mountainous basement rocks (zone 1A) are found, with at most locations slopes which are steeper than 10^o (zone 5). Mostly at the edges of zone 1A plane basement areas are found (zone 1B).

Sanddams

At the steep parts of the basement (zone 5) sanddams are a possibility. However, because of the steep slopes, which can also be expected in the river bed, the reservoir that will be created behind the sanddam will have a limited volume. Moreover, in this area the demand was indicated to be very small. Therefore, the focus of the interventions will probably not be on these steep areas. An example of an area feasible for sanddams was found near Nakabosan, where a sanddam has been constructed recently (Figure 7-2, example 1). The highest sanddam potential is expected in zone 1A and the gentle sloping parts of zone 1B.

In the examined area in Turkana rock barriers were found at the edge of zone 1B, between Keekunyuk and Nakabosan (Figure 7-2, example 2a). These natural barriers function as a subsurface dams from behind which water was subtracted by scoop holes in the past, according to the community. Currently these are no longer in use, because water from a nearby borehole became available. Nonetheless, this shows the potential in the area for the use of (natural) subsurface dams. When the borehole may not be able to fully fulfill the demand, the water stored behind the natural barrier can be used again, which may also provide a cheaper alternative. The scoop holes, or improved wells can be restored to subtract water when necessary. Annex 8 provides some general guidelines for siting and design of sanddams and subsurface dams.

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 the Turkana area mainly overlays the sedimentary formations (Zone 4C). In this zone indeed rivers with sandy sediments were found. Observations of the riverbed sediments showed that it had a porosity that was suitable for water storage, tests indicated a porosity between 25 and 35%. This sediment most likely originated from the basement areas surrounding the sedimentary area (zone 2). Zone 2 covers most of the target area, and provides extensive subsurface dam potential to the area. The potential for sanddams or subsurface dams depends largely on the characteristics of this underlying formation. At various places in the area a non-permeable layer was reported in the area. Interviews with the local communities indicated that a clayish layer is present at about 2-8m below the surface. This was confirmed by an observation within a sandy riverbed near the village Keekunyuk (see Figure 5-4), where probing indicated the existence of a heavy clay layer. A profile pit was dug in the river bed of the sand river, which indeed revealed a clay layer with weathered rocks at a depth of about 2,5m below the surface. The information from the local community, the field observations, and the appearance of vegetation all indicated that in most of the target area such an impermeable layer is present.

Subsurface dams

The surbsurface dam at Kalemngorok (Figure 7-2, example 2b) is constructed by Arid Lands (NDMA) in 2007. Currently the dam is not visible at the surface, but local informants who were involved in the construction were interviewed. The interviews indicated that the dam was excavated up to 6 m below the riverbed, and raised up to up to about a meter below the surface. It stores water that is currently gathered from the scoopholes behind the dam. Additionally, a shallow well located 500m upstream, currently provides water whole year round, which was not the case before the installation of the subsurface dam, according to the local users. In basis, this provides a good example of how the water availability can improve due to the installation of a subsurface dam. Nonetheless, at that location some improvements are possible. Previously, a gallery with a hand pomp was constructed. However, this hand pump is non-functional since a few months after it has been constructed, according to the community.

This subsurface dam is expected to have a large potential when the subtraction from the reservoir is improved. The table below gives an estimate of the volume that may be expected to be stored behind this existing subsurface dam. A simple estimation was made to indicate the direct storage capacity of the dam. This estimate does not include other factors that influence the available volume of water during the dry season. These factors include both losses and recharge, losses include: evaporation, infiltration to deeper groundwater, and leakage around the dam, recharge includes: riverbed-groundwater flow from upstream and recharge from the riverbanks.

	Dimensions				
Site	Depth sand bed (m)	Average width (m)	Length stretch (m)	Porosity sand	Water storage capacity (m3)
Kalemngorok subsurface dam	5	25	2,500	25%	39,000

A second subsurface dam is present at Kakong, based on the comments of the local community, this subsurface dam appeared not to be constructed correctly. The scoopholes behind the dam provided more water than before the installation of the subsurface dam, but the effect was less pronounces as expected. It seemed from local information that the subsurface dam was not constructed deep enough to be based in the impermeable layer, and that water could still flow below the subsurface dam. Repairing this flaw will take about the same effort as constructing a new subsurface dam. This example shows that for future construction supervision is recommended to assure proper construction.

The combination of the correct sediment and the existence of an impermeable layer indicates the very high potential for subsurface dams. It is therefore recommended to construct more subsurface dams in this area. The potential for subsurface dams is not limited to the Turkana target area, a comparable situation may be expected further to the north and the south in the sedimentary formations along the Turkwel river.

7.5 Zone 4A Alluvial sedimentary formations

In the Katilu sub-location the Turkwel river is surrounded by alluvial sediments. The combination of these sediments and the perennial river provides for example opportunities for the existence of shallow groundwater. Here riverbank infiltration can be used to subtract the water that infiltrates from the perennial river into the ground. Shallow wells appear to contain fresh water, while at some meters deeper the salinity tends to increase (see chapter 5). Therefore, shallow groundwater wells, which are recharged by the river and the other shallow (ground)water flows are recommended.

Irrigation is in these areas already applied, especially along the Turkwel River (Figure 7-2, example 5b) and may be extended. This can be combined with run-off reduction like pits or eybrows to increase the effectiveness of the irrigation. Some examples of this were already found (Figure 7-2, example 5a). This area is further away from the perennial river, and seasonal flood water is buffered through these kind of techniques. Applying such techniques could for example enhance the agricultural potential of the area.

7.6 Zone 4C Other sedimentary formations

Appearance of the zone in the target area

A large part of the Turkana target area consists of sedimentary formations. The sediments consists of colluvial deposits, pebble sheets, and other quaternary sedimentary formations. The soil types and permeability of the top soil and deeper layers vary. In this target area the sedimentary formations (zone 4C) were observed to provide good opportunities for the application of subsurface dams as is described in zone 2. Currently some pans exist in this area, and two subsurface dams.

Pans

In the Turkana target area one recently rehabilitated pan was found south of Kakong, which seemed to be 4b functioning well (Figure 7-2, example 5b). Like most pans in the area, this pan is mainly used for livestock watering. It is sited to accumulate water from two streams, and was filled with water when visited at the beginning of the dry period. This pan was sufficient deep and a good silt trap is observed to be constructed at the inlet of the pan, as well as a by-pass. The rehabilitated pan may be further improved. Currently the banks of the pan are not vegetated, this may be due to the recent rehabilitation. Otherwise it is recommended to cover the banks with grass to prevent erosion of the banks into the pan. Additionally fencing is recommended, to prevent pollution from the cattle entering the pan.

Some of the other pans found in the target area appeared not sited and/or constructed well, as they were too shallow, and apparently did not capture enough water from the small catchment behind the pan to fill the pan. Therefore, these pans have limited potential. Nonetheless, in one of these pans located east of Nakabosan (see Figure 5-8 and Figure 5-3), the amount of water that is led towards the pan can be easily improved by restoring the dike that leads the water from the road towards this pan. Even though the potential is limited, this can at least improve the functioning of the pan. Annex 8 provides some general guidelines for siting and design of pans and dams.

7.7 Other 3R options in the area

Closed tanks

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

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 (Figure 7-2, example 6b). Additionally at locations where the road crosses rivers with sandbeds, sand accumulates behind the concrete structure (Figure 7-2, example 6a). Local interview indicated that scoopholes are dug during the dry season behind some of these crossings. The effectiveness of these structures for water storage depends on the presence of an impermeable layer, and whether the structure was based in this layer or not.

8 Developing solution strategies for the pilot area

8.1 Introduction

In the previous chapters an overview was given of the available resources in the target area, the current infrastructure and management, the expected water demand, and the potential for improving and creating new interventions. In this chapter a first step is made towards finding long-term sustainable solutions for the 3R/MUS pilot areas. These solution strategies cover a wider range of areas and also have a longer time perspective than the KALDRR project, which has a two-year timespan only and has a strong infrastructure development focus. It is also key that all different stakeholders, including communities, government, civil society and private sector will take up responsibilities and play a role to realise the solutions.

This report covers mainly the situational assessment of the cycle presented in figure 3-1, and makes a start with developing a vision and water resource and service management strategy for the pilot area. Chapter 8.2 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. 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 organisations 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 is the lacking support to the agencies that are supposed to provide the necessary services. The WMCs, WUA, and WMCs hardly receive any support from the government structures. They clearly lack the capacity to carry out key tasks as monitoring of services, oversight of the services providers and coordinate the longer term planning. Coordination has more the character of fire fighting. On top of this, there is a confused institutional set up where the DWOs are providing most of the support to the communities. But they are part of the system from before the sector reform and their role should have been taken over by the Water Services Boards, but which are at a very big distance from the communities and their organisations. At the moment it is still unclear if the decentralisation under the new constitution will improve this situation. Part of this problem is also that the market doesn’t offer much technical capacity nor are options for low cost solutions and technologies available.

A last category of problems can be found at the service level. On the one hand users have clear demands for higher service levels. For domestic people want 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.

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 people want cleaner water or water nearer to their houses. In area which are for now mainly pastoralist, 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. 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.

Expected changes in future demand

Water demand is a dynamic component, and water demand tends to increase with the amount of water made available. Although 20L/person/day has been considered as an average for all calculations throughout the study, discussions with the population have shown that in times of high water scarcity, quantity of water for domestic use can drop to a level as low as 10L/person/day. On the other hand, when water is made available, another set of activities develop. In the target area in particular, members of community which are by tradition 100% pastoralist (such as Keenunyuk) have started initiatives of farming and locally-made irrigation scheme.

For this reason, expected changes for future water demand encompasses two components: the growth of population, which comes with a growth of livestock, but also a development of activities which requires water, such as farming in the area outside the Turkwel river.

Another factor, more difficult to assess, is the increase of migrating population towards new water points. Exact figures of number of people moving around seasonally with their livestock to the water points is already difficult to assess currently, and further investigations are necessary to determine with precisions how many people and livestock shall be taken into account.

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.

The visioning discussion provided the first building blocks for a vision and longer-term plan for the area. Stakeholders were put into groups of 3 or 4 people and were asked to think about two questions between 5-10 minutes. The feedback received is included in table 8-1 and figures 8-1 and 8-2.

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.

Tabel 8-1 Results of the visioning workshop

	A - How would you like to see the situation in your area in 2025?	B - What are the main issues we should work on to get to this situation?
Group 1	- Water accessible in every HH, - Safe water in every house, - Improved hygiene/cleanliness, - Livestock gets enough water within less than 500 m, - Human health improved thanks to enough water availability, - Forestry coverage shall increase by 10%, - Agriculture improvement though increase of agricultural land availability, - Education improved, - Insecurity decrease.	- Identify water catchment areas, - Put in place management team to oversee on-going projects, - O&M put in place and active, - Capacity building of community members and leadership of management team [management team = WUA (Water User Association) + WC (Water Committees)], - Proper storage of water, - Recharge of groundwater to improve water sources (sand dam).
Group 2	- Water volume will decrease, - Increasing population thus increased number of people atWP - Solar panel will weaken, - Quantity of water will drop, - Water disease will increase.	- Empower communities with skills / accountability / management of water resources; make the communities more responsible, - Encourage implementation of CLTS to eradicate OD for a safe env., - Develop water quality analysis; if possible, having our own laboratory to test / regulate quality of water.
Group 3	- Every HH has clean/nearby water available, - More water available for larger storage quantity, - 70% of the people have water in their house, - Decrease of water disease by 90%, - Better environment, - Increase of HH food security by increase of HH farming, - Increase of rainwater harvesting, - Good quality of water / people will have ways to keep the water clean.	- Good management of water sources and water resources, ○ Cohesion between policies / needs / capacity, ○ Put in place an efficient service delivery charter: government empower communities to have them manage their resources better, - Construction of water collection storage for every HH, - More water points, - Increase the latrine coverage to decrease OD, - Increase quantity of run-off water, - Sensitization of communities on environment, - Support from the government, - conflict-prone area: look at peace-solution with neighbouring communities and have a secure way of managing the resource.
Group 4	- Demand will be high because population increases, - More intervention are required, - Literacy increases: better knowledge and hygiene, - People will waste less water (more buffering), - People will learn more about water technique / harvesting, - People will learn how to improve on environmental preservation.	- Plant trees to improve forest coverage and increase the water ress., - Water harvesting shall be emphasized, - Encourage people to construct water points and sand dam, - People sensitized on proper use of water, - Encourage people to reduce size of livestock (to decrease water use), - Carry-out more exploration of underground water.

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 planned 3R/MUS pilot area includes Keekunyuk, Nakabosan and Ngamor Apolice/Kalokoda. For the Turkana 3R/MUS pilot area the following preliminary selections were made:

- Construction of a subsurface dam at Keekunyuk. The community currently depends for all their water needs on a single well, which has a dropping yield during the dry season. The community has initiated an agricultural project. They plan to use the well for irrigation, which is expected to create water shortage. A subsurface dam could boost the yield of the existing well and provide an additional water resource.
- Riverbank infiltration through a shallow well and possibly cconstruction of a subsurface dam at the larger river 1 kilometer south of Nakabosan. Nakabosan community currently depends on a borehole with a low yield and two shallow water pans for its water needs. This river has natural barrier of hardrock before which groundwater is expected. This resource could be utilized for livestock watering, or pumped to the village trough a piped scheme. Currently there is a sanddam and a well 2.5 km upstream in this river, with a solar system and a pipeline to the village. This solar system got vandalized directly after it was constructed. This risk should be taken into account when considering the construction of a new water abstraction and supply system, any intervention should be robust and easy to maintain. A shallow well with a handpump or improved open scoopholes for livestock watering, could be feasible interventions.
- Riverbank infiltration through a shallow well at Ngamor Apolice/Kalokoda. This community currently does not have an improved water source within a distance of 6 km and depends on open hand dug scoopholes. The community indicated that the scoopholes are dug up to a depth of 8 to 10 m during the dry season, but water is always present. Optionally a subsurface dam could be constructed to increase the water storage in the riverbed.
- Kalemngorok is not included in the pilot, because of the size of the town and existing interventions, however WVI might still consider the potential of a subsurface dam for the town water supply in their program

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 Kalemngorok / Katilu 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 analysing the total costing (both capital and recurrent costs (including the direct institutional costs)) and identify and agree on sources for financing. The latter including user fees and tax and transfer subsidies.
- Make clear arrangements for O&M to ensure that the water facilities are kept functional. The arrangement and agreement should be part of the MoU.
- To make sure that the WMCs/WUAs/WSPs/traditional water supervisors can do their job, the support to these organisations need to be committed and integrated in the MoU.
- Use the 3R potential analysis and provided tools for identification of possible water buffering methods, followed by a local study and siting for final selection of the most feasible intervention technique. The chosen intervention should match as much as possible with the water demand (quantity and quality), community preferences and the local capacity for O&M and management.
- 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.
- Optimise the use of grazing lands by developing water sources near the grazing lands, taking into account the risk of overgrazing and/or increasing the influx of herds from other areas.

To improve agricultural use, interventions to be considered are:

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

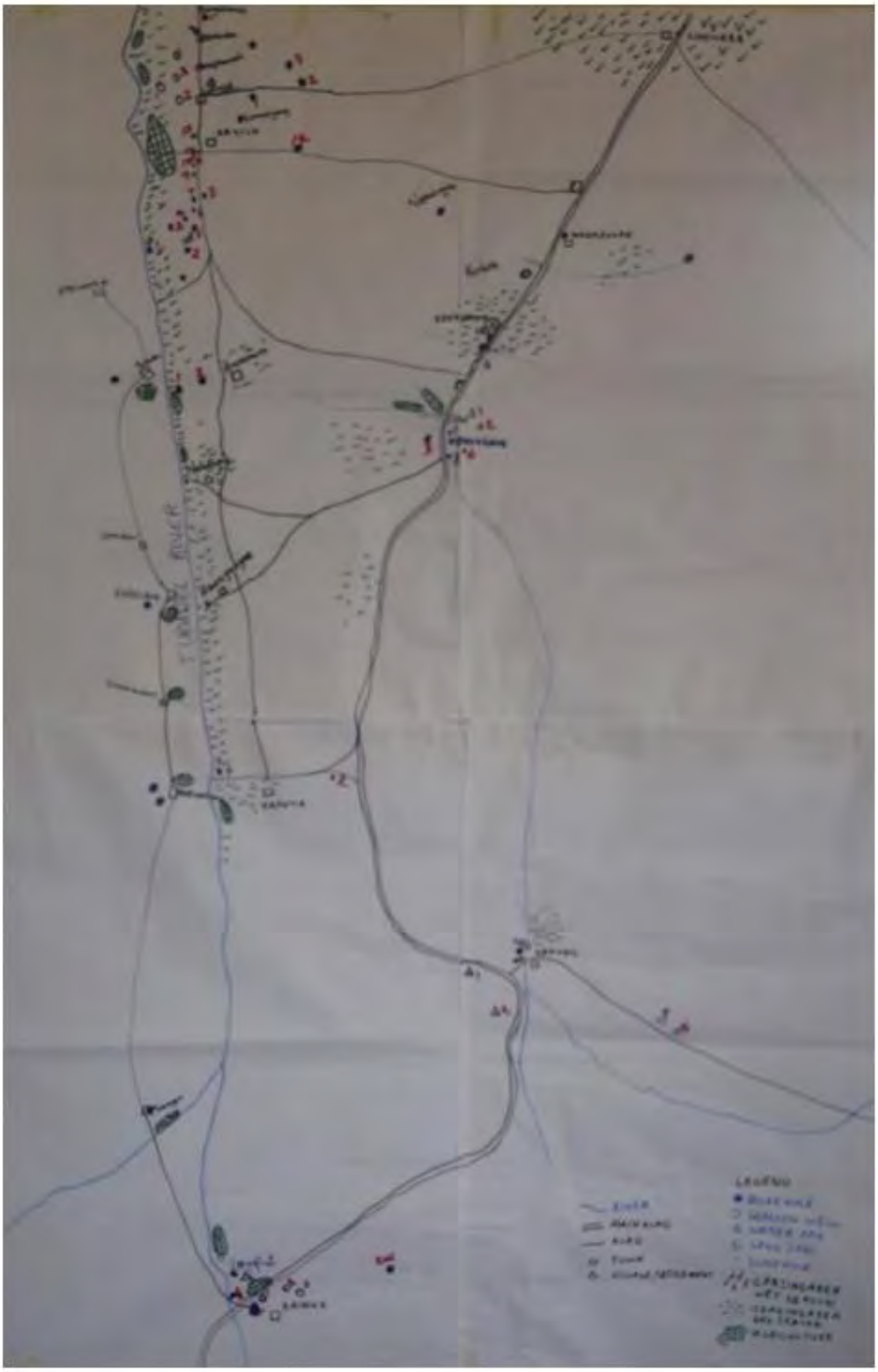


Figure 8-1: Water maps of 3R/MUS pilot area drawn by stakeholders (Group 1)

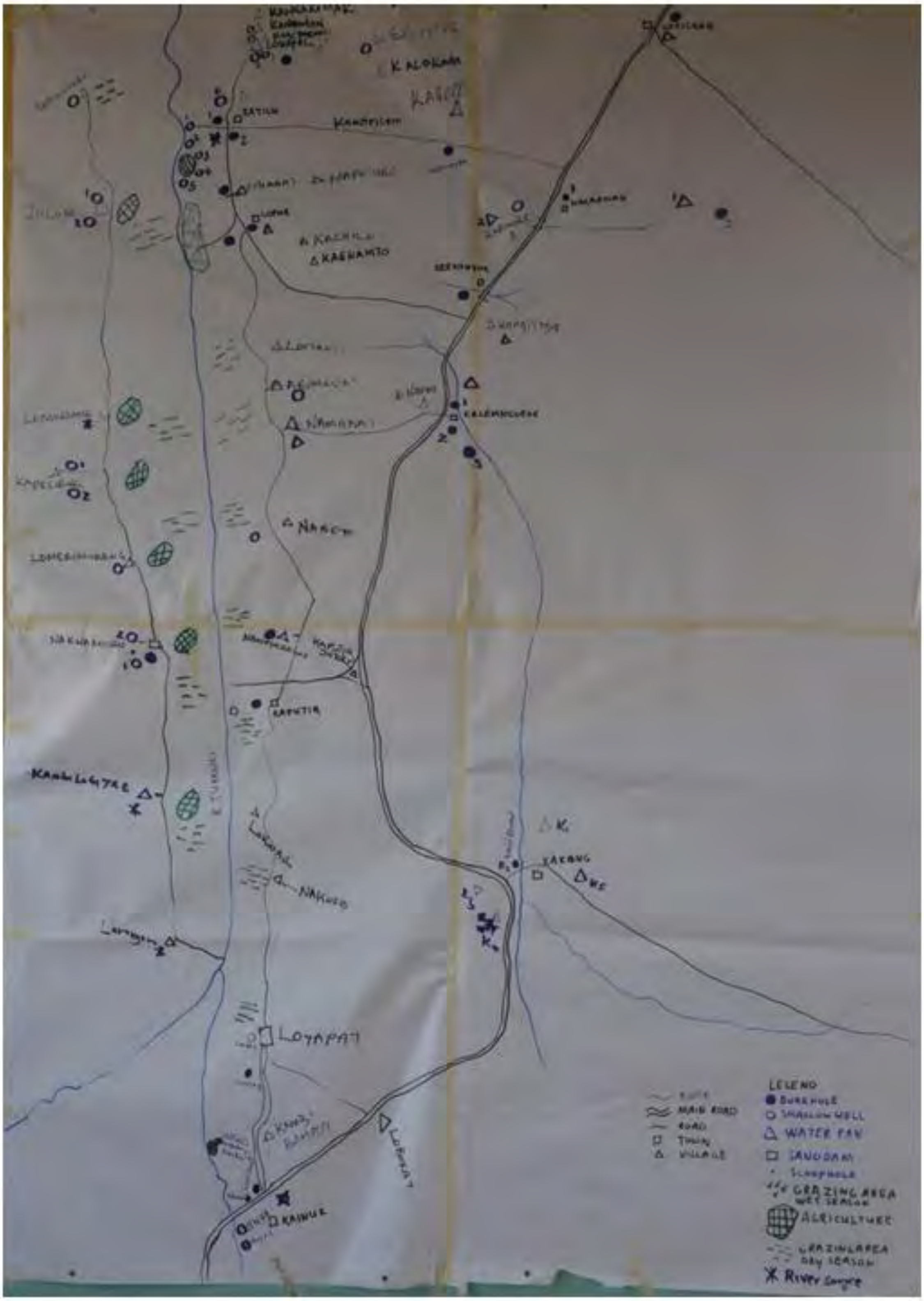


Figure 8-2: Water maps of 3R/MUS pilot area drawn by stakeholders (Group 2)

References

Adank (2012). Guidelines for Planning and Providing Multiple-Use Water Services, *Adank et al.*, MUSGROUP, IRC and IWMI, 2012.

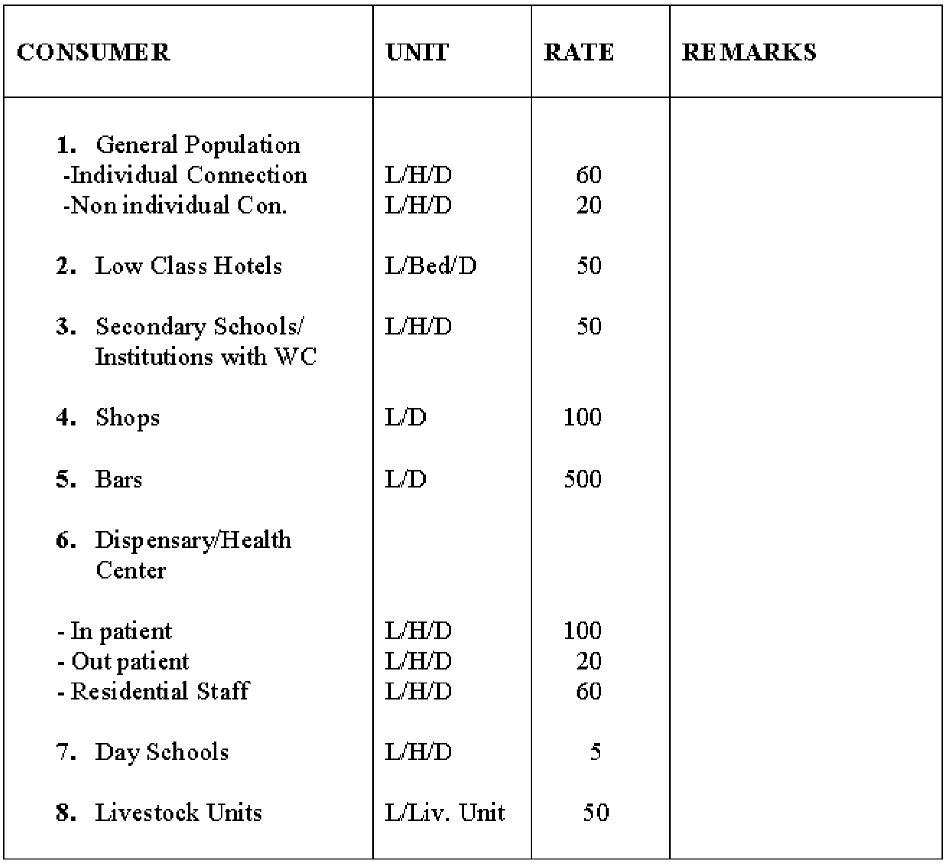
Butterworth (2011). Multiple Use Water Services in Ethiopia - Scoping Study; *Butterworth et al.*, IRC, The Netherlands, 2011.

Empowers (2007). The EMPOWERS appraoch to water governance. Guidelines, methods and tools. *Moriarty et al.*, INWRDAM, Jordan, August 2007.

Tuinhof (2012). Profit from Storage, the costs and benefits of water buffering. *Tuinhof et al.*, Wageningen, The Netherlands: 3R Water Secretariat, 2012.

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)					

<u>Source:</u> *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.

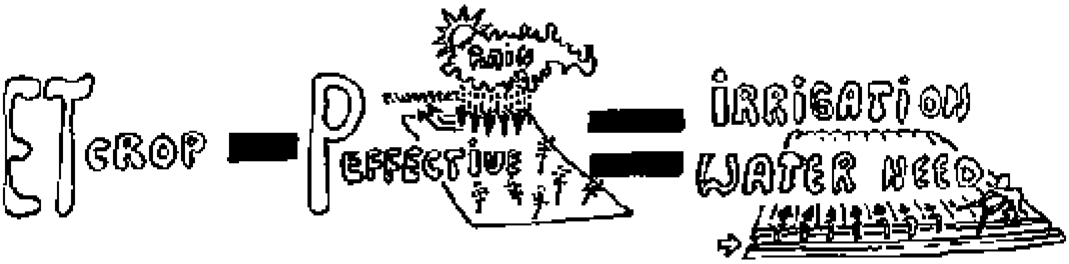
Water demand for livelihood: agriculture

[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.

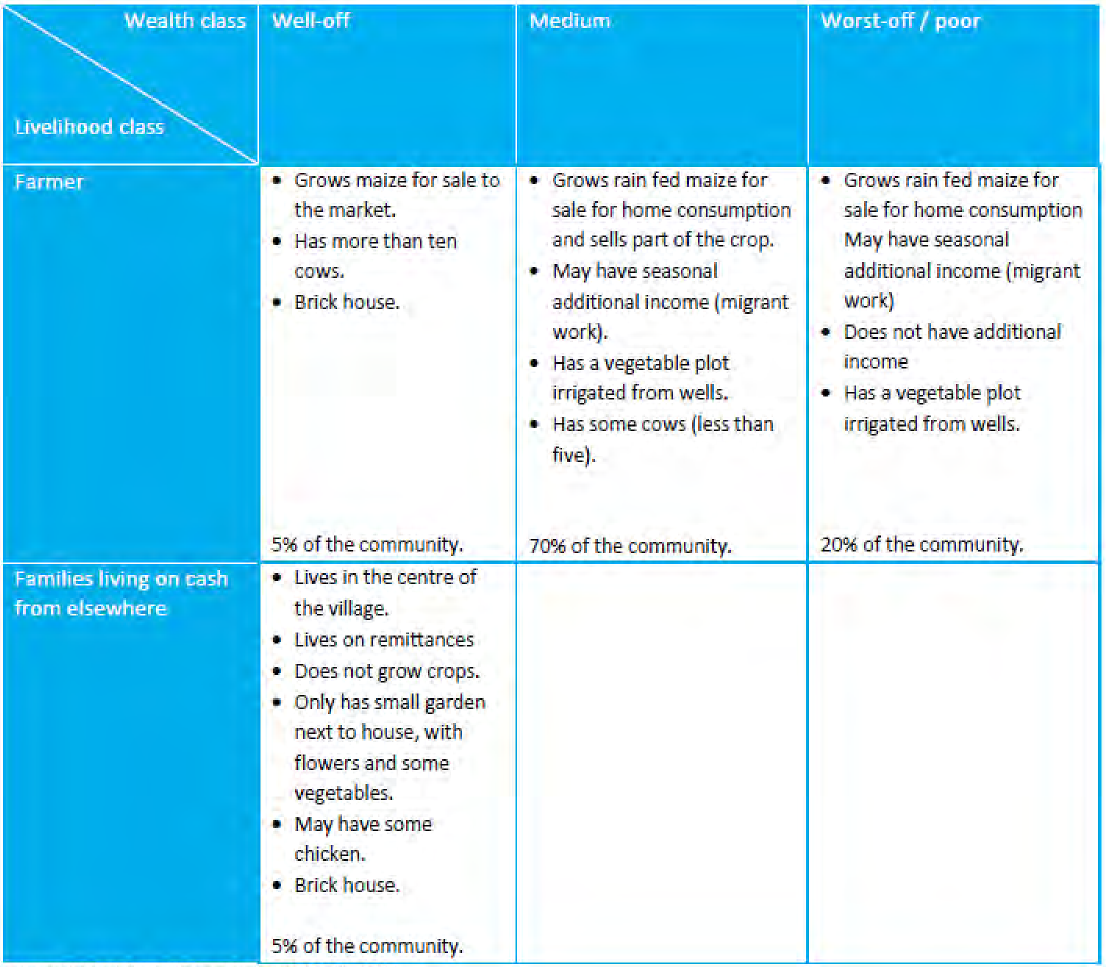
ANNEX 4: Tools for assessment of water access

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).

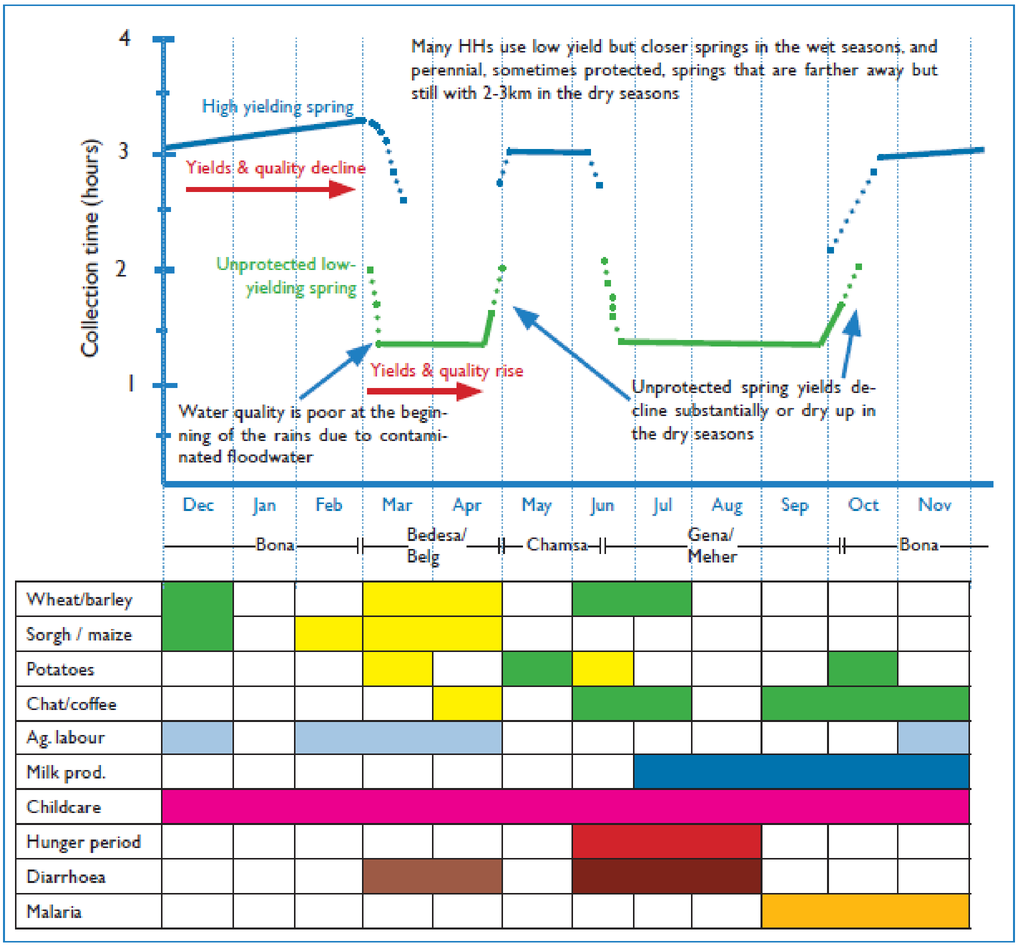
Periods of vulnerability are those where both assignments (seasonal labour and water collection) are high – where HH may struggle to obtain enough safe water for survival or livelihood protection.

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.



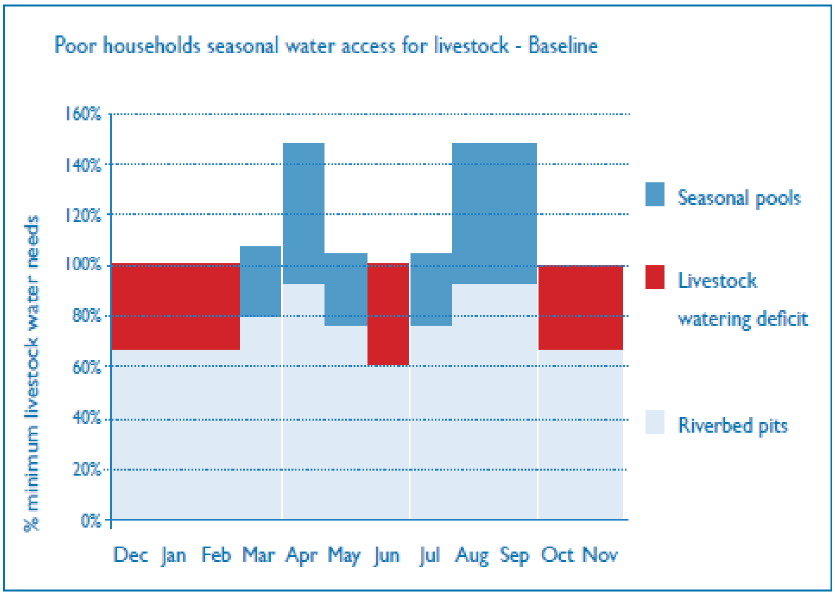
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Wheat/barley	🟩			🟨	🟨		🟩	🟩				
Sorgh / maize	🟩		🟨	🟨	🟨							
Potatoes				🟨		🟩	🟨				🟩	
Chat/coffee					🟨		🟩	🟩		🟩	🟩	🟩
Ag. labour	🟦		🟦	🟦	🟦							🟦
Milk prod.								🟦	🟦	🟦	🟦	🟦
Childcare	🟪	🟪	🟪	🟪	🟪	🟪	🟪	🟪	🟪	🟪	🟪	🟪
Hunger period							🟥	🟥	🟥			
Diarrhoea				🟫	🟫		🟥	🟥	🟥			
Malaria										🟧	🟧	🟧

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:

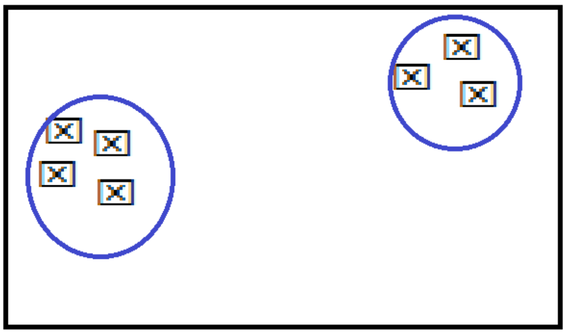
- That a good diversity of pens and pencils in different colors are available to the participants,
- As for the font used, the overall map of the area can be either drawn by the community on a simple blank A3 paper, or provided by the facilitator (Google map printing, map of the village, map of the area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

Location	Type	Pump/power	Status	USE	Water quality	Seasonality	Nomads?	X	Y	Elevation
Arumrum	BH	Handpump	F	D	Good	All year around	No			
Arumrum	BH	Handpump	NF - collapsed	N/A	N/A	N/A	No			
Ekoropus	BH	Handpump	F	D/L	Good	All year working	Yes			
IDP camp - Lopur	BH - solar powered	Solar	F	Domestic	Good	All year working	No			
Kagitangori	SW - HP		F	D/L	Good	All year working	Yes			
Kainuk	BH solar/powered	Solar + Genset	F	Domestic	Good	All year around	No			
Kainuk	SW 1		F	Domestic	Good	All year around	No			
Kainuk	SW 2		F	Domestic	Good	All year around	No			
Kainuk	SW 3		NF	Domestic	N/A	N/A	No			
Kainuk	BH solar/powered	Solar + Electric	F	Domestic	Saline	All year around	No			
Kakong	WP 1		F	D / A	Good	1 month	No	113064	224579	785
Kakong	WP 2		F	D / A	Good	All year around	No	112975	222064	796
Kakong	WP 3		F	D / L	Good	All year around	Yes			
Kakong	WP 4		F	D / L	Good	All year around	Yes			
Kakong	BH solar/powered	Solar	F	D	Good	All year around	No			
Kakong	Subsurface dam		PF					113744	225779	787
Kalemngorok	BH solar/powered	Solar	F	D	Good	All year around	No			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	No			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	NO			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	No			
Kalemngorok	WP		F	D						
Kalemngorok	SW		F	D	Good	yes		110596	236158	744
Kalemngorok	SW-HP at Ssdam		NF	D	Good	yes		110545	236393	742
Kalemngorok	Subsurface dam1		F					110573	236657	742
Kalemngorok	Subsurface dam2		F					110545	236393	742
Kanaodon	BH	Handpump	F	D / L	Good	All year working	Yes			
Kariole	SW		F	D/L	Good	All year around	Yes			
Katilu	BH solar/powered	Solar	F	Domestic	Good	All year working	No	110812	236068	745
Katilu	BH	Generator	F	Domestic	Good	All year working	No	102202	251873	689
Katiu secondary school	BH	Generator	F	Domestic	Good	All year working	No	102367	251525	687
Keekunyuk	BH solar/powered	Solar	F	D / L	Good	All year around	Yes	115981	245330	801
Keekunyuk	WP		F	D / L	Good	All year around	Yes			
Lokapel	SW		F	D / L	Good	All year working	Yes			
Lokapel	SW		NF							
Lokapel	SW		NF							
Lokapel	BH	Generator	F	D/L		All year working	Yes			
Lokapel	BH	Handpump	F	D/L		All year working	Yes			
Lokapel	BH		NF							
Lopur	BH solar/powered		F	Domestic	Good	All year working	No	102548	247339	698
Lopur	BH		NF							
Lopur	SW			Domestic	Slitghtly saline			102637	247514	699
Loyapat	BH solar/powered	Solar + Genset	F	Domestic	Good	All year around	No			
Loyapat	SW		F	Domestic	Good	Dries up in dry season	No			
Loyapat	SW		NF	Domestic	Good	Dries up in dry season	No			
Loyapat	WP		NF High infiltration	N/A	N/A	N/A	No			
Loyapat	BH solar/powered	Solar	F	Domestic	Good	All year around				
Nabeiyei	BH	Handpump	F	D	Good	All year around	No			
Nakabosan	BH solar/powered	Solar	F	D/L	Good	All year around	Yes	117558	250449	812
Nakabosan	BH solar/powered	Solar	F	D/L	Good	All year around	Yes			
Nakabosan	SW/HP		NF					119710	247886	859
Nakabosan	WP1		NF					118691	249895	836
Nakabosan	WP2		F			Few months		116404	249284	820
Napusinyan	BH	Handpump	F	D/L	Good	All year working	Yes	114445	251476	789
Nawoyeragae	BH	not yet equiped	NYE	N/A	N/A	N/A	N/A			

*Data obtained through field visits and stakeholder meeting

ANNEX 7: Field observations

Auger profiles

Profile 1			
Location	Keekunyuk, double ring 01		
UTM-X	116158	**UTM-Y**	245520
Depth	**Color**	**Texture**	**Remarks**
0-5	light brown-yellow	Fine silty sand with some coarse particles	
5-120	Light brown-red	Sandy loam with some gravel	
Profile 2			
Location	Kakong, double ring 02		
UTM-X	113979	**UTM-Y**	224967
Depth	**Color**	**Texture**	**Remarks**
0-30	brown	silty loam	
30-100	light brown	silty loam	
100-120	light brown	silty loam with some sand	
120-150	white brown	course sand with some silt	
Profile 3			
Location	Kakong, double ring 02		
UTM-X	113977	**UTM-Y**	224967
Depth	**Color**	**Texture**	**Remarks**
0-30	brown	silty loam	
30-100	light brown	silty loam	

Sand pits

Location	Keekunyuk sand river, probing 01		
UTM-X	116185	**UTM-Y**	245509
Depth	**Color**	**Texture**	**Remarks**
0-100	Sand	middle course sand, with some gravel layers	Excavated by community
100-170	Sand	Course sand with thick gravel layers	
170-200	Dark brown	Course sanand with gravel and fine material	
200-250	Grey	Clay with weathered rock, hard	
Location	Kakaong sand river, subsurface dam		
UTM-X	113744	**UTM-Y**	225779
Depth	**Color**	**Texture**	**Remarks**
0-3.5	Sand	middle fine sand	Information obtained from the community
3.5-4.5	Reddish sand	Course sand mixed with murram	Subsurface dam was constructed up to 2mbgl, and did not reach the clay layer
4.5-6	Black-grey	Clay	

Double ringinfiltrometer

No.	Location	WGS 84, 36N			Area description	Soil description	Plot description	Infiltr. cap. (cm/hr)
		UTM-X	UTM-Y	Z				
1	Keekunyuk	116158.2	245520.0	810.3	Sedimentary lowlands, with sparse grasslands and shrubs	Fine silty sand with some coarse particles at the top, after 5 cm sandy loam with gravel	Riverbank, next to Kariwole River	20
2	Kakong	113977.8	224967.0	789.8	Sedimentary lowlands, with sparse grasslands and shrubs	Light brown-red silty loam, with some sand	50 m from river, test done on bare soil	7.5
3	Kalemngorok	109228.5	234830.9	760.7	Sedimentary lowlands, Area is almost flat, some shrubs, sparse grass and bare soil	Brown-red, sand with some silt and loam, gravel and quartz cobbles	Bare soil, with cobbles in the surroundings	12
4	Nakabosan	120064.4	252216.1	1164.6	Mountainous area, with grass, outcrops and bare soil	Light brown silt, after 15 cm black-white/grey weathered rock	bare soil, with some grass	12
5	Kainuk	111651.6	196721.1	831.9	Sedimentary lowlands, with some slope, covered with grasslands and bush	Light red-brown silty sand, with quartz cobbles	Grass and bare soil	6

Open hole tests

1	Keekunyuk	113977.8	224967.0	789.8	See double ring 1	See Auger profile 1	depth 120 cm	240
2	Kakong1	113978.8	224967.0	789.8	See double ring 2	See Auger profile 2	depth 120 cm	240
3	Kakong2	113976.8	224967.0	789.8	See double ring 2	See Auger profile 3	depth 60 cm	180

River bed probing

					Bedwith	**Test 1**		**Test 2**		**Test 3**		**Test 4**		**Remarks**
No.	**Location**	**UTM-X**	**UTM-Y**	**Elevation**		**Distance**	**DTBR**	**Distance**	**DTBR**	**Distance**	**DTBR**	**Distance**	**DTBR**	
1	Keekunyuk River	116185	245509	807		middle	2							Clay layer with weathered rock
2	Nakabosan river	116694	248645	844	30	10	1.8	20	+ 2.5					
3	Nakabosan river	116867	248633	839	20	0-5	OC	10	0.5	12-15	OC	18	0.8	At rock barrier in river bed

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 A7-8-2 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.

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 plains with a gradient of the bottom of the riverbed of < 1 promille	The evaporation loss is rather small. Leakage depends on the permeability of the layer on which the subsurface dam is based. This can be larger in e.g. the sedimentary areas. Therefore, depending on location of application the efficiency of sanddams may be somewhat smaller than that of sanddams.
D	**Shallow, phreatic groundwater: wells and riverbank infiltration**	Location dependent, depends on the aquifer characteristics	-
E	**(Flood)water spreading and spate irrigation**	See D, additionally, this techniques are often applied to create grazing grounds or to irrigate agriculture, rather than storing water.	-
F	**Gully plugging, retention weirs, and other run-off reduction/infiltration options**	Depends on the possibilities to retrieve the water (e.g. springs). Additionally, this techniques are often applied for erosion reduction and to create grazing grounds or agriculture, rather than to store water.	-
H	**Closed tanks**	Generally 5-200 m3, also depends on the amount of water to fill a tank. With e.g. rooftop harvesting this can be the limiting factor (a roof of 30m2 provides with 300mm rain 9 m3 of water).	When the tanks are properly constructed, the losses will be minimal. When the tank is filled, not all water may be stored, because the first flush may be excluded to improve the quality.

ANNEX 10: Example methodology for matching RI and DA

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

Step 1: agreement on planning year in the future

Year: 2023

Step 2: Length of typical dry period in month

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

Step 3: Estimate of water gap for the whole area

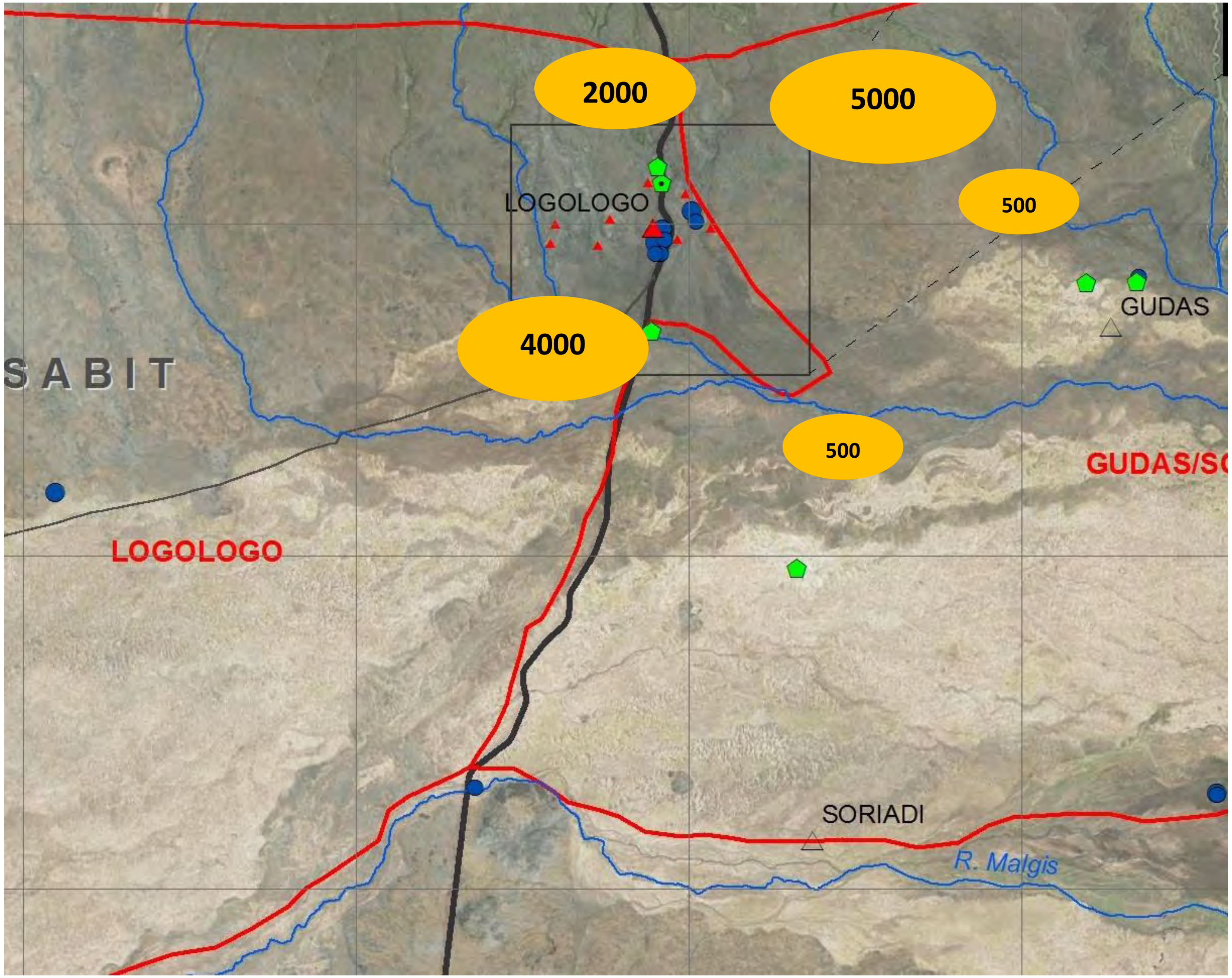
1. Using the estimate methodology of chapter 6, provides the values for the demand in 2023. In the case of Logologo, wildlife is assumed to make use of the same infrastructure (remote water pans), during the same periods as the migrating herds for a period of 3 months only
2. Infrastructure has been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

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

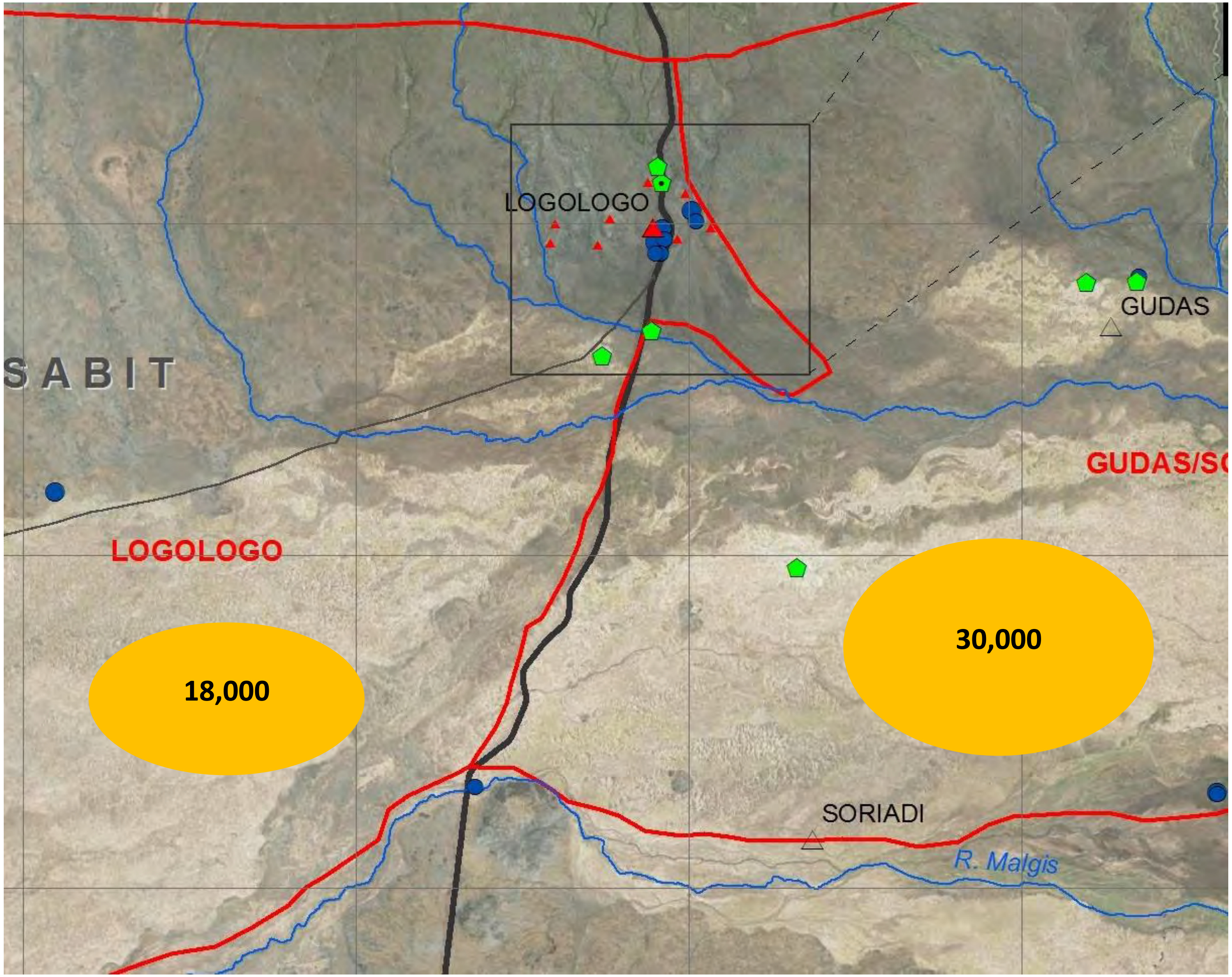
[1]: *in m^3 covering an agreed dry period*

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

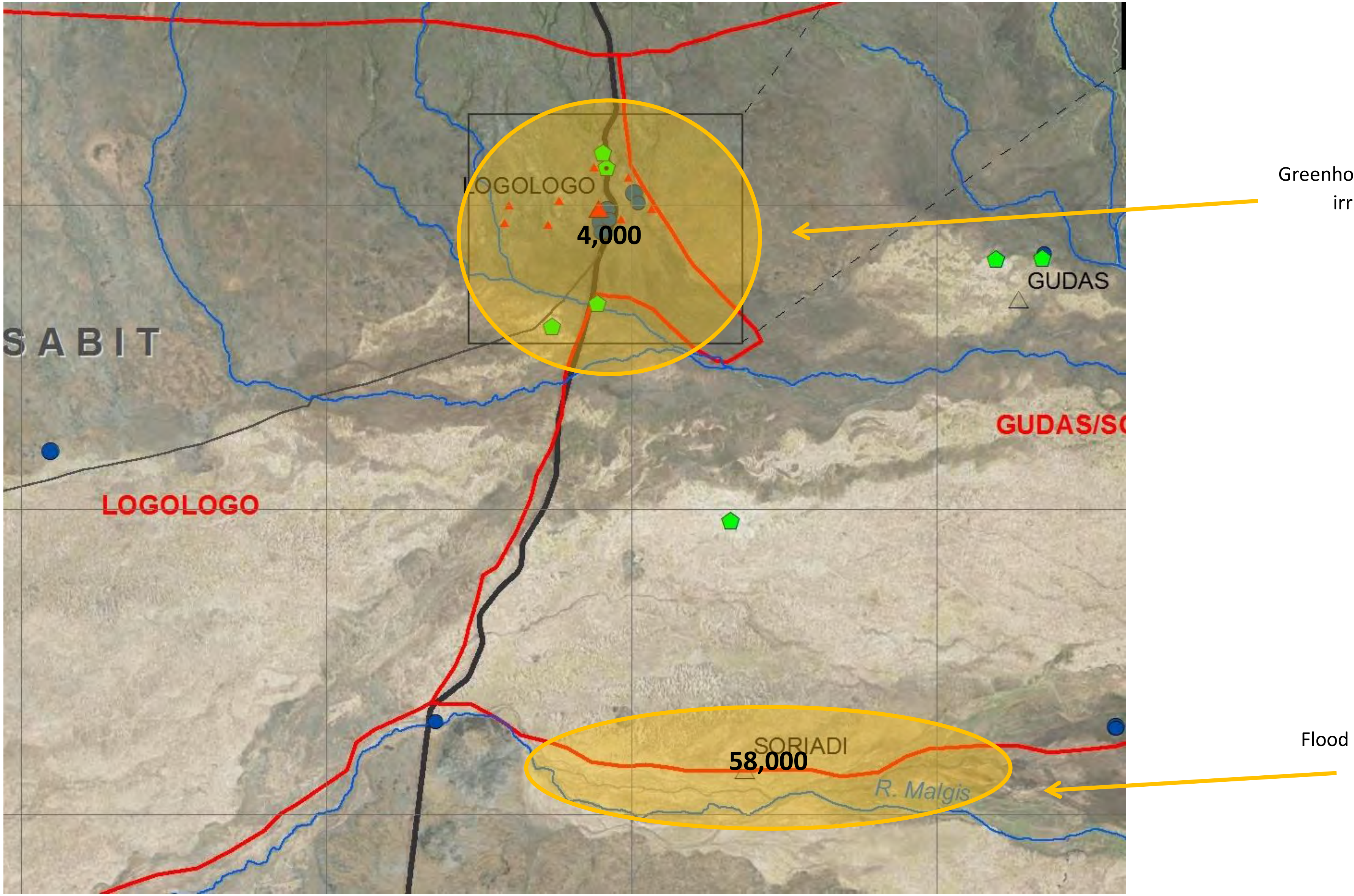
Gap domestic water demand Logologo 2023 (m^3)



Gap livestock water demand Logologo 2023 (m^3)



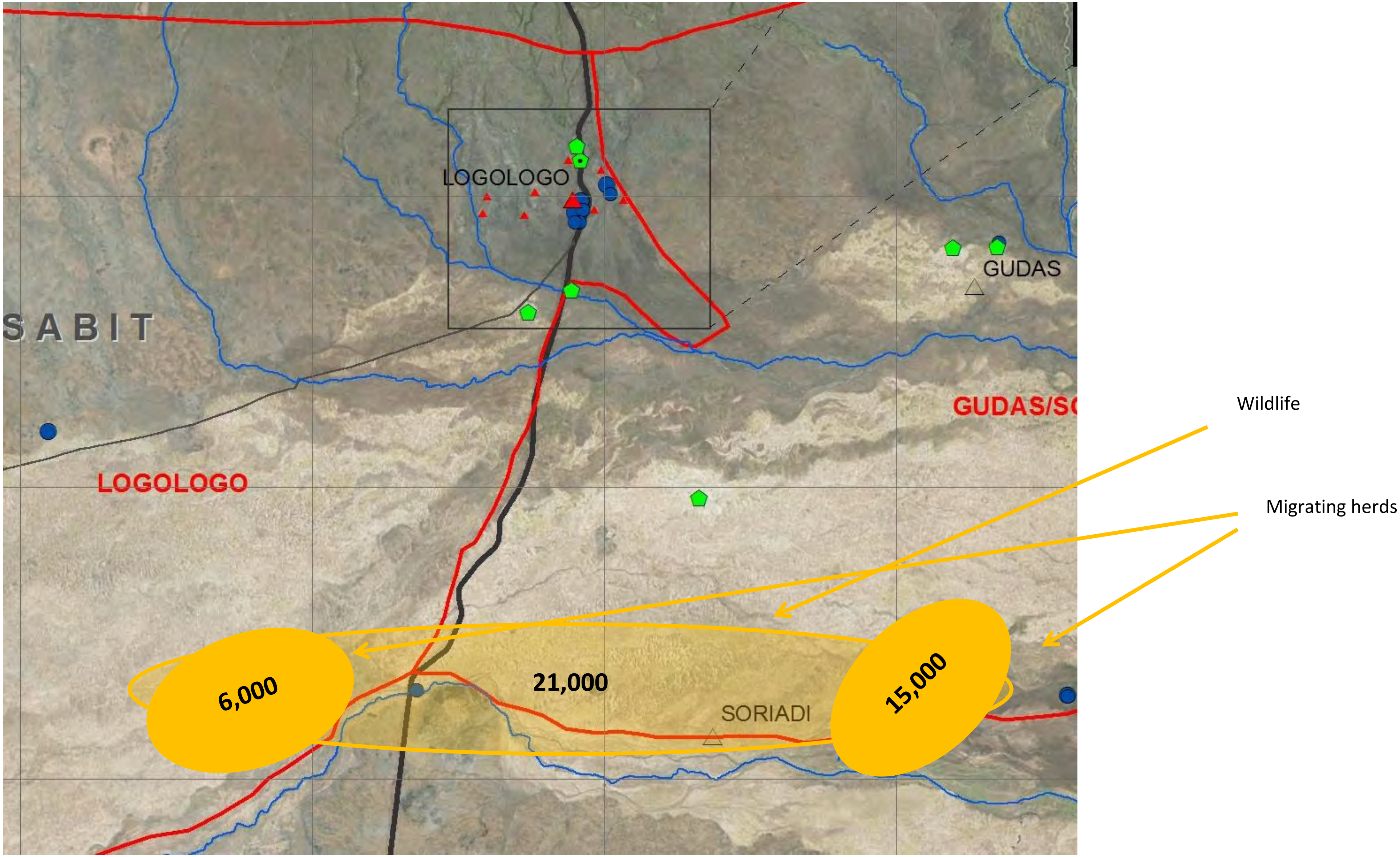
Gap agriculture water demand Logologo 2023 (m^3)



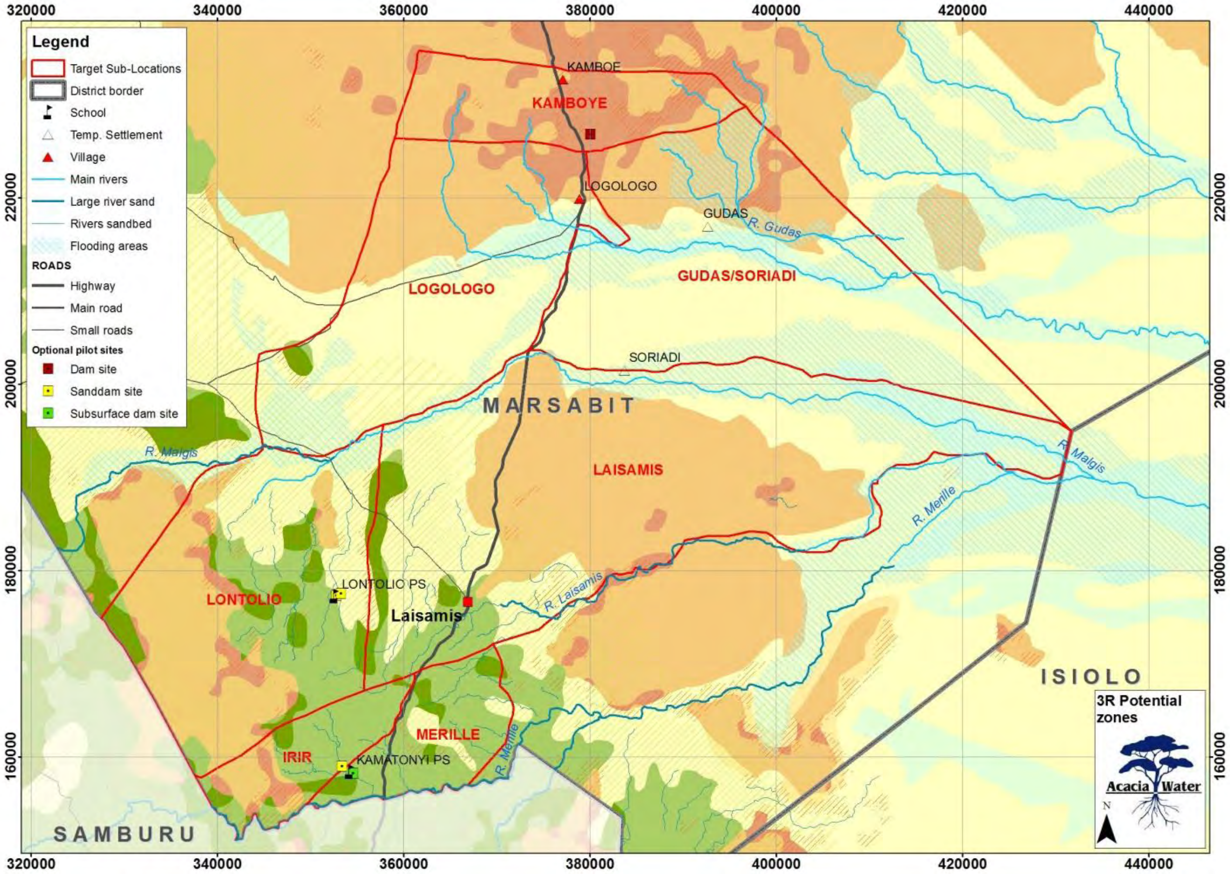
Greenhouse with drip irrigation

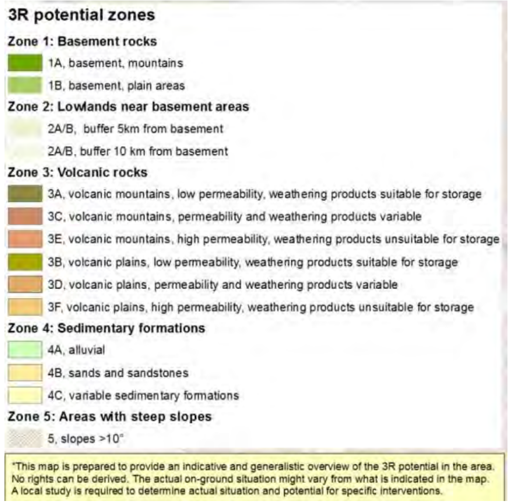
Flood irrigation

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





3R potential zones

Zone 1: Basement rocks
🟩 1A, basement, mountains
🟩 1B, basement, plain areas

Zone 2: Lowlands near basement areas
2A/B, buffer 5km from basement
2A/B, buffer 10 km from basement

Zone 3: Volcanic rocks
🟫 3A, volcanic mountains, low permeability, weathering products suitable for storage
🟫 3C, volcanic mountains, permeability and weathering products variable
🟧 3E, volcanic mountains, high permeability, weathering products unsuitable for storage
🟫 3B, volcanic plains, low permeability, weathering products suitable for storage
🟧 3D, volcanic plains, permeability and weathering products variable
🟧 3F, volcanic plains, high permeability, weathering products unsuitable for storage

Zone 4: Sedimentary formations
🟩 4A, alluvial
🟨 4B, sands and sandstones
🟨 4C, variable sedimentary formations

Zone 5: Areas with steep slopes
▨ 5, slopes >10°

"This map is prepared to provide an indicative and generalistic overview of the 3R potential in the area. No rights can be derived. The actual on-ground situation might vary from what is indicated in the map. A local study is required to determine actual situation and potential for specific interventions.

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

	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

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 10), 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.

ANNEX 10: Existing water infrastructures

Location	Type	Pump/power	Status	USE	Water quality	Seasonality	Nomads?	X	Y	Elevation
Arumrum	BH	Handpump	F	D	Good	All year around	No			
Arumrum	BH	Handpump	NF - collapsed	N/A	N/A	N/A	No			
Ekoropus	BH	Handpump	F	D/L	Good	All year working	Yes			
IDP camp - Lopur	BH - solar powered	Solar	F	Domestic	Good	All year working	No			
Kagitangori	SW - HP		F	D/L	Good	All year working	Yes			
Kainuk	BH solar/powered	Solar + Genset	F	Domestic	Good	All year around	No			
Kainuk	SW 1		F	Domestic	Good	All year around	No			
Kainuk	SW 2		F	Domestic	Good	All year around	No			
Kainuk	SW 3		NF	Domestic	N/A	N/A	No			
Kainuk	BH solar/powered	Solar + Electric	F	Domestic	Saline	All year around	No			
Kakong	WP 1		F	D / A	Good	1 month	No	113064	224579	785
Kakong	WP 2		F	D / A	Good	All year around	No	112975	222064	796
Kakong	WP 3		F	D / L	Good	All year around	Yes			
Kakong	WP 4		F	D / L	Good	All year around	Yes			
Kakong	BH solar/powered	Solar	F	D	Good	All year around	No			
Kakong	Subsurface dam		PF					113744	225779	787
Kalemngorok	BH solar/powered	Solar	F	D	Good	All year around	No			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	No			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	NO			
Kalemngorok	BH		NF - high salinity	D	N/A	N/A	No			

Kalemngorok	WP		F	D						
Kalemngorok	SW		F	D	Good	yes		110596	236158	744
Kalemngorok	SW-HP at Ssdam		NF	D	Good	yes		110545	236393	742
Kalemngorok	Subsurface dam1		F					110573	236657	742
Kalemngorok	Subsurface dam2		F					110545	236393	742
Kanaodon	BH	Handpump	F	D / L	Good	All year working	Yes			
Kariole	SW		F	D/L	Good	All year around	Yes			
Katilu	BH solar/powered	Solar	F	Domestic	Good	All year working	No	110812	236068	745
Katilu	BH	Generator	F	Domestic	Good	All year working	No	102202	251873	689
Katiu secondary school	BH	Generator	F	Domestic	Good	All year working	No	102367	251525	687
Keekunyuk	BH solar/powered	Solar	F	D / L	Good	All year around	Yes	115981	245330	801
Keekunyuk	WP		F	D / L	Good	All year around	Yes			
Lokapel	SW		F	D / L	Good	All year working	Yes			
Lokapel	SW		NF							
Lokapel	SW		NF							
Lokapel	BH	Generator	F	D/L		All year working	Yes			
Lokapel	BH	Handpump	F	D/L		All year working	Yes			
Lokapel	BH		NF							
Lopur	BH solar/powered		F	Domestic	Good	All year working	No	102548	247339	698
Lopur	BH		NF							
Lopur	SW			Domestic	Slitghtly saline			102637	247514	699
Loyapat	BH solar/powered	Solar + Genset	F	Domestic	Good	All year around	No			
Loyapat	SW		F	Domestic	Good	Dries up in dry season	No			
Loyapat	SW		NF	Domestic	Good	Dries up in dry season	No			

Loyapat	WP		NF High infiltration	N/A	N/A	N/A	No			
Loyapat	BH solar/powered	Solar	F	Domestic	Good	All year around				
Nabeiyei	BH	Handpump	F	D	Good	All year around	No			
Nakabosan	BH solar/powered	Solar	F	D/L	Good	All year around	Yes	117558	250449	812
Nakabosan	BH solar/powered	Solar	F	D/L	Good	All year around	Yes			
Nakabosan	SW/HP		NF					119710	247886	859
Nakabosan	WP1		NF					118691	249895	836
Nakabosan	WP2		F			Few months		116404	249284	820
Napusinyan	BH	Handpump	F	D/L	Good	All year working	Yes	114445	251476	789
Nawoyeragae	BH	not yet equiped	NYE	N/A	N/A	N/A	N/A			