Sand storage dams in Kitui – Kenya: community perspective on access to water

An evaluation using Q-methodology

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By

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in partial fulfilment of the requirements for the degree of

Master of Science
in Watermanagement

at the Delft University of Technology,
to be defended publicly on 19th of June, 2020 at 10:00 AM.

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Abstract

Ephemeral rivers are common hydrological features in Southern Africa where periods of up to 9 months occur, without significant rainfall. These rivers are important in the Kitui region of Kenya, where water shortage impedes rural and urban development. The seasonal rivers of Kitui provide suitable water for domestic, livestock and agricultural use, particularly small-scale irrigation. A majority of the population of Kitui county depends on the ephemeral river for water supply. In dry periods, water levels drop and water can only be found in scoop holes (holes dug in the riverbed). The water shortage is where NaBWIG, an abbreviation for Nature-based water infrastructures in Ethiopia and Kenya for #GlobalGoals (NaBWIG), focuses on. Its goal is to increase resilience through sustainable water supply with the use of stored water within ephemeral sand rivers (Karimi, 2018). This research is part of NaBWIG where, based on 2 months fieldwork trip to Kenya, an evaluation was done using Q-methodology. This study aimed to define which elements of water access are valued by people who use water from sand storage dams in two sub-regions in Kitui – Kenya. This research revealed the broad definition of access to water, specifically when zooming in to local sand dam utilization. Main elements that seem to be most important like distance, time, water quantity, water quality and also reliability of a water source. Other elements are also related to water access such as social capital, income and terrain. Results suggest that 'one community' does not exist in either of the regions. The results from the Q-method show different perspectives within both communities on both domestic and agricultural water use, with specifics of perspectives depending on whether one takes the respondents as a whole or analyses them per community. In both regions, comparable elements arise, but different groups appear too. These two 'communities' are diverse in perspectives and one must look at both regions with different 'lenses' as their position is different from each other. The researcher may force these people into groups, which then are called a community, but in reality, is still a group of people with different interests. The alignment of these different factor groups is important to ensure the community benefit the most of a sand dam structure, which does not stop after construction. This research aimed at creating a better understanding of the interplay of multiple factors regarding water access and provided a more thorough understanding of the dynamics of local communities and their appreciation of water access regarding sand storage dams.

Keywords: Sand storage dams, water access, Q-methodology, community dynamics

Acknowledgements

At first, my greatest appreciations to the community members who participated in this work by sharing their stories and opinions.

Then, I would like to thank Poolad Karimi for giving me this opportunity to explore the field of sand dams within Kenya. Also many thanks to my supervisors Erik Mostert and Leon Hermans for their academic support in helping me to create this final thesis. As a daily supervisor, I would like to thank Maurits Ertsen for his expertise and support.

This work was partly made possible through the NWO funded Nature-Based Water Infrastructure for #Globalgoals project (NaBWIG: http://www.nabwig.org) and the associated partner institutions: IHE Delft, Jomo Kenyatta University of Agriculture and Technology Kenya, Mekelle University Ethiopia and South Eastern Kenya University. I would like to show my appreciations to my research assistant and friend: Nicholas. I also wish to thank the organization of SASOL and Meta Meta who gave me support and facilitation during my stay.

Lastly, a thank you word towards my family, friends and boyfriend who gave me support and confidence in completing my master thesis: with a special thanks to my father, who provided me insights and created the opportunity for me to complete my studies.

Content

Abbreviations

CFA	Centroid Factor Analysis
NaBWIG	Nature Based Water Infrastructure for Global Goals
PCA	Principal Component Analysis
SASOL	Sahelian Solutions Foundation
SD/SSD	Sand storage dam
SEKU	South Eastern Kenyan University
WPI	Water Poverty Index

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1. Introduction

Ephemeral rivers are common hydrological features in Southern and Eastern Africa, where periods of up to 9 months can occur with no significant rainfall. NaBWIG (Nature-based Water Infrastructures in Ethiopia and Kenya for #GlobalGoals) focuses on increasing resilience through sustainable water supply using ephemeral sand rivers (Karimi, 2018). The parties within this project are IHE Delft, South Eastern Kenyan University (SEKU), Mekelle University, Ethiopia, Jomo Kenyatta University of Agriculture and Technology (JKUAT) and students from IHE. This MSc research is part of NaBWIG. Based on fieldwork in Kitui, Kenya, an evaluation was made how two communities in Kitui assess the change in water access since they have a sand storage dam. The study employed Q-methodology. Its outcomes create a better understanding of the dynamics of local communities concerning and their appreciation of water access regarding sand storage dams.

1.1 The NaBWIG project

Climate variability and extremes hinder food security for smallholder farmers in semi-arid regions. Water storage to buffer rainfall gives people access to reliable water supply. However, large water infrastructures such as big dams and reservoirs can be disruptive and not always beneficial for local communities. The focus of water planners and managers has been to meet growing demands for water by increasing the supply through technical solutions based on medium-term (around 30 years) demand projections. Large infrastructures have become less popular. The development of new and the revival of traditional approaches like integrated water management and rainwater harvesting can have more potential. Previous research shows that smallholder farmers use old riverbeds as water storage for irrigation and that there is upscaling potential (Gupta & van der Zaag, 2008).

The NaBWIG project aims at improving the resilience of smallholder farmers in Kenya to cope with climate variability and water shortage with the use of water storage in ephemeral rivers. The project aims to develop a portfolio of storage options in Kajiado, Kenya (Figure 1) within sand rivers. The project aims to develop knowledge about the characteristics of ephemeral sand rivers and its application to serve people's needs for sustainable and reliable freshwater. NaBWIG uses adaptive investment pathways (Haasnoot et al., 2012), which is a step-wise and result-based approach. This approach is expected to result in smaller storages distributed over the area, instead of large lump sum investments in large infrastructures.

For NaBWIG project-specific objectives are defined. The first objective is to co-create sustainable water storage options together with local stakeholders, combining a basic understanding of the hydrogeological behavior of shallow alluvial aquifers, socio-economic drivers for water use and local knowledge on agricultural practices. Secondly, NaBWIG aims at developing adaptive investment pathways for sustainable water storage, integrating knowledge on biophysical aspects of alluvial aquifers and investment risks posed by climate variability, uncertain socio-economic circumstances and changing stakeholder demands. The third objective is to generate new, evidence-based knowledge that bridges the gap between fundamental understanding of the hydrogeological aspects and water storage potential in dry riverbeds and stakeholders' needs and capabilities to sustainably balance water supply and demand. Lastly, the project aims at providing policymakers, planners, extension workers and relevant professionals with knowledge and tools to develop and implement investment plans in nature-based water storage.

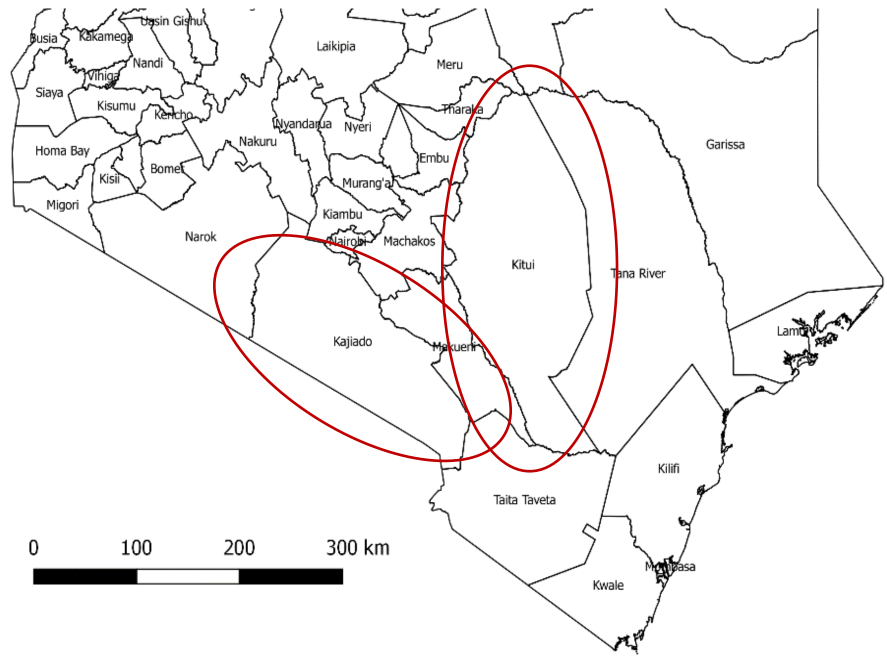

Figure 1 Map of Kenya highlighting the counties of Kajiado and Kitui (USGS).

Master students from IHE (4 in total) have participated in the NaBWIG project related to the specific objectives mentioned. This MSc thesis focusing on Kitui is added as fifth research, to learn from Kitui for Kajiado's future. The interaction between students and supervisors from different backgrounds and institutions has stimulated both academic and cultural knowledge exchange, enhancing collaborations within this research.

1.2 Previous research on Kitui

The area of Kitui has already seen several studies on its water situation on several topics. These include water use changes, the effects on hydrology and socio-economic development, and other fields such as the planning and implementation aspects, the construction of sand-storage dams, the effect on groundwater levels and the networking effect of sand-storage dams. Within this section, the multiple studies are chronologically described and briefly explained based on the key findings.

The approach followed by the local NGO Sahelian Solutions (SASOL) to implement sand-storage dams in Kitui is described by Thomas (1999). SASOL's main goal was to achieve better living conditions through an ensured and increased water supply. SASOL took the initiative and provided funding and knowledge for the construction of sand-storage dams. In 2001, a student team from Technical Univesity of Delft studied the design and maintenance of the sand-storage dams and suggested improvements (Beimers et al., 2001). In 2004, another study was completed on the construction and operation of sand-storage dams in Kitui (Munyao et al., 2004).

Rempel (2005) performed a study at 30 dam sites, including interviews with six people. The results of the study show many responses related to agricultural production, crop changes and time spared on fetching water. Rhebergen & de Bruijn (2005) studied households with dams and without. Their results showed changes in social and economic standards in two areas: the Kiindu catchment with dams and the Koma catchment without. The results suggest that dams have a positive social and economic effect on local people. Regarding the scope of the research, with 19 households with a dam and 18 households without a dam, this study remains a small sample, leaving out the complexity of individual households in a holistic view. Also in 2005, Ertsen et al. (2005) suggested that the construction of sand-storage dams has not resulted in stronger organizational structures. They also found that after the construction of the sand-storage dams, the community became less active, compared to during construction, in participation around the sand-storage dams. This could be caused by the predefined implementation approach.

The sand-storage dam structure itself and its construction process are described by Nilsson and Peterson (2006). In 2006 and 2007, a series of master thesis projects was done by students from the VU Amsterdam about the effect of sand-storage dams on the hydrology of the Kiindu catchment (Borst and De Haas, 2006). Based on the hydrology of the catchment, the study concluded that the downstream effect of sand-storage dams is very insignificant. Hoogmoed (2007) studied the impact of sand-storage dams on groundwater flow and storages, whereas Gijsbertsen (2007) performed a study on the up-scaling of sand-storage dams in relation to the sedimentation transport processes upstream of them. Janssen (2007) performed research on rainfall-run-off response and water availability in the area of Kitui. In the same year, Delft University of Technology student Orient Quilis (2007) modelled sand-storage dams systems in seasonal rivers in Kitui. She focuses on the long-term effect of sand-storage dams over several decades. She mainly looked at groundwater and found that the effect of a network of sand storage dams depends on the distance between single dams. From Loughborough University, Hussey (2007) defines how to abstract water from sandy rivers.

Forzieri et al. (2008) looked into the suitability of sites for construction of sand-storage dams using remote sensing. This was not done in the county of Kitui, but as a case study in Mali. Lasage et al. (2008) analysed the potential for community-based adaptation to droughts in Kitui county. Their main result showed an increase of 60% in income. In this year, a research was published by Pauw et al. (2008) about how living conditions changed after the construction of the sand-storage dams and change in land cover. They distinguish primary and secondary benefits. Primary benefits focus on stored water in the catchment, with secondary benefits being found in the sectors of education, increased agricultural yield, ownership and income.

Hut and others published an article on a simple groundwater-flow model which was developed to understand hydrological processes and flows around the dam. Two different locations in Kenya were studied with the model. The first case in Voi and the second case in Kitui. It showed relatively mild effects of household water use on groundwater levels (Hut et al., 2008).

Ertsen & Hut discussed what lessons can be learned from the experiences in Kitui to upscale the construction of similar technologies in other areas. This discussion focused on three dimensions: planning, scale and use (Ertsen & Hut, 2009). A groundwater model for a single sand-storage storage dam was developed by Quilis et al., and the results confirm that, from their measurements and modelling, sand-storage dams can effectively increase water availability throughout the dry season (Quilis et al., 2009).

Lasage et al. (2013) analysed the effect of sand-storage dams on environmental flow downstream for different climate scenarios, this time in a catchment in Ethiopia. Their main findings were about the increase of sand-storage dams and their result of low flows downstream, with an assessment that overall benefits of the dams outweigh this impact downstream.

In his MSc thesis, Strohschein (2016) showed the long term effects of sand storage dams on hydrology and water use in the Kiindu catchment near Kitui town. The study shows that the sand dams in general lead to larger amounts of water available in the catchment, but that this is not equally distributed over the catchment. In 2017, Schulthess provided a deeper understanding of sand storage dam performance in the specific case of the Kiindu river catchment as a MSc thesis at the TU Delft. A model was built that allowed equal agency to human and non-human actors, reflecting socio-hydrological interconnections between human and non-human agencies. She stated that the model can be further improved regarding the chosen representation of erosion, its linkage to dam performance and human decision-making processes.

Lastly, in 2020 a research by Ngugi and others was published. The objective of this study was to determine whether distance to a permanent water source influenced the attainment of education and livestock accumulation. Results showed the level of education achieved by the residents is weakly correlated to distance to a permanent water source for the children. For the fathers, the distance to a water source played a role in the level of education they attained. The level of education influenced the kind of livestock kept by the more educated residents who prefer smaller livestock (Ngugi, 2020).

1.3 Research gaps and relevance of this study

Many countries and regions depend on their agricultural production to ensure food security and to contribute to economic development. Likewise, the availability of water plays an important role in the daily activities of the inhabitants of Kitui. Besides agriculture, other sectors impose a demand on water resources in the area. Declining water supplies (in terms of less rain) and growing demand, require additional water storage and improved water access, to overcome water shortages (Gupta & van der Zaag, 2008). Within the county of Kitui, catchments have been receiving less precipitation every year, resulting in less available water each year. Additionally, climate change in combination with population growth will further threaten food security and economic development. Within the area of Kitui, already from 1990 onwards, many sand-storage dams have been built to cope with the variable rainfall and its deficits (Lasage, 2008). A main issue within the area is the pace and amount of sand-storage dams that have been implemented, from 0 to 500 and more sand-storage dams in decades. Although execution of the sand-storage dams is clearly defined in the literature, it is unknown what the effect is over time, how small-scale links to large scale and how this contributes to the full potential of a sand-storage dam in terms of water access. Literature showed that out of the sand-storage dams that have been implemented from 1995 only a part is currently in use (Strohschein, 2016). These results highlight the importance of not only investigating what the change of water access to Kitui communities has been directly but also how this relates in a broader scope which can be of interest for upscaling this technique to other regions like Kajiado.

Within the area of Kitui, the unequal functioning and different uses of the sand-storage dams is difficult, especially within the perspective of upscaling. Opinions are divided within the area of Kitui on the value of the dams, but detailed research has yet to be performed. Currently, the social structure is partly known but can be assessed in more detail. Ertsen (2005) already stated that only a few activities take place after construction, but a deeper understanding is necessary of how the communities are structured. Besides this, the effect of sand-storage dams related to local circumstances is important to address, which is currently understudied. These issues together highlight the potential of socio-hydrological studies, especially for holistic water management, as societies are complex, including human behavior (Doorn, 2019).

1.4 A sneak-peak into water access

The term 'access' is frequently used within studies on property and natural resources, but is not often clearly defined. Ribot and Peluso developed a concept of access and examined a broad set of factors that differentiate the definition of access. They define access as 'ability to derive benefits from things' and later on broadened this to 'the right to benefit from things'. They stress that access is similar to 'a bundle of powers' rather than to a 'bundle of rights'. Analysing 'access' is about identifying patterns, relations and processes that enable various actors to derive benefits from a resource (Ribot & Peluso, 2003), which is, in this case, a water resource. Access to water can be studied in many ways and scales – an international scale versus a local scale, domestic versus agricultural water access – and differs per structure, which is in this case a *sand storage dam*. Challenges of water access in semi-arid lands put residents at a great disadvantage towards achieving other positive social-economic indicators (Ngugi et al., 2020). It is a dynamic definition and those dynamics of water access are shown in this thesis. It will illustrate the 'messiness' and multiple faces of water access.

1.5 Research objective and research question

NaBWIG is in line with Sustainable Development Goals, number 6 in particular: 'To ensure access to water and sanitation for all'. The broad scope of 'water access' though gets a different 'look' when zooming in to local situations. The different uses and opinions regarding a sand-storage dam need an integrated view, as done by this study. Societies are complex including different human behavior. Therefore different typologies appear. The aim is to get a clear view of perspectives within communities regarding water access. This is in line with the work package of NaBWIG which includes 'assessing existing natural and built storages, their use and contribution to livelihoods' and 'providing baseline information on typologies, distribution and the use' of natural and built storages. One of those built water storage options is a sand storage dam and evaluated in this thesis. Therefore, the following objective is formulated: *To evaluate how communities in Kitui assess the change of water access since they have a sand-storage dam.*

The main research question which is answered in this thesis is:

What elements of water access regarding sand storage dams are valued by people living in Kitui - Kenya?

To evaluate this in a step-wise approach, several aspects need to be clear. At first, water access is defined, based on both literature findings and findings from the field, to create the different elements of water access that come into play in Kitui. Thereafter, the field data is analyzed, resulting in how different groups (or typologies) with differentiating characteristics can be distinguished, with the use of Q-methodology. This suggests which elements are important to the group as a whole and two different regions.

1.6 Readers guide

The structure of this report contains this logic and reflects the approach taken. First, **background information** is given concerning the study area and characteristics of sand storage dams. The **methods** used for this research are addressed in the next chapter of 'Methodology', explaining the five steps of Q-methodology, which serve as the body of this research. In the **Q-set development,** the concourse is developed based on the definition of water access. The next chapter contains the **data analysis** of the results gathered in the field. Towards the end of this report, the findings are being reflected upon and if needed criticized within the **discussion** part, followed by the answer to the research question in the last chapter: **Conclusions**. To finalize the report, **thoughts on future development & NaBWIG** are highlighted.

2. Background

2.1 Study area

This research study area is located in the county of Kitui (Figure 2), approximately 150 km eastward from the capital of Nairobi. Kitui county is one of 48 counties in Kenya.

The county covers an area of around 30,500 square kilometres, equivalent to the total surface of The Netherlands. It shares borders with seven other counties and has eight sub-counties. Further division of the counties is called wards, 40 in total in Kitui, which is then again subdivided into 247 villages. The population of Kitui is mostly made up of the Akamba ethnicity people, which is the fifth largest tribe in Kenya within a total of approximately 1,1 million people. The majority of the people living in the county are Christians. The county also has a significant number of Muslims and therefore several mosques are seen around the county's urban areas (Ntarangwi, 2019).

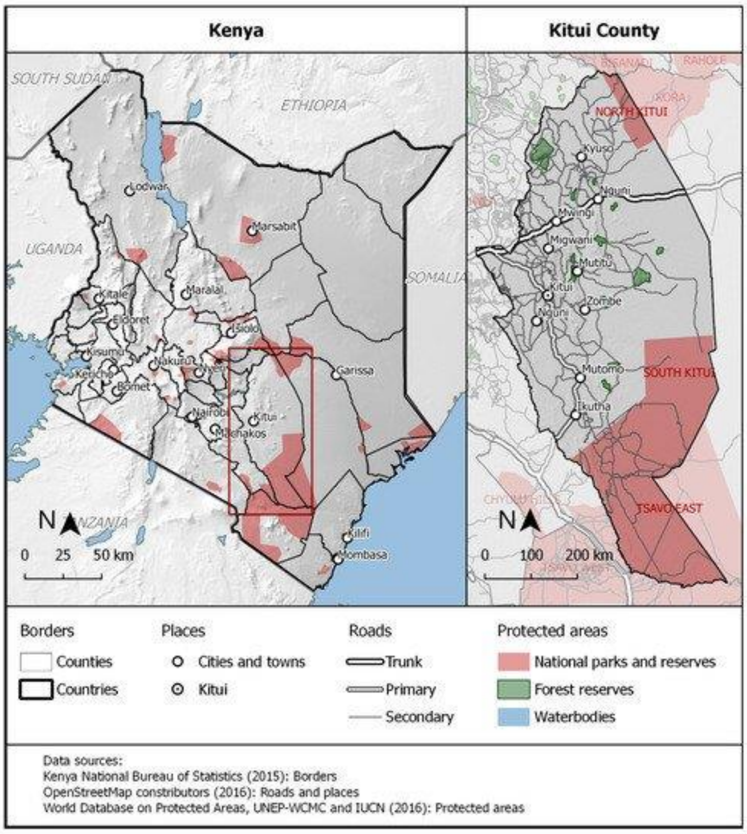

Figure 2 Map of Kenya (source: Kenya National Bureau of Statistics).

The capital of Kitui County in Kitui town and the research area is about 12 km south and 10 km north of Kitui town. The spring of the Kiindu is south of the village of Wikilyle and the general drain direction is south. The Kiindu river is an ephemeral river with al length of approximately 16 km and in the south, the Kiindu river flows into the bigger Nzeeu river. Another river, the Mutendea river, situated north of Kitui town, flows into the Nzeeu river. This again flows into the bigger Tana catchment which eventually discharges into the Indian Ocean. Most of the dams built by SASOL are located within this area. The advantages of the study area are that the area contains a large number of dams and is easily accessible from Kitui town (Gijsbertsen, 2007).

The geological characteristics are as followed: the area ranges from 1100 meters above sea level in the north to around 950 meters above sea level in the south of the catchment. The soil surface mainly consists of a sandy or clayey layer build on top of weathered rock. The river bed thickness varies from a few centimetres to more than two meters (Borst et al., 2006). The average annual temperature is 21.4 °C in Kitui and the county receives between 500mm and 1050mm of rainfall annually with an average rainfall of 900 mm a year (Climate-data, 2019). The annual evaporation in this area is around 1800 mm. Regarding the land use and characteristics: the area is dominated by homesteads on irregular plots of cropland surrounded by natural vegetation where the Acacia trees are common. Currently, most agricultural land is used to do rainfed agriculture, but since the construction of sand-storage dams, plots are also being irrigated cultivating crops like maize, beans and peas (Borst et al., 2006).

The specific study area consists of 2 areas within the county: the *Kiindu* catchment and the area of *Mulutu* (Figure 4). These catchments were chosen as several studies have been performed here focusing on hydrology, sand storage dams and on the impact on local communities. This is helpful for interpretations of the results, which build on known characteristics of the area. A comparison study was done between both areas where Kiindu contains fairly old sand dams and Mulutu a fairly new sand dam. Both areas are easily accessible and are comparable in hydrology (same catchment) (Figure 3).

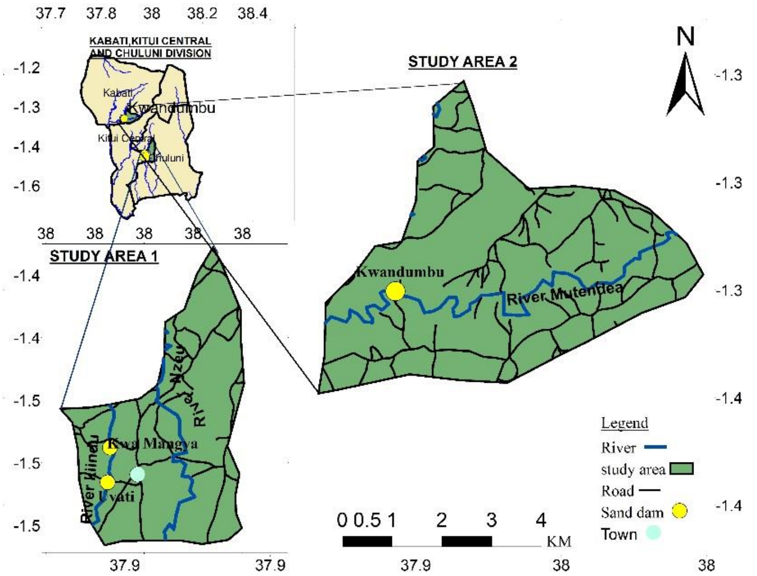

Figure 4 Study area.

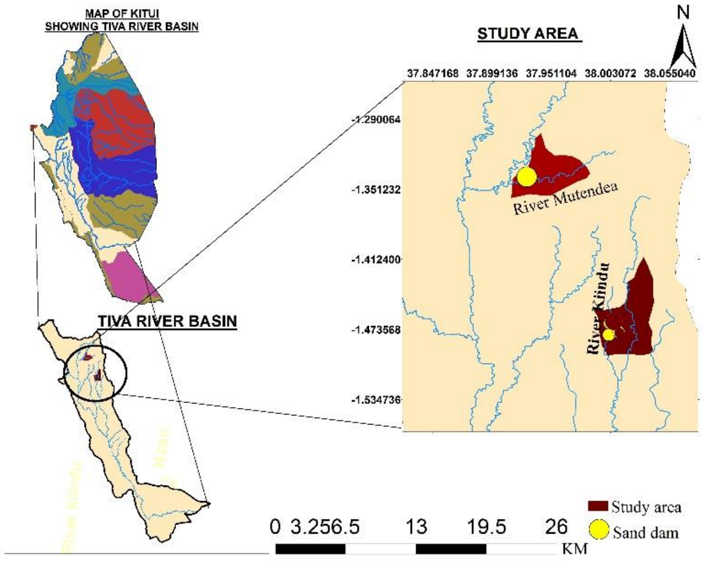

Figure 3 Hydrology of Kitui, Tiva river basin & study area.

2.2 Background on sand-storage dams

The seasonal rivers of Kitui region in Kenya are representative of typical seasonal river found in the arid and semi-arid Sahelian belt of Africa. These rivers are important in the Kitui region of Kenya where water shortage impedes rural and urban development. A majority of the population of Kitui county depend on the ephemeral river for water supply. The seasonal rivers of Kitui provide water for domestic, livestock and agricultural use, mainly small-scale irrigation. In dry periods, the water levels drop and water can only be found in scoop holes (holes dug in the riverbed). During dry periods there is no water left in the river at all, only in some catchments, forcing people to walk long distances to other rivers that still contain water. This could lead to failing harvests and may cause famine. Development programs by an NGO like SASOL, have created multiple sand-storage dams (Figure 5) in the county of Kitui to address the chronic shortage of water to rural communities. The seasonal rivers are exploited through the construction of sand-storage dams within the sandy riverbeds (Kitheka, 2016). SASOL, helped local communities with the design and construction of sand dams to increase the water storing capacity of seasonal (ephemeral) rivers. The goal of SASOL is to reduce the distance to a water source to less than 2 km for the entire Kitui District and improve overall water availability (Lasage et al., 2008).

Figure 5 Sand storage dam during wet season.

2.3 The principle of sand-storage dams

A sand storage dam is a dam in a riverbed, built on an impermeable layer of underlying bedrock (Figure 6), with its sides either into the bedrock material or into the riverbanks of the ephemeral rivers. Behind the dam, if local conditions are suitable, sand will accumulate. This process resulted in the name: *sand-storage dam*. The dam obstructs the flow of groundwater and the water that percolates in the pores of the sand after a rain event. After a rain event, the reservoir gets saturated and the remaining flash flood will pass over the dam. The pores of the sand bed make up around 35% of the volume of sand resulting in a specific yield of 27% (Borst et al., 2006). The term specific yield is the available pore volume of water that can freely drain from saturated rock or soil under the influence of gravity. The yield is normally expressed as a percentage of the total volume of the aquifer and not just the pore space. The total volume of sand-storage dams differs per region and per site but it ranges from 100 m^3 to 50,000 m^3. The volume has a wide range as well as the dimensions. A typical height of a sand-storage dam ranges from 1 to 4 metres above the surface (Hut et al., 2008).

The dams are constructed using raw material (e.g. stone, water, sand) collected from the surrounding area. The local community offers labour to gather these materials and builds the dam. Material costs per dam are around 7000 euros on average. According to Rempel (2005), the time saved on fetching water represents a level of payoff that justifies the investment by a community. After construction of the sand dam, the dam officially belongs to the community surrounding it, including the water retained behind the dam. When water is stored, it reduces evaporative losses, health risks and serves as an extra water buffer which can be used to bridge dry periods, which are common in this area (Gijsbertsen, 2007). Over the last 10 years, SASOL has developed more than 500 dams in the county of Kitui.

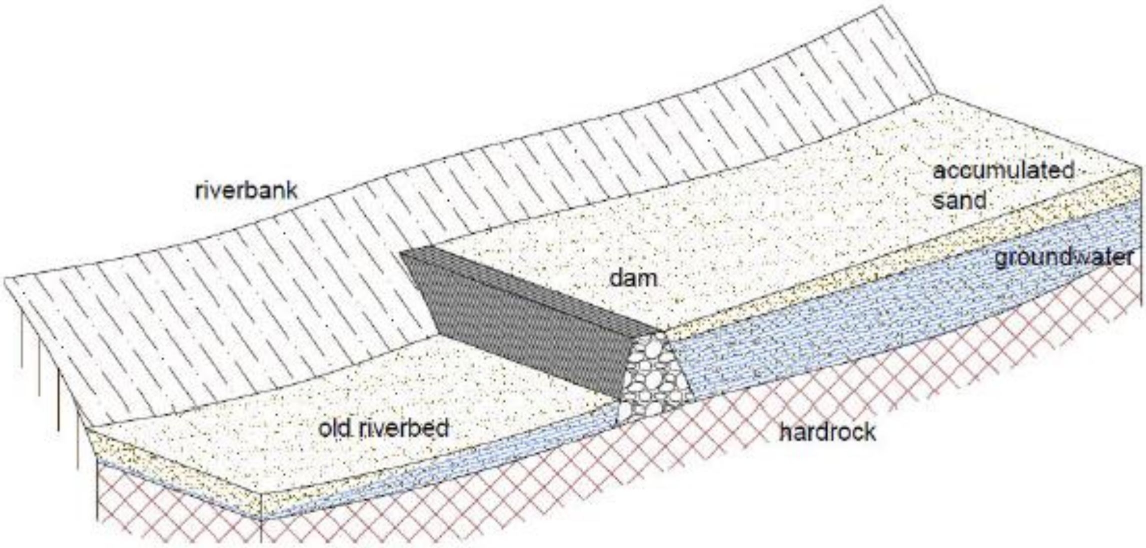

Figure 6 Schematic drawing of a sand-storage dam (Borst & de Haas, 2006).

2.4 The use and maintenance of a sand-storage dam

Communities collect water from the sand dam using simple holes scooped into the sand (Figure 7). Sand dams raise the water table, making water more easily accessible from scoop holes all year-round. Acacia and thorns are regularly used to protect the scoopholes from livestock. A separate livestock watering point is normally established below the dam, to mitigate contamination of the water. You can also collect water using an infiltration gallery. Pipes are built into the wall of a sand dam and connected to an infiltration gallery. This way you can provide water 'on-tap'. Sometimes these infiltration galleries are connected to a tank which allows water to be pumped for agricultural use. Sometimes the sand dam is also connected to a shallow well in the river bank with or without a hand pump (Maddrell, 2012).

Figure 7 Extracting water from a scoop hole (Maddrell, 2012).

Households that invest in labour to construct the dam and build it become owners and are allowed to fetch water from the dam. A majority of the people is aware of this, although some people think that the Kenyan government or SASOL has ownership over the dam. Although sand dams are robust concrete structures, they need some maintenance, especially along the riverbanks. However, only several households take the responsibility to act and protect the dam. Maintenance measures include protection of the riverbanks, not to let animals drink at the dam or locking the well, if possible. Many people say to protect the dam but forget the banks. The concrete can last, but the connection to the riverbank is vulnerable to erosion. This process makes water flow around the dam, degrading its function. The dam should work as both a barrier and spillway. This way it is ensured that the erosion will not affect the riverbanks. Some people even cultivate on the riverbed, thereby changing the watercourse and jeopardizing the performance of the dam. (Pauw et al., 2008)

2.5 Advantages and disadvantages

Underground water storage has some advantages over open water storage. Less water evaporates since no water is subjected to direct solar radiation. Surface water normally has high evaporation rates and can get easily contaminated. Moreover, mosquitoes can breed in it, causing malaria (Borst & de Haas, 2006). Water stored in subsurface aquifers barely suffers from these difficulties. Water is less affected by biological contamination than open water. As water flows subsurface it is also filtered and bacteria and other biological threats are reduced. Since the water is contained underneath the surface, it is much less subjected to littering than open water (Hoogmoed, 2007). Sand dams increase the sub-surface aquifer of an ephemeral river. A matured dam (filled with sand) stores around 1.8-3.8% of the annual local rainfall. Lastly, since salinity increases with evaporation, water quality remains more constant (Lasage et al, 2006).

The main disadvantage of selecting a sand dam as a water reservoir is that it must be planned, designed and constructed according to specific technical requirements. Else, high costs, low yields and siltation can become a problem (Schreiner et al., 2013). The technology is labour intensive and most local communities cannot implement it without external aid.

The sand dam can also take several years to 'mature' or fill in with sand, anywhere from 2 to 7 years. They can also cause higher rates of erosion downstream: sometimes this has to be maintained when it gets too harmful. Another disadvantage is that it is difficult to control who and what has access to the water from the sand dam. Usually when sand dams are built, the community decides that whoever helped building it, gets access to the water. This is however hard to control since it is just like a river and anyone can walk right up to it as they please. It is also difficult because cows or other livestock, if not watched as they drink from hand-dug holes, could defecate too close or right in those holes used for water extraction. This could lead to contamination of that scoop hole or of that section of the sand dam (Maddrell, 2012).

2.6 Sand storage dams for this research

For this research, a comparative study is done between two regions, two sand dams and two communities making use of it. These two regions were chosen based on SASOL's knowledge. Their expertise lies within construction, training of sand dams communities and geographical locations and performances of the sand dams in the area of Kitui. Within a conversation between the chief officer, the structural engineer and myself, a clear distinction came out between old and new sand dams in the area of Kitui. SASOL clearly showed a preference for comparing an area with old dams with an area with new dams. A list of all sand dams was provided by SASOL and together with a member of SASOL who regularly visits the sites, possible sand dams for this research were discussed. Suitability of the area depends on the following aspects: *accessibility* (preferably within one-hour travelling), *diverse communities* (age, gender, occupation, income etc.), *different activities* (agricultural, livestock, etc.) and *willingness to participate to research*.

It is important to have two comparable regions, based on location, water use from the sand dam and demographic characteristics. The **Kwa Ndumbu dam** (Figure 8) in Mulutu was suggested by SASOL to include as the 'new dam'. The dam is surrounded by an active community with close relationships with SASOL, which eases the process of data collection. It is also the only new dam in the area easily accessible from Kitui town. This is a single dam with many households surrounding it, however approximately 30 using this exact dam. This dam was built in 2017 and finished in 2018 and has not yet fully matured. The construction was done with the financial support of the local church and technical support from SASOL. Within six months the construction was completed and afterwards, the roads towards the sand dam were optimized by the Kitui County Department. After construction, a well was placed by SASOL to ease the job of fetching water even more.

Sand-storage dam in Mulutu: Kwa Ndumbu

Built in: 2018

Built by: The community, under supervision of SASOL

Water use purposes: Agriculture, domestic, livestock and activities like brickmaking

People relying on a sand dam: 30 households on average

Design characteristics: Length: 29 m Width: 0.8 Height: 1.60 m

Other information: Design by SASOL, Funded by the local church, Very active sand dam committee, Hand pump near the sand dam; for domestic purposes

Figure 8 Sand dam characteristics Mulutu.

For the old sand dams, the Kiindu catchment was suggested as this area contains many old sand dams. An explorative field visit was done to the Kiindu area where multiple sand dams are located and in use. Here it showed that the upstream dams were not used as much as those downstream. This area contains in total 43 sand dams where 22 dams were built before 1995 and thus suitable as the 'old sand dam area'. To select an area within these 22 sand dams, several field trips were done to explore the area. Travelling for 1 hour in total led us to the location of a sand dam number. From that location, walks were done going upstream towards dam to explore the 22 sand dams. Based on accessibility, functioning of the dam and out of interviews finally the area around the **Uvati dam** seemed to be a suitable area (Figure 9). This dam was built even before SASOL built their dams, around 1959. The area contains other dams from SASOL that are sometimes being used (if it contains water during the dry season) when the Uvati dam is getting 'crowded'. The area around the Uvati dam contains around 160 households, with approximately 5 people per household, however, approximately 30 households make use of this exact dam. The community practices agriculture, both rainfed as irrigated, people keep livestock and the community is diverse and willing to participate in the research. Therefore this area was chosen for the ‘old sand dam’ area. This dam was built in 1959, during the colonial times. The main goal then was to decrease the rate of erosion, contain valuable soil and supply local communities with domestic water, according to one of the community elders. Within the ’90s a well with a hand pump was also created near this sand dam by SASOL, however, this structure got stolen several years ago and thus not in use anymore. The dam itself is still in good condition as maintenance and repair activities are hardly done by locals.

Sand-storage dam in Kiindu: Uvati

Built in: 1959

Built by: Government during colonial times in cooperation with community

Water use purposes: Agriculture, domestic, livestock and activities like brickmaking

People relying on a sand dam: 30 households on average

Design characteristics: Length: 17.5 m Width: 0.6 m Height:1.50 m

Other information: Build during colonial times, Within a cascade of sand storage dams, The hand pump was stolen No sand dam committee active

Figure 9 Sand dam characteristics Kiindu.

Both sand dams, *Uvati* and *Kwa Ndumbu*, are being used for agricultural and domestic purposes. A comparable number of households are making use of it and both regions were willing to participate in the research. Therefore both regions seemed comparable, also according to the local knowledge SASOL about both regions.

3. Methodology

This chapter starts with an introduction of the method used: Q-methodology. After a motivation of the method, we go through the 5 steps of Q-methodology. Each step is explained including its additional methods used within. This chapter ends with an explanation of the trial run done and the limitations of Q.

An introduction to Q-methodology

Q-methodology is a unique research method that investigates associations, feelings, opinions and ideas that an individual has about a topic. Statements are collected from the participant's opinion and organised by the participant him- or herself. This provides greater insight into what an individual feels about a topic (Herrington, 2011). The method has its origins in factor analysis, with the difference being the inversion of rows and columns. With this inversion, the focus is on the inter-correlations of *people,* rather than their traits and similarities of their views. The rank-ordered statements define what is relevant for him or her. The measuring unit in Q-methodology is the *significance of each statement* for each individual which becomes clear through the position of statements in the Q-sort. The significance indicates engagement or disengagement. By giving the self-significance of measuring units, validity happens internally rather than externally as there is no external criterion for a person own point of view (Pereira et al., 2016). In Q-method diversity of views is the focus rather than a selection of subjects. Normally it requires 40 to 60 participants and can vary from a using a few statements to 50 statements. The Q-sorts from all participants are correlated and factor analysed to explore groups of people who have similarly ordered the statements. The statements itself have little importance as the relationship amongst statements is more important, which is shown by the way participants sort them (McKeown, 2013). The results include factors which represent viewpoints. The higher the participants loading on a factor, the greater is that personal association with the viewpoint represented by that factor (McKeown, 2013). Interpretation of factors occurs by consistently producing explanations for factor results. Then, descriptions are established for the factors that explain the characteristics to summarise the viewpoints represented by the factor (Addams, 2000).

The motivation for this method

Q-method is a methodology that aims to shed light on complex problems in which human subjectivity is involved. The term 'subjectivity' is understood as to how people communicate their point of view about a topic (McKeown, 2013). Q-method was used initially in psychology, then in political science, and after that in several other fields such as policy evaluation, understanding decision-making, or participatory processes. The responses of Q-method are measured using the same unit, which is called the significance and they indicate engagement or disengagement (Zabala, 2014). The method can deal statistically with small samples. It is predominantly self-exploratory, as patterns or views emerge from the statistical processes applied, which prevents the researcher from making too many a priori assumptions. It is a semi-qualitative method: data collected is analysed quantitatively, but the interpretation is extensively qualitative. Several research methods and designs measure subjectivity, but few measure subjectivity using rigorous statistical analysis. Q-methodology offers such design, but within the field of water management, Q- methodology is only slowly adopted. Implementing Q- methodology research into water management related activities diversifies the research toolbox and provides researchers with opportunities to explore perspectives related to diverse issues within this field. Within the context of this research, Q-method is a suitable method to address a complex definition like 'water access': it is a topic of which opinions are divided. This will become clear in the next chapter. Q-methodology can cover the 'disorderliness' of water access in this research. My Q-method aims at revealing patterns of association between different measured variables of water access.

The steps of Q-methodology

Q-method involves the following stages which are shown interlinked in Figure 10:

1. ***Concourse development.***
2. ***Identification of the Q set.***
3. ***The undertaking of the Q sort.***
4. ***Factor analysis.***
5. ***Interpretation of factors.***

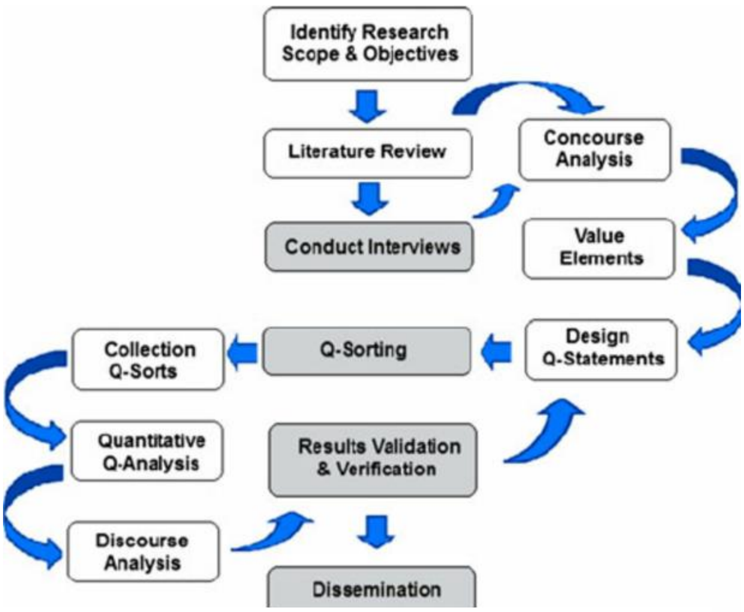

Figure 10 Steps within Q-methodology (Nijnik et al, 2014).

These steps are common for the use of Q-methodology (McKeown, 2013). The most involved stages of Q are the development of the concourse and the Q sort. According to these **5 steps**, the methods used within this research are explained.

1. Concourse development

The first step, according to McKeown (2013), is the 'concourse development' which includes an ordinary conversation about everyday life and includes all communication about a specific topic: in this case the access to water from a sand storage dam. This is done through a *literature review*, *field observations* and *semi-structured interviews*.

Literature review

First, a literature study is done to gather information about the general characteristics of the area, sand storage dams and the definition of water access. Also, the literature study is important to validate the research question and to create a foundation for the other methods. Based on the 'Literature review Research Skill Module' (Ertsen, 2019) a list of useful literature is created and a more in-depth review is done. A broad search for relevant literature is done using mostly Scopus and Google Scholar. Several keywords were used such as *water access, water rights, water allocation, sand storage dams, ephemeral rivers, socio-economic factors.* Also related to the methodology used several papers were reviewed under key words like *Q-methodology, Q-method and water management, Q-study and diversity.* As NaBWIG enhances adaptive pathways, this was another search for literature using keywords like *adaptive pathways, adaptive investment pathways, tipping points and adaptation pathways.* The sources and literature found were evaluated based on several questions like: What problem is the author addressing? What are key concepts? What are the results and conclusions of the article? How does the publication contribute to my understanding of the topic and what are key insights and arguments? Next to this, the credibility is checked based on H-index of the author and the journal where it is published. It is was preferred to use papers that are recently published. Next, trends and patterns were found by answering the following questions: what questions or concepts recur across the literature? What conflicts and contradictions can be found? And lastly, gaps were identified to see what is missing from the literature. To convert the findings into a literature review, a structure was chosen around the definition of water access. This is done according to scale, going from a national to local scale, highlighting the different findings from the literature. The review is written according to an introduction, body and conclusion. The gaps that appeared when interpreting results were lastly backed up with additional literature.

Field observations

Via selective field trips, observations on water use from sand-storage dams are the basis in the first stage of the fieldwork. Field observations are a method where you observe people in 'real' conditions and situations. These observations can be helpful to understand people's behaviour, habits, needs and social relations in their environment. It gives unique information as you do not have to rely on verbal interpretations as you see it for yourself. The NGO SASOL gave important contact persons who helped to get 'permission' to observe in the study areas. This to get familiar with the location and observe the actions that take place. While observing, notes were taken and recordings were made using a video camera and audio recorder (if people allowed it). The goal is to understand the study areas and situations. The field observations helped to get to know the target group and their context and how communities are 'functioning' in both locations and situations. As those observations can take quite a lot of time (including travel time) it was a balance between quality and importance of the information found. Different aspects were the main focus of those observations: *people's behaviour, demographic characteristics, environmental characteristics* and *water use* from the sand dams. Afterwards, the data was analysed to get meaningful information out of it, which helped with interpreting the rest of the study results. These observations are important to examine biased answers, interpret interviews and narrow down the Q-sort. Therefore this kind of data gathering helped to gain a clear image of the daily use of a sand-storage dam, the operation and the state of sand-storage dams.

Semi-structured interviews

Interviews were held to gather insights on water users in the area and to eventually select a 'sample' group for further analysis based on Q-methodology. According to the research skill module by Erik Mostert, multiple ways of structuring an interview are possible, but for this research semi-structured interviews were held (Mostert, 2019). This method is based on creating several interview topics/questions as a guideline for the interview but leaves the opportunity for other input from the participant. This kind of data collection is selected to allow the interviewees to have the freedom to give information in their own words. The interviews are recorded, later on, transcribed in a Q&A format, and structured per interview. Important elements are highlighted and used as the 'concourse' of the Q-method. An overview of topics related to the key informant is listed in Table 1.

Table 1 Overview of key informants and topics per interview.

Key informant	Main topics of the interview
SASOL	- Stakeholders involved in building/use of sand-storage dams - Current use of sand-storage dams - Appreciation of sand-storage dams - Work of SASOL in the area - Contacts within the research area - Prospects
The county department of Kitui	- Appreciation of sand-storage dam - Current challenges in the area - Role of municipality related to sand-storage dams - Contacts within the research area
SEKU contacts	- Previous/recent work about sand-storage dams in Kitui - Discussion of research objective + narrowing down Q-sort
Participants near the sand dam in Kiindu and Mulutu	Characteristics of water user; - Occupation, age - Role in community - Use of the sand-storage dam - Opinion about the accessibility - Current challenges/developments in the area
Community representative	- Development of sand-storage dams over time - Appreciation of the sand-storage dams - Current challenges/developments in the area

*SSD = Sand-Storage Dam

2. Identification of Q-set

The Q set is the collection of various elements related to the research topic which the participants will sort (Watts, 2005). The identification of the Q-sort includes statements based on the valuable information gathered from the concourse: in this case, the literature review, semi-structured interviews and observations. These are selected purposefully according to categories related to the main objective and definition of water access which are addressed in chapter 4.

Q-sort cards

Statements that need to be arranged by participants are written individually on Q sort cards that are comparable to the size of playing cards. There is only one individual statement per Q sort card, written in the language familiar to the participants: on the front *English* and on the backside the local language of *Kamba* (Figure 11). The statements are numbered to ease the further data analysis, whereby only needed to be taken. This helped to organize the statements and transcribing them from pictures to raw data in excel. To speed up the conductance of Q-sorting the set of statements were created in triplicates.

Figure 11 Statement cards in English and Kamba.

3. Undertaking the Q-sort

Once the statements are generated, they are then known as the *Q-set*. The Q-sort cards for participants can then be sorted on a so-called *Q-diagram* (Figure 12). Starting at one end of the Q-diagram, the participants are asked to select the statements required to complete the most extreme columns first under the +4 column, if they strongly agree with the statement. The participants continue placing the statements on the diagram according to their agreement with the statement, working towards the other end of the diagram by filling all columns with statements until all 'agreed with' statements are depleted. The same principle applies to the statements that they most disagreed with, and these are placed under the -4 column and are placed on the diagram in the same way as the agreed statements, except that

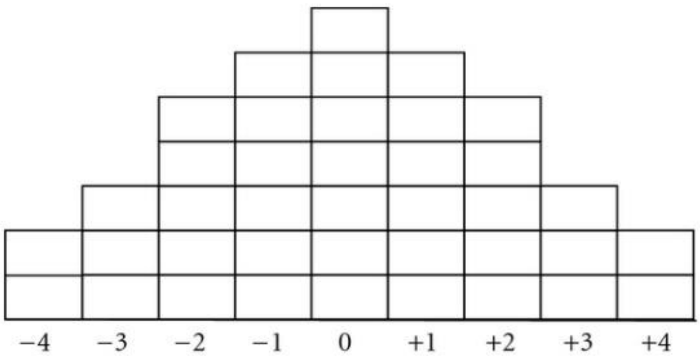

Figure 12 Q-diagram (Herrington, 2011).

they are placed in the opposite direction. The spaces in the middle of a Q-diagram are for *neutral statements.* Once all statements have been placed on the Q-diagram, and the participant is happy with their sorting, this becomes known as the *Q-sort*: a participant's Q-sort now reflects their perspective on the topic (Herrington, 2011).

Person sampling

A person sample is a group of participants selected from the people involved in the concourse to sort the statements from the Q-set (McKeown, 2013). The group of participants should be a representation of the *population diversity,* rather than a representative sample of the inhabitants. The strategy is to obtain as much diversity as possible by selecting participants for example on gender and age. Even though as much diversity as possible should be included in the person sample, the sample does not need to be statistically representative of a specific category, such as gender or age. Different insights can be obtained from men and women or old and younger people. (Pereira, 2016). By creating a diverse group as possible you can uncover patterns. The sample of respondents does not need to be large, but, as stated before, it must be diverse and thus preferable the most diverse range of opinions, regardless of whether they are the minority ones (Zabala, 2014). Enough participants are required to compare one factor with another. Since factors are '*qualitative categories of thought'* additional participants should have virtually no impact on factor scores. Watts (2012), suggests that 40 to 60 participants are usually adequate, however, in some cases, even fewer participants can be enough. Within this research extensive person-sampling is done, where participants sort the Q sort cards under an identical condition of instruction (see instruction letter in Appendix 1). Based on the Q-method literature mentioned above, a number of 40 to 60 participants is aimed for to execute the Q-sort. These people are selected based on:

a) *Their water use: making use of the water from the sand storage dam.*
b) *Their willingness to participate.*
c) *Having a diverse group as possible.*

To get a diverse group as possible, as many different households were visited as possible. It was also tried to conduct the Q-sort with both men and female. Next to this, it was tried to get people from all ages groups and on different locations by physically visiting the homesteads in the area.

4. Factor analysis

The fourth step within this Q methodology is to compare the Q-sorts done by the participants through factor analysis. This is a statistical technique to simplify complicated data in an orderly way. When a group of people have a lot in common, a factor exists. A factor determines which sets of people cluster together. A common definition of factor is that it represents a group of participants that sorted the 'Q-sort puzzle' in a similar way (Herrington, 2011).

KADE software

To compare the statement spreads done, KADE software tool is used. (Figure 13). The tool contains seven simple steps and generates results in an output file including tables of relative rankings of statements per factor. Overall, the software produces hierarchical factor structure tables and visualizations, which help in identifying an appropriate number of factors to extract (Banasick, 2019).

Motivation for this software tool

KADE is an application for the analysis of Q-methodology which has a graphic user interface which makes it easy to use. The software provides several features, as it includes interactive visualizations which make it easier to interpret the data gathered in the field. The output file from KADE provides tables of relative rankings of statements between factors. Besides these advantages, the software tool can export the visualizations as PNG files. Furthermore, the software tool makes it possible to change confidence level settings, depending on the nature of the data. Also, the reproducibility of the research is an advantage as it is fairly easy to quickly see which steps and settings were used within the software (Banasick, 2019).

Figure 13 KADE software interface.

The software package of PQmethod is commonly used within research as well, however, this software tool lacks the visualization which KADE gives.

The seven steps of KADE

To go from raw data to factors, ready for interpretation, you need to go through seven steps of KADE, which are briefly explained here (Banasick, 2019):

1. *Input*: raw data is given as a CSV file, including the Q-sorts on the y-axes, the statements on the x-axes and the value of the statement as data filled in, varying from -4 to +4.
2. *Data*: here data is checked to see if all data is correctly imported and settings are made whether the Q-sort is forced or unforced, according to the layout of the diagram. In this case, the diagram as forced, as people can only place one statement card on one place in the diagram.
3. *Correlations*: the correlations are calculated by using the *Pearson correlation coefficient*. Pearson's correlation coefficient is a statistical test that measures the relationship between two variables or in this case: persons. It gives information about the magnitude of the correlation, as well as the direction of the relationship.
4. *Factors*: here the number of factors are chosen to be extracted (up to 8 in total). You can conduct a centroid factor analysis or principal components analysis.
    a. <u>Principal Components Analysis (PCA)</u>: when using PCA, the goal is to explain the maximum variance for the least factors. As a result, the first factor extracts the most variance from the dataset and the second factor extracts the most variance from the remaining variability among the dataset. For this research, this PCA is chosen, as it is most commonly used.
    b. Centroid Factor Analysis (CFA): when using CFA you extract the largest sum of absolute loadings for each factor in turn.
5. *Rotation*: here the factors are positioned according to statistical criteria. Within rotation, there are two options again, namely:
    a. <u>Varimax</u>: this option is based on purely statistical criteria. Varimax distributes the variance across the factors so that each Q-sort has the highest degree of association with only one factor. This way most of the Q-sorts will be linked to a factor thereby analysing the group as a whole holistically. Therefore this rotation option is chosen.
    b. Judgemental: this option makes use of rotation, using a two-dimensional plot, which enables people to change the perspective on how you look at factors. Though, this creates a more subjective view on data when and can thus lose its 'objective nature' (Watts & Stenner, 2012).
6. *Loadings*: the key aspects that help the researcher understand the process of analysis in KADE are factors, factor loadings, z-scores and factor scores. *Factor loading* is given by correlation of each Q-sort with each formed factor and can vary from -1 to 1. The flagging process shows the most representative Q-sorts for each factor. The 'Auto-flag' option of KADE provides the possibility to automatically flag Q-sorts. There are two standard criteria for automatic flagging namely Q-sorts which factor loading is higher than the threshold for p-value <0.05 and Q-sorts which square loading is higher than the sum of square loadings of the same Q-sort in all other factors. This auto-flagging option is chosen for this research.

7. *Output*: Lastly, within 'output' an overview of the factor characteristics is given and the visualizations are shown complying with the number of factors chosen.

To summarize this in one figure, Zabala has created a visualization (Figure 14) of all steps mentioned above (Zabala, 2016)

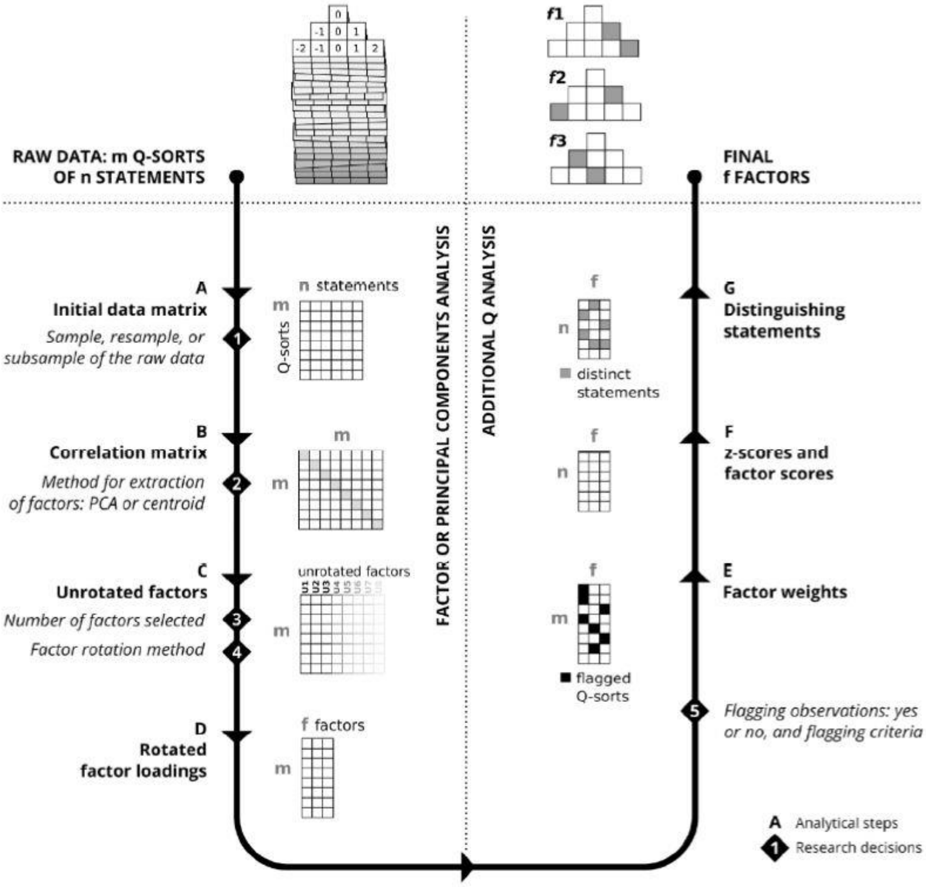

Figure 14 The analytical process of Q-method (Zabala, 2016).

Criteria

One of the researcher's decision to make is to decide how many factors should be extracted for interpretation. This is based on several criteria, which is briefly discussed in this paragraph.

- At first, the *eigenvalue* is taken into account. If the eigenvalue is <1.0 the factor becomes non-interpretable and the participants are perhaps grouped by chance. The eigenvalue is calculated as the sum of the squares of the factor loadings (Watts & Stenner, 2012).
- The explained *variance* is another criterion taken into account. This is the variance of the respective unrotated factors and calculated using the equation of variance which is: 100 * Eigenvalue/n (n = number of participants).
- Up next is the *composite reliability*. This is the reliability of a factor which means the number of distinguishing statements in a factor and the number of participants loading to one factor. According to Huang et al. (2019), you need to have at least four significantly loading participants after rotation. The composite reliability is calculated as followed: 0.8p / (1 + (p – 1) * 0.8), whereby p is the number of flagged Q-sorts for the respective factor and the value of 0.8 = value used as an average reliability coefficient (the expected correlation between two responses given by the same person (Watts & Stenner, 2012)). This reliability factor is therefore always same or greater than reliabilities of the participants composing it – the more participants define a factor the higher the reliability. According to Ghazali (2018) a reliability composite of or higher than 0.94 seen as reasonable, if lower it can be seen as unreliable. A composite reliability of 0.94 is sufficiently high to obtain a clear reading of the factor and thus used as a criterion.
- Another criterion is to seek a factor solution which consists of at least 50% of the participants loading on one factor. This is called the *representativeness criterion*. When many people are excluded from a factor, another factor analysis was chosen with higher representativeness.
- And lastly, there is the criterion of *interpretability*. The number of factors chosen should represent the variety and the subjectivity of the group while still providing enough information to interpret the results (Watts & Stenner, 2012).

These criteria all played a role in defining the number of factors chosen to further analyse the data. The outcomes eventually lead to a preferred iteration to elaborate on. Which factors were chosen and why is explained in chapter 6.

5. Interpretation of results

After passing the criteria mentioned before, the factors are ready to be analysed and interpreted. Based on these results, interesting perspectives are derived, supporting the research question. When interpreting the results, keywords are given to each factor. By pulling together identified statements a visualization image is produced that incorporates the typical or ideal Q-sort matching that factor. The process of describing the factors is fundamentally interpretive and seen as the most difficult part of this method (Banasick, 2019). Eventually infographics are created including keywords, description, an example from somebody loading to this factor, statistics and to which elements of water access the factor relates.

Evaluative interviews

To help interpret the data coming out of the analysis, evaluative interviews were done. It is important to conduct these evaluative interviews so that the Q-sorter can elaborate on his or her point of view. The Q sort provides focus to the interview by indicating which of various topics in the Q set are most worth talking about. In this case, most extreme statements scoring a +4 and -4 were discussed. Same accounts for statements of +3 and -3, which also underpin the Q-sorter's perspective. Besides discussing the statements of interest, as previously mentioned, personal information such as age, occupation and other variables were gathered. This kind of information helps to interpret the factors which come out of the factor analysis. Per participant, notes were taken or the conversation was recorded and later on transformed into '*personal pages*', of which an example is shown in appendix 2. Lastly, the conversation ends with an open question to get the 'story' from the various people, to eventually create the narrative you need for the factor descriptions.

Q-sort trial

Why a Q-sort trial can be of value

When doing Q-methodology for the first time, it can be useful to perform a Q-trial before applying the method in the field. This allows you to get familiar with the method and practical aspects such to become more confident before fully applying it in the field. Therefore this was done in an early stage of the fieldwork trip.

Method

At first, a set of statements is created based on the concourse development from the conducted semi-structured interviews and literature study. The Q-statements consist solely of things which people have said, from literature or observations (Watts & Stenner, 2012). The Q-sorting is tried to be wholly subjective in the sense that it represents 'my point of view', with the 'me' at issue. An overview of the statement database can be found in Appendix 3. Based on this database, three different Q-sets were generated to cover all the 51 statements. If you would give a Q-sort of 51 statements to one person, conducting a Q-sort would take too long and people can get distracted. Therefore, the 51 statements were split up, resulting in three slightly different Q-sorts. This approach is chosen, since then each Q-set would contain 34 statements, which is doable timewise for participants to conduct it. The statements are translated from English to the local language of Kamba, printed and pasted on cardboard cards and brought to the field. The Q-trial sets have been conducted in both regions of Mulutu and Kiindu with three different participants varying in age, gender and location. During a trial, it can be seen that conducting a Q sort by more than one person is fair, as it creates the possibility of discussion and consultation. An example of this process is shown in Figure 15.


Figure 15 Q-trial participant.

Evaluation of Q trial set

During the Q trial, discussions arise, which is done speaking the Kamba language. A translator showed to be of extreme value in cases like this, to translate the opinions of the locals to English. Several aspects to evaluate the Q trial are discussed. How understandable is the Q-set? Are statements unclear and need extra information? Statements might also be inapplicable in this region and therefore not necessary to use in the final Q set. The translation from English to Kamba can be another hurdle: several words in Kamba can have multiple meanings and can, therefore, be confusing. Based on the evaluation, several tips and tricks arise, such as having the statements in both English and Kamba on one card, so the participant can choose which is easiest to read. This can be different per age group. The trial evaluation also suggested that a good approach in conducting the Q sort, is to start with the most extreme values, thus +4 and -4 and work their way in towards 0 by putting down the statements per box. Even though when a value line is full, it is seen to be useful to put down the statement card and rearrange later. Lastly, it is shown that a Q set of 34 statements is a fair number: it does not take too long and still triggers the people to conduct the Q sort according to their opinion, without being distracted.

From Q trial to final Q set
The above-mentioned trial and related discussion points, eventually led to a compressed final Q set. Here only the statements are taken into account that are of interest in the region, clear and understandable for the participants in both language and message, and cover the elements of water access.

Limitations of method

As all research methodologies, Q-methodology also has its limitations. One of the limitations mentioned by McKeown is that the Q-sorting process can be time-consuming. This is due to preparations and instructions to explain the participants the method when people are not familiar with it. However, this is overcome by generating a research objective which already clearly specifies the elements which need to be taken into account. In this case, the definition of 'water access'. When holding on to a clear concept, the preparations become less time-consuming. In the field, the job of explaining how a Q sort works was simplified by having a clear letter in both English and Kamba to brief the people about this method.

The sorting itself can be another time-consuming aspect. Participants can take up multiple hours to sort a large Q set, which impacts on the number of participant's. People might not want to complete a Q-set when it is too long. This is overcome by reducing the number of statements in a Q-set to a number which stimulates the participant's involvement. This is tested during a Q trial, and reduced from 51 statements to a Q-set of 34 statements.

Another limitation is that some people with limited education need to have additional information to proceed with their Q-sorting. This is overcome by giving an example done by the researcher herself or by another Q-sort participant who does understand the process of Q-sorting. Another way to overcome this limitation is to show a previously done Q-sort to give an overview of what a final Q-sort might look like. Lastly, it is suggested to start with the most agreed and most disagreed sides, work their way in towards the neutral boxes and later on create the possibility to rearrange. Related to the previously mentioned limitation, is illiteracy. This might interfere with the validity as they lack comprehension which might lead to misinterpretation. This is overcome by conducting the Q-sort with people who are literate in the first place, or who have a relative assisting them in translation. However, the latter sometimes resulted in a time-consuming process.

Participants can also object to the 'forced choice' between statements, in having to categorise every statement. In the Q method, even though individuals may hold ambiguous opinions on certain topics, they must categorise every statement. To ease the process of categorizing, a Q set is created which contains both statements most probably being agreed with and statements most probably being disagreed with. By creating this balance, it becomes easier for the participants to categorise each statement.

Q-method has also been criticised because of its small sample group, as output cannot be generalised to the rest of the population (McKeown, 2013). However, when having a group of people who is diverse in opinion and perspective, the results of Q-method gives you insightful information. It indicates different perspectives, which do not apply directly to every other region, however indicating possible viewpoints. Watts and Stenner state that a Q set needs to contain a representative condensation of information gathered around the research topic to do its jobs effectively (Watts & Stenner, 2012). However, when lacking the ability to create this representative condensation of information, you only get a semi-representative data set which does not contain all important know-how. Therefore to overcome this limitation, a lot of time was spend on developing the concourse to generate the final Q-set. It was made sure to cover all data to create a representative Q-set. This is done according to multiple methods such as a literature study, semi-structured interviews and personal observations.

Lastly, in the evaluative-interviews, individuals only have their own experiences and views to draw on, thereby limiting the possibilities that can be discussed. Therefore when multiple people join a conversation to discuss and elaborate on the question/topic discussed, this was seen as valuable to overcome this limitation. Next to this, a semi-structured interview goes along some pre-written topics of interest and follows the story of the person speaking. Thereby creating the opportunity for a person to tell everything they might know which is of interest.

4. Q-set development

Without access to water, less economic development is viable. Furthermore, access to health, education and autonomy of women all are influenced by water access. Overall, improved water access can be seen as a tool for poverty mitigation as access to water is seen as a priority for development in emerging countries (Merrey, 2005). Different elements of water access come into play, but which ones and why? Within this section, an overview of **the scope of 'water access'** is given, which serves as a base for the rest of this research. It is based on a (1) literature study and (2) information gathered during the field visit. The literature review identifies several themes and debates and highlights the gap within the scope of 'water access'. To complement this literature knowledge, findings from the interviews and personal observations are formulated afterwards to eventually create an image of this research' scope of *access to water.* Afterwards, these findings were used to eventually create the final Q-set used within this research.

4.1 Literature

The literature found on access to water is broad and covers many themes on different scales. Therefore it is chosen to elaborate on the literature findings from a *general & global scale* to a *specific & local scale*, thereby addressing the different themes that come into play in the water access domain. Furthermore, this research was also based on a comparison between *domestic* and *agricultural water access*.

Water access on a global scale

The water access debate on a global scale mostly focuses on *drinking water and sanitation*. In 1995 the WHO defined water access as: 'The receipt of 25-30 litres of safe water per person per day which is also generally accepted and measurable in terms of water quantity per person per day.' In 2000 the WHO changed their definition to: 'access to an improved water source as having an improved water source within 1 km of the dwelling' (Water, 2004). In this case, an improved water source is defined as a type of water source that, by nature of its construction or through active intervention, is likely to be protected from outside contamination. The definition of 'water access' is now also part of the 2030 agenda of the Sustainable Development Goals (SDG). Specifically SDG number six, with its several sub-goals closely relates to the definition of access. Overall the SDG6 aims at achieving equitable access to safe and affordable *drinking water for all*. Goal number six is about achieving access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of woman and girls and those in vulnerable situations. SDG 6.4, also addressed in the NaBWIG project, focusses on the substantial increase in water-use efficiency across all sectors and ensuring sustainable withdrawals and supply of freshwater to address water scarcity and reduce the number of people suffering from water scarcity. The next goal is about implementing integrated water resources management at all levels, including through transboundary cooperation. The sixth goal focuses on protecting and restoring water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. This aims to be done by expanding international cooperation and capacity-building support to developing countries in water-related activities and programmes including water harvesting, water efficiency, recycling and reuse technologies. This goal also addresses the support and strengthening of the participation of local communities in improving water and management of water resources they use.

In the climate change debate, Gasson states it is important to take '*reliability and equitability*' into account. People need reliable and not intermittent access to water (Gasson, 2017). Linkages between access to water and climate impacts on water supplies are less known and understood by decision, policymakers and planners, especially in developing countries, since they normally focus their attention on development strategies like growth, employment and poverty mitigation. In the context of climate change, Watts stated that water access must reach a higher level of priority on the international development agenda. This because the difference is increasing between people in developed and developing countries who have access to safe water (Watts, 2003).

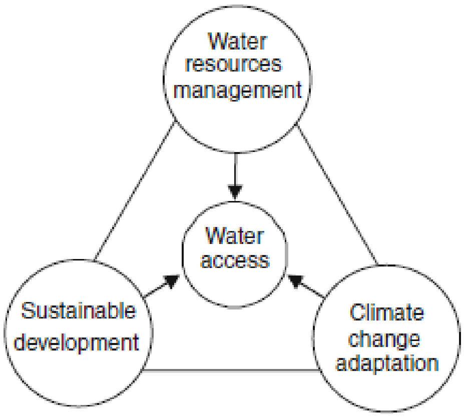

Figure 16 Water access according to Mukheibir, 2010.

When zooming in from global scale, Mukheibir stresses the integration of climate change adaptation with sustainable development and water resources management (Figure 16) (Mukheibir, 2010). According to him, the issue of access to water can be located in the *sustainable development discourse*. A definition used for this requires that social, environmental and economic considerations need to be taken into account. For a balancing system between the consumption of resources, the conservation of natural resources and the equitable access to resources, good social governance is important to achieve sustainable development.

According to Watts, a way forward is to build on the adaptive water management paradigm, by including access and affordability of water as a driver, thereby developing a *holistic watermanagement discourse*. This approach, to increase the adaptive capacity of society, can address equitable water access under future projected climate impacts. The issue of water access has the potential to cover adaptation in uncertain times of climate change with its impact on the water cycle. Also according to Jeffrey and Geary, dealing with water access requires a shift in thinking. 'Water access' should move from supply reliability and demand reduction to more complex matter, including variable water quality and quality. This shift requires social, cultural and economic adaptation. The level to which a society can adjust to uncertain or undefined change is called '*adaptive capacity* (Jeffrey and Gearey 2006).

Water access on a national scale

The Water Poverty Index (WPI), which contains five components (resources, access, use, capacity, and environment), is often used as a tool for monitoring and comparing water sectors on a national scale. Of the five components, access to water has been the most representative water-related indicator and plays a key part in the WPI, according to Gasson (2017). At the country level, governments normally modify the broader definition of water access to apply to their population. Three elements—*distance*, *time*, and *water quantity*—are variously used to address the country-specific definition of water access (Gasson, 2017).

Kenya's water policy, at the time of independence, put a lot of emphasis on the participation of stakeholders like the department of water and NGOs. The focus of water management at that time was on the *supply* of water mainly for domestic use. The 1974 Water Act and chapter 372 of the *Laws of Kenya*, formulated the government's institutional effort for the management of the water sector. In the same year, the National Water Master Plan was launched to increase household's water access. To achieve this objective, water supply systems, boreholes, catchment dams and conveyance infrastructure were constructed (Ogendi, 2009). Due to increased human settlements and agriculture, which impacts on forests and wetlands, the surface and groundwater quality and quantities decreased rapidly. So, around 1980, the demand for water outweighed the supply in both rural and urbanized areas. Therefore, involving other stakeholders in the provision of water services, to improve water access, was done which was known as 'handing over'. A revised water policy came into effect in 1999: the National Policy on Water Resources Management and Development. This policy, among other things, emphasized increased participation of local stakeholders again and the private sector.

The 2002 Act, stresses the active participation role of local communities, this mostly related to catchment management by creating so-called Catchment Advisory Committees (CAC) to control, develop, protect and conserve water resources within the catchment areas. This act enables active participants to go the extra mile for success, by including them in the decision-making process. This act also created the Water Resources Management Association (WRMA), whose main responsibility is to link stakeholders to create better regulation and management of water resources. Previously a 'top-down approach' was entailed, which ignored input from local people, however, this act stresses the 'bottom-up' approach. A revised Master Plan, which is called the Strategic Plan 2005 – 2009, seemed necessary to address upcoming issues within the water resource development and in October 2016, a new Water Act 2016 was launched. The Act states that it is needed "to provide for the regulation, management and development of water resources, water supply and sewerage services, and related purposes". The Act recognizes that the responsibility for the provision of water-related functions is a shared obligation between the national government and decentralized county governments which gives priority to the use of water for home consumption over-irrigation and other purposes (Kenya Water Act, 2016).

Domestic vs agricultural water access

The definition of water access is broadly defined from a *domestic/sanitation water use perspective*. However, the definition of water access can also be observed from an *agricultural perspective*. When doing so, water access also closely relates to the definition of 'water rights' and 'water allocation'. Rights to water and food highlight the importance of access. Sufficient water for domestic and agricultural use describes a situation where people are dependent on growing (a portion of) their food for consumption or grow crops for sale, which provide an income to buy food. Small-scale water users who mobilize capital and skills to grow their crops should be encouraged, according to Schreiner & van Koppen, as they are lifting themselves out of poverty. Overall, they state that a lot of attention is given to water for domestic purposes, but small-scale productive use is not supported like the domestic perspective of water access (Schreiner & van Koppen, 2020).

Access to reliable water improves productivity, enhances employment opportunities and stabilizes income and consumption. Access to resources, such as land and water, is fundamental for households that rely on crop and livestock production for their livelihoods (Ribot & Peluso, 2003). Research often assumes that agricultural production, which leads to food security, are favoured by tenure security of resources: 'bundle of property rights'. However this 'bundle of property rights' is also represented within a 'bundle of powers'. The *Theory of Access* developed by Ribot and Peluso state main factors of a bundle of rights and powers, which influence household food security such as yield-enhancing inputs. These inputs allow farmers to *diversify into-high-value products* and can, therefore, fulfil multiple needs of a household. Next to that, access to water can contribute to *nutritional diets, health and social equity*. A net impact of agricultural water access depends, according to Namara and others, individually or synergistically on the working of both negative and positive pathways of agricultural development (Namara et al., 2010).

Mutea's research showed that household food security also relates to access to farm technology, such as hand tools or pumps. Access to authority and valuable social relations are considerably correlated with access to technology (Mutea et al., 2020). Veldwisch and others describe the relation between local principles of sharing access to land and water and the recurrent need to invest in the construction and maintenance of irrigation systems. Anybody who wants to gain access to the local water resource needs to negotiate with the community where through conflict a misbalance might arise about ownership on who made the investment into irrigational infrastructures and who had the right to use. A division might arise when water users are denied access to irrigation water if they do not pay water fees for example. However, in practice, this is not enforced most of the time (Veldwisch et al, 2013). Kemerink and others also build on this theory and stress that, especially in Kenya, addressing the colonial legacy and invest directly in infrastructure for marginalized water users targets the actual distribution of water to the multiple users. In their eyes, this can be more effective than focusing exclusively on institutional reforms and policy (Kemerink, 2016).

Access to water is a significant driving force behind the flow in investment and payment systems in farmlands. Water issues regarding this access have received less attention than for example land grabbing and food security. The water resource is vulnerable to the impacts of farmland investments (Fiamingo, 2017). Schreiner & van Koppen explored the agricultural system across Africa who use a water-permit system for small scale irrigation. They tried to understand the implications of permit systems for both the most vulnerable and the ones who are not. They identified options for pro-poor water legislation that also meet the water governance requirements of the state. They open up the debate on how these permit systems criminalize instead of protecting the water rights of small-scale farmers. Their study suggests a hybrid system of water rights, that recognizes the customary land and water tenure systems present in small scale farming in Africa, together with the use of permits. This way serving the interest of both the state and small-scale farmers (Schreiner & van Koppen, 2020).

Mabhaudhi and others focus more on agricultural productivity. They state that it has always been a prominent feature on the regional agenda due to food and nutrition insecurity. The nexus between water-energy-food shows gaps and opportunities for improving irrigated agriculture. However, increasing the area under irrigation will also place additional pressure on already scarce water resources. They pose the question '*Is increasing irrigated agriculture a solution to improving water access and food security?'*. There are prospects for increasing the area under irrigation and therefore improve agricultural productivity. Though, there might also be trade-offs and unintended consequences. It is important to take these trade-offs and synergies within and among farmers and community members into account (Mabhaudhi et al., 2018).

Cele & Wale also address these water- and land-use trade-offs and how these *enable* or *hinder* a productive use of irrigation water. Their findings indicate that the productive use of irrigation water is positively influenced by land- and water-use rights, with *committees* being a point of contact for 'beginning farmers' when they need access to land or water. They suggest that a higher authority is needed through which farmers can help each other improve their access to water through collective action. A holistic approach is needed to improve the farmer's productivity: this through a 'body' which can represent them in policy formulation and implementation (Cele & Wale, 2018).

These trade-offs are also discussed by Boelens and others, who say that access to water is a *relative matter*. Access to irrigation water was previously not used as an indicator of well-being. Nowadays communities who do have access to irrigational water is usually a reflection of land ownership. Some people with less than two hectares of land appear as 'rich', while people owning the same amount at other locations appear as 'poor'. They state that you should not express well-being based on the area of land in general terms, but to also take into account the quality of the land (e.g. cultivatable land, depending on geographical location). The 'rich' normally do have larger areas of cultivated land at better locations, but they are also characterized by having more animals which help them to realize higher production levels. These people are normally also characterized as having the capacity to work hard, being educated and perform communal tasks within their livelihoods, therefore having a responsibility here. Large households often have higher income levels because more people means more contribution. On the other hand, poorer people can have worse land conditions, fewer animals available and lower production levels. They are also considered to be less capable, e.g. less educated and more excluded from social relations. The differences in well-being are not so much a reflection of access to land or irrigation, but also to human capital, e.g. people's capacity to work hard. The importance of this capital is important to take into account together with location-specific characteristics. How these patterns of human capital evolve, depends on the characteristics of a community and how this will result in upward mobility depends again on patterns of investment, as stated by Boelens and others (Boelens et al, 2010).

Many policymakers and researchers in the area of natural resource management stress human- and social capital and responsibility to communities. Though, people tend to ignore *gender* and other forms of an intra-community power difference for the effectiveness and equity of water. A research done by Zwarteveen shows that within the agricultural sector, people often exclude women through formal or informal rules and practices. Women, for example, might have another way in obtaining irrigational water access, sometimes in informal ways which can be less secure. Greater involvement of women can also strengthen communities by improving women's compliance with rules and maintenance contribution (Zwarteveen & Meinzen-Dick, 2001).

In the case of sand dams, maintenance and sand dam related activities are the responsibility of the community after construction. These activities commonly include creating committees to determine access and maintenance arrangements. Sand dams sometimes come with a well or handpump to ease the job of fetching water even more. However, when transferring hand pump ownership and operational responsibility to a community of water users, research has shown that individual users are sometimes not able to manage hand pumps reliably. Theft, destruction, different water use priorities or socio-cultural differences can lead to conflict. Allan and others state it is important to make clear arrangements on use, maintenance and other activities using to prevent conflicts in using hand pumps for agricultural purpose (Allan et al., 2019).

Water access on a local scale

The role of water access and water use in communities needs special attention according to Maganga and others (Maganga et al., 2002). Human settlements such as villages have long been constructed based on access to water. The availability of surface and groundwater are conditions taken into consideration when villages and other human settlements are established. Current approaches incorporate environmental issues and equity in the user allocation sense, but it does not concern issues of water access at the community level (Sorenson, 2011). Obeng-Odoom brings a new name into the debate with his 'deep access'. One of the meaning concerns water *quality* and *reliability*. The *cost* of water is another dimension which is closely related to reliability because interruption in the supply of water normally increases the cost of accessing water. Another dimension under the umbrella term is how *equitably water is distributed* among citizens of a community. Therefore, Obeng-Odoom states that there is a strong nexus between income, quality and quantity of water and a correlation between place and people poverty, as poor people are often close to poor water facilities. Improved access should consider dimensions of reliability, sufficiency, affordability and equal water supply. The current definitions of 'water access' can be misrepresented this way as there may be an improvement in access to safe water but this says nothing about how reliable the resource is, how affordable (if applicable) and how equitably it is distributed.

Other themes also come into play, such as '*the right to water'*. The question of whether access to water is a human *right* or a human *need* arises in several articles. It involves a discussion on the meaning of 'rights' at a local scale and the context of limited resources and capacity at the local government level. It also requires a shift in focus from '*institutions of delivery'* to the '*recipients of services'* including issues of water access and equity. The 'right to water' issue may interfere with the task of providing access to water to the poor as well as the wealthy (Mukheibir, 2010). Obeng-Odoom states that moving beyond 'water access' also implies moving beyond thinking about water as an economic good. He states that we should consider it a right, a so-called 'water for life' paradigm. Therefore he states it must be regarded as a need, not a want: a universal right, not an economic good which, when priced excludes rather than includes (Obeng-Odoom, 2012).

Then, there is a tendency to ignore social elements, however important to be mentioned. Self-organisation of local communities is a common feature on a local scale, which is called *Harambee,* or the *Harambee spirit.* This stands for 'the spirit of pooling resources together for social and economic development*' (*Ogendi, 2009). Also, Bisung (2014) stresses the importance of these 'mutual support groups' however states that this is not sufficient for improving water access in communities. Claridge stresses the importance of social capital, which relies on features like trust, common rules, norms and connectedness in groups, which are seen as necessary resources for facilitating positive individual and collective actions. Social capital could enhance the diffusion and adaptation of water-related behavioural interventions and facilitate collective action related to watermanagement, indirectly influencing personal wellbeing and development. In the management of a water resource, collective action is shown to be important in contrary to privatization or state regulation, especially in rural settings (Claridge, 2004). There is a consensus among the authors mentioned that public institutions have been too slow in extending access to water and that they can be inefficient and corrupt (Watkins, 2006). This can create water scarcity and social stress, generally for the poor. Wutich suggests that water-related emotional distress can develop as a by-product of issues within water access and its distribution, because of an absence of clear procedures or water rights, rather than absolute scarcity of water (Wutich, 2008).

Another important aspect, already briefly highlighted in the agricultural water access domain, is *gender* and vulnerability of children, women, and the elderly, who are 'main victims' of poor water access. When the nearby water supply is not sufficient quality or quantity one or more members of a household or community must take time and energy to obtain it elsewhere. Most common water carriers are women. A review of non-scientific and scientific literature, poetry and painting indicates that fetching water has been a task for woman and children. Little research has quantified the burden of this work on women, who bear the responsibility to identify appropriate water containers, carry them to the water source, sometimes over a great distance and difficult terrain, obtain the water, and return home with heavy loads. They can spend a lot of time supplying water to their households depending on: household size, distance, seasons and other variables such as household income (Sorenson, 2011).

Two other elements of *health* and *economics*, are elaborated in research on woman's work in supplying water. Water-borne diseases are common in developing countries, and from a 'health' perspective focuses largely on the consequences of using contaminated water. The economic perspective focuses primarily on water fetchers and their lack of agency. *Opportunity costs* are about assuming that women will devote their time to income-generating activities and increase household incomes. Although, having time does not necessarily translate into having access to income-generating activities (Strohschein, 2016). Social networking and political participation of women concerning water are subjects less understood. Political representation is a component of women's participation within a community. Greater participation of women in planning and decision making may benefit within a community but can also change established roles and structures. Overall, research on multiple impacts of fetching water on woman's lives is incomplete. There is a lack of gender-related data which leads to an incomplete understanding of the gender inequality, however, according to Sorenson, there is a direct positive association between not having access to an improved water source and the percentage of water fetchers who were women. With an improved water source, there seems to be less uniformity and men and children participate more (Sorenson, 2011).

When zooming into Kitui, access to water eventually needs to be addressed regarding sand storage dams, however, what is known thus far? These dams operate at a larger scale than within-field systems, often on a watershed scale, and thereby other issues are necessary to address such as ownership, local institutions and land tenure (Ertsen & Hut, 2009). A majority of the water users in the region of Kitui perceive water sources as community property, while a considerable minority considers the NGO as the owner of the sand-storage dams. A participatory approach for building and maintaining the dam, which is applied in the case of Kitui, is not fully clear among community members as it has not resulted in clear ownership. Although communities are encouraged to organize themselves in their way and the community decides on the composition of a sand-storage dam committee, this process does not result in clear communal activities and procedures after dam construction (Ersten et al., 2005).

Measurable indicators regarding water access on a local scale

This research aims at evaluating what different elements people value regarding water access. Besides the different elements mentioned above, other things might come into play. The weight of a vessel to carry water, the condition of the terrain and the number of trips, for example, can provide greater insights towards water access. Several measurable indicators are needed. An overview of measurable indicators is shown below, based on the scientific papers discussed before.

- *Linear distance*: this entails access to an improved water source as having an improved water source within 1 km of the dwelling.
- *Time spent:* this element is sometimes seen as a better indicator of the burden of fetching water as in densely populated areas, improved water sources might be nearby but waiting in line can take an hour or more.
- *Opportunity cost*: this considers what people would do with their time if they did not spend it collecting water. For girls and young women, the opportunity cost can be attending school for example. Or people can spend their time on income-generating activities.
- *The number of trips*: the number of trips a day might vary per person/household, also during the dry season.
- *Condition of the terrain*: uneven, steep hillsides and gullies can affect the ease to fetch water.
- *Priorities in water use*: drinking and cooking are priorities in domestic water use where personal hygiene and sanitation are likely to be sacrificed when the supply is low. Also status within a household can affect allocation e.g. when men have priority for bathwater.
- *Caloric expenditure*: people can suffer from malnutrition. The energy consumed in fetching water, particularly during periods of scarcity, can worsen this malnutrition. Health risks can even extend to children when the water carriers are pregnant. Also, during droughts, multiple trips must be made each day to obtain sufficient water for their household, thereby increasing caloric expenditures at a time when health is likely already compromised.
- *Road casualties*: transportation infrastructure is poor in developing countries, especially in rural areas. Water fetching often involves walking on poorly designed and chaotic roadways (often the only place to walk), and pedestrians share the roadways with vehicles and cyclists with injuries and death as a result: over 90% of the world's roadway fatalities occur in low and middle-income countries, and a substantial portion are pedestrians and other vulnerable road users.
- *Health outcomes*: the spread of diseases from bacteria can be facilitated by human and animal traffic around water sources.

4.2 Semi-structured interviews

National-level aggregate indicators of access to water often do not capture significant intra-country and local variations, according to the literature study previously described. Therefore, next to the literature, the definition of water access is also explored during the fieldwork trip. An interview analysis is given to summarize different elements that came across. An overview of the interviews held can be found in Appendix 4.

Interview analysis

Water access towards the sand dam is hereafter explained per category according to the findings from the interview analysis. Based on the interviews with participants, the most important content is used to create the statements for the final Q-set (which is shown later this chapter).

At first, there is a *distance* from the households to the sand them where people fetch water. People assume to be fairly close to the sand dam within a radius of approximately 500 metres. Further away, people already tend to say they live further away. However, this distance is not experienced to be far still.

Figure 17 Fetching water from scoopholes using jerry cans.

The *time* to fetch water can be defined as the time leaving the homestead towards the sand dam, fetching water with the use of jerry cans of 20 litres and filling them with the use of a funnel created by a jerry can cut in half (Figure 17). Afterwards, the jerry cans are loaded on a donkey or oxen, or the person carries it on her or his back. These times vary from half an hour to multiple hours, according to the season for example. During the dry season queuing occurs and people have to wait in line to fetch water from a scoop hole. This queuing occurs because this takes less time compared to creating their scoop hole. Also, the depth of a scoop hole creates a delay when very deep as fetching water is a more challenging task then. During the dry season, it also takes longer for a scoop hole to fill up again after fetching.

Reliability seems to be an important aspect as well. A reliable source is, according to the interviews, having water available throughout the year. However, the water table drops during the dry season. In some places to a point that there is no water available. This flux in water table results in a less reliable water resource according to people living around it.

Figure 18 Donkey carrying empty jerry cans.

Closely related to the previously mentioned reliability of the source, is the amount of water available: *water quantity*. When water tables are high, more water is fetched according to the interviews. This also relates to having a hand pump available yes or no. In Mulutu, the ease of fetching water making use of a hand pump is an advantage over fetching water using scoop holes only in Kiindu. On average people fetch around 4 jerry cans a trip, when they have a donkey (Figure 18). The number of trips they make depends mostly on the size of the household and water use purpose.

Another important aspect mentioned during multiple interviews is the *quality of the water*. The beauty of sand storage dams is their filtering ability where through the water is fairly clean and ready to drink for domestic purposes most of the time. However, when a nearby water source is not sufficiently clean, a household member must take the time and energy to obtain it somewhere else or treat it using chlorine, or water guard. The quality is, according to several people, affected as well when people bring their animals to the water source. Through defecation and urination, the water quality gets affected negatively and changes odour and taste.

Figure 20 Gully formation.

The *terrain* in both areas is uneven and in some places steep and hilly. Therefore, travelling towards the sand dam has more challenges, especially during the wet season, when the soil gets very slippery. Also, gullies (Figure 19) make the travel towards the sand dam more difficult, especially with animals, as they might have difficulties in moving from and towards the sand storage dam. Because of this, some households decide to carry the water themselves.

Although water from the sand dam is a free water source, people living further away from the sand dam fetch water in other ways too. They buy water from a water kiosk for 3 shillings a jerry can. To get it transported from the market to their homes (if roads allow it) a tuk-tuk (small three-wheeled vehicle) drive costs an additional 14 shillings.

Figure 19 Rainwater harvesting.

Some homesteads back up their water supply using rainwater harvesting (Figure 20). With rain barrels attached to a drum from the roof they collect water during the rainy season and store this in large vessels of 1000 litres. These investments are closely related to the availability of capital to spend money on this. Another aspect related to *income* is that some people can buy a pump to pump water directly from the scoop holes to their plots. Lastly, some women generate some income through fetching water for other households.

Closely related to income are the *costs* of water. As stated before the water from the sand storage dam is for free, however fetching water from a kiosk a price needs to be paid. Also when people want to make use of the sand storage dam in the area of Mulutu, a fee needs to be paid to the **sand dam committee**, when they have not participated during construction.

Textbox 1 - Sand dam committees

Before the construction of the sand dam, these committees are formed to oversee the process and afterwards 'watch over' it. Sand dam committees are formed according to several characteristics such as sexes, education level and age. A sand dam committee typically has 13 members but this can vary per region. For the case of Mulutu, the sand dam committee is slightly bigger aiming 20 people, but this varies as well. They have a meeting once per month and discuss the development of the area. The people in those sand dam committees are being elected from different families. The chair of the sand dam committee in Mulutu is a lady, next to her you have the treasurer, secretary, vice chair lady and vice secretary.

Another example related to the *cost* of water is from the area of Kiindu. During the dry season, the community mobilizes itself to create scoop holes. When somebody wants to fetch water from it, but has not participated in creating the scoop hole, the person in charge can ask for a small fee.

Access to water creates the possibility for agriculture according to several interviews. Instead of rainfed crops, such as maize and beans, people can fetch water to irrigate crops like vegetables and fruits. Or, they can plant and harvest multiple times a year to supply themselves with food instead of buying these at the market. Some farmers irrigate to grow cash crops (such as maize, cowpeas, beans, pigeon peas, mangoes and pawpaw), which they sell at the local market. These *agricultural activities* seem to be extremely important resulted from improved access to water.

Time saved not fetching water is considered as *opportunity cost*. For the women and men, opportunity cost might be participating in income-generating activities such as brickmaking, having a small shop or robe braiding for example. But, it does not need to be related to income-generating activities, as people also spend their time doing household duties for example.

How to extract water from the sand dam and what can be expected from the water availability of it, is partly based on *education*. This education can be done through a sand dam committee which is the case in Mulutu, through a church, NGO or relatives and friends. Another way to look at education is the opportunity time since water fetching times are shorter. This allows children to go to school instead of fetching water thereby helping out their parents or siblings with the job.

A strong sense of *ownership* within a community living close to a sand dam makes people further away feel excluded and might be excluded from using a sand dam, according to interviews. Longer waiting queues or even having to come back later are results of their location and ownership feeling towards the sand dam.

Water quality-related, the water might be polluted when defecation and urination occurs. People treat their water, however, some do not. If the quality is not sufficient, people might get sick from the water. From an agricultural perspective, people can grow or buy more nutritious crops through improved access to the sand dam. A varied and healthy diet is then a result of it, improving the household's *health*.

Sand dams overall do not need a lot of *maintenance*, however, maintaining the river banks is a must, according to the interviews. At least 10 metres from the riverbank, no cultivation must take place as siltation might occur faster. Grasses like Napier grass or Bermuda grass enhance soil conservation and prevents siltation. People who are cultivating close to the river are encouraged to keep these kinds of measurements. When this is underperformed, the risk of siltation or the river bypassing the sand dam is increased, which may lead to malfunctioning of the dam in the long term. The activity of sand harvesting is seen to be important, both related to maintenance and the environment (Textbox 2).

Textbox 2 – Sand harvesting (Mwaura, 2013)

Sand harvesting is the removal of sand from the ephemeral river beds. The sand is used for all kinds of activities such as construction. In the past few decades, the demand for construction-grade sand is increasing in Kenya, Kitui. To address the pressure on the valuable resource explicit laws and regulations were developed by the county to facilitate enforcement and compliance at all levels within the social settings.

This sand harvesting has economic and social benefits as it creates an income when applied in construction works or for own housing.

However, environmental problems occur when the rate of extraction of sand, gravel and other materials exceeds the rate at which natural processed generate these materials. Morphologies of this sand harvesting have its impact as it can destroy the cycle of ecosystems. It also harms sand storage dams as sand normally captures and stores water. Removal of sand behind the sand storage dams can lower the performance of such a structure as less water can be stored, water tables drop and thus less water can be available for use.

Figure 21 Sand harvesting example (Kairu, Daily Nation, 2019)

Closely related to maintenance are the local circumstances regarding the *environment* such as weather patterns, vegetation and conservation that play a role in slowing down the water and storing it behind a sand dam, making more water available. According to the interviews held, this rainy season of 2019/2020 is extraordinary with plenty of rainfall. This is an exception compared to the extremely dry years in the past. Within 2020 the 'newer' sand dam, built-in 2018, already replenished a lot of water through the latest rainy season.

Lastly, the aspect of *social capital* has shown to be of importance to the local communities. The social aspects of fetching water like networking and social interaction, but also physical support are stressed to be of value. When the women fetch water it is mostly done in groups, in cooperation with each other, to ease the work done. However, men, mostly fetch water individually. For the youngsters, the sand dam is seen as a place to reconnect, spend their free time and do sports (during dry season).

4.3 Recap on water access

In Sub-Saharan Africa, a lot of people gained access over time. This improvement is seen as a 'success story', but also needs to be addressed carefully within local communal life. Besides improved water access on a global scale, it is also important to take into account development and differences on a local scale (Obeng-Odoom, 2012). This literature overview and interview analysis have shown that access is necessary, but not sufficient and therefore important to go beyond the broad view of access to water and dive into the local scale of access to water.

A statement mentioned earlier that 'access to water' has increased worldwide can grossly misrepresent people's experiences in accessing water at a local scale, as different elements appear from literature and interviews. Whether people have the skill to manage these categories is key to determining success. This way moving beyond access to water to consider dimensions of reliability, affordability and all this equitably. Based on this analysis the SDG overlook the important dimensions such as quality, cost, distribution and other elements that come into play on a local scale.

Figure 22 Elements of water access. Grey: direct elements of water access. Blue: indirect elements of water access.

When looking at *how* water access can be defined several resemblances can be seen between literature and interview analysis. There are main elements that seem to be most important such as distance, time, water quantity, water quality and also reliability of a water source. Water quantity uses differ per water use purpose. Only domestic purposes require fewer trips to fetch water compared to agricultural water. The latter then depends on crop choice, irrigational activities and size of the plots. An example from the interviews shows a water fetching activity of two times a day, fetching 80 L of water, for both irrigational and domestic purposes.

Besides these categories also other categories overlap in literature and interviews such as: social capital, opportunity cost, health aspects, ownership, education, costs, income and terrain. According to Obeng-Obeng, these categories are called 'deep access'. To combine and summarize the findings from literature and interviews, an overview is created within Figure 22.

4.4 Final Q-set

After a Q-trial, the conducted Q-sort was discussed, to explore any misunderstandings, unclear statements or missing elements etc. (Figure 23).

Interviews held and literature study led to a final Q-set. During fieldwork, the final Q-set was benchmarked and subsequently peer-challenged with other parties such as experts from SEKU. Thereby creating a Q-set which is robust and representative.

Based on the literature study and analysis of the interviews held in the field, the most important categories linked to water access were defined. The following Q-set is created based on these categories, which is used to conduct the Q-sort with in the field (Table 2).

Figure 23 Interview after conducting a trial Q-sort.

Table 2 Overview of statements with complementing elements of water access.

Overview of statements with its complementing elements of water access.

Nr.	*Statement*	*Element of water access*
1	I do not mind using a water source that is further away.	Distance
2	I find a water source being close to me very important.	
3	I can more easily cross the river via the sand dam during the wet season.	
4	I go through somebody else's land to get to the sand dam.	
5	Fetching water from the sand dam costs me less time compared to other sources.	Time
6	During the dry season, I have to wait in the queue regularly for a long time.	
7	During dry season, I have to dig deeper to fetch water from the scoop holes.	
8	I use more water since I make use of the sand dam.	Water quantity
9	I can carry more water since I have a donkey/oxen.	
10	My livestock has more water to drink since I use the sand dam.	
11	People close to the sand dam have more water available than people further away.	
12	The sand dam gives me enough water during long dry periods.	Reliability
13	The sand dam is a reliable water resource.	
14	I find clean water important.	Water quality
15	The donkey/oxen causes water pollution through urination and defecation.	
16	I treat the water before I drink it (boiling/waterguard).	
17	During the dry season, I find the water to be saline.	
18	My path to the sand dam is more difficult during the wet season.	Terrain
19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)	Opportunity cost
20	I only use the water from the sand dam for domestic needs (e.g. washing clothes, cooking, washing utensils).	
21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.	Health
22	I use the water from the sand dam for irrigating my crops.	Agricultural activity
23	My children can go to school fully since I use water from the sand dam.	Education
24	I have a higher income since I started making use of the water from the sand dam.	Income
25	I know who owns the sand dam.	Ownership
26	We, as a community have ownership over the dam.	
27	I find that everybody in the area can use water from the sand dam.	
28	I find having a sand dam committee within our community important.	
29	I feel responsible for maintaining the banks of the river to prevent siltation.	Maintenance
30	I find sand harvesting to be a problem affecting the sand dam.	Environment
31	I experience conflicts over water from the sand dam during the dry season.	Social relations/capital
32	I experience conflicts over water from the sand dam throughout the year.	
33	I find the sand dam to be a good place to chat with my friends.	
34	I am happy with the sand dam.	

Based on concourse development

The

Shape of the Q-sort table

As shown in Table 2, in total 34 statements were created resulting in the diagram shown in Figure 24. The diagram contains value boxes from +4 till -4.

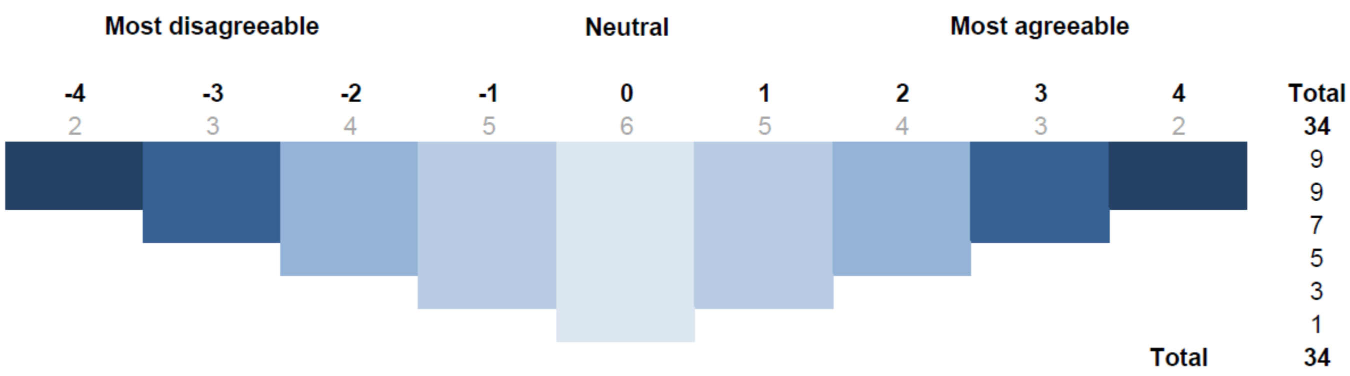

Figure 24 Diagram of final Q-set.

5. Conducting Q-sorts in the field

The Q-sorts were conducted by 50 individuals consisting of participants living in the region of Kiindu and the region of Mulutu. Several of the people were initially interviewed during the concourse development and were revisited to conduct the Q-sort. The interviewees expressed their interest in how their interview resulted in a Q-sort. This as well to create a relationship and become familiar among other community members which ease the further process of conducting Q-sorts. The people who participated are farmers, unemployed people, head of the households and people in other sectors such as security of shopkeepers. Further characteristics are shown in the textbox below.

Textbox 3. Characteristics of the sample group

In total *50 participants* have conducted the Q-sorts (example within the field of sorting a Q-puzzle is shown in Figure 25). From those 50 Q-sorts, 26 have been conducted in Mulutu and 24 have been conducted in Kiindu. From the 50 participants the following characteristics are known in general:

Water use: domestic, livestock, irrigation and other activities such as brickmaking

Occupation: farming (majority is rain-fed, 74% of people) and other jobs in town such as cashier, shops, hotels, security.

Household characteristics: an average of 4-5 people, mostly women fetch water and only men help when water is needed for irrigation

Frequency of water fetching: varying from once a day to three times a day using jerrycans of 20L, carried by a donkey or on people, backs.

Gender: 75% of the people are women, 25% are men

Figure 25 Participant conducting the Q-sort.

Age: 16-30 years: 40%, 31-45 years: 30%, 46-60 years: 22% and 60+ years: 8%

Before conducting the Q-sorts, the participants were first instructed on how the puzzle works. As Kamba is the most commonly spoken language, a translator joined in the field to ease communications. If participants felt that they agree with the statement they could place it at the right of the Q diagram. If they disagree, they could place it on the left side of the Q diagram. More details about the research and additional information are given in the instruction form (see Appendix 1). The statement cards were printed on cardboard cards and the diagram was drawn on a large paper which could easily be rolled out and used. The Q-sets were made in trifold, so if multiple people would want to perform the Q puzzle, this was possible. The average time of conducting a Q-sort was 30 minutes to an hour. Several people experienced the Q-sorting as a challenge, rearranged the statements multiple times and therefore took more time to finalize the puzzle. Several times it occurred that not an individual performed the Q-puzzle, but multiple people from one household. These outcomes are shown as 'mixed' within chapter 6. After completing the Q-sort, the participants were asked to check their Q-sort: are they content with their findings or do they want to switch any statements? The final Q-sorts contains a full Q diagram of 34 statements arranged from agreed to disagree statements. Each card was given a number which makes documentation easier, especially when the translation in Kamba was shown instead of the English translation. A picture was taken of a completed Q-sort as well as the GPS location of where the Q-sort took place: their homesteads. The pictures were later transcribed to Q-diagrams in excel, as shown in Figure 26, and later on, transformed to RAW data (see Appendix 5). Afterwards, the most agreed and disagreed statements were discussed to evaluate the further meaning to the participant. Furthermore, the participants were asked about their age, occupation, etc. and the evaluative interviews ended with an open question on if they would like to add anything. This to get the story behind a person.

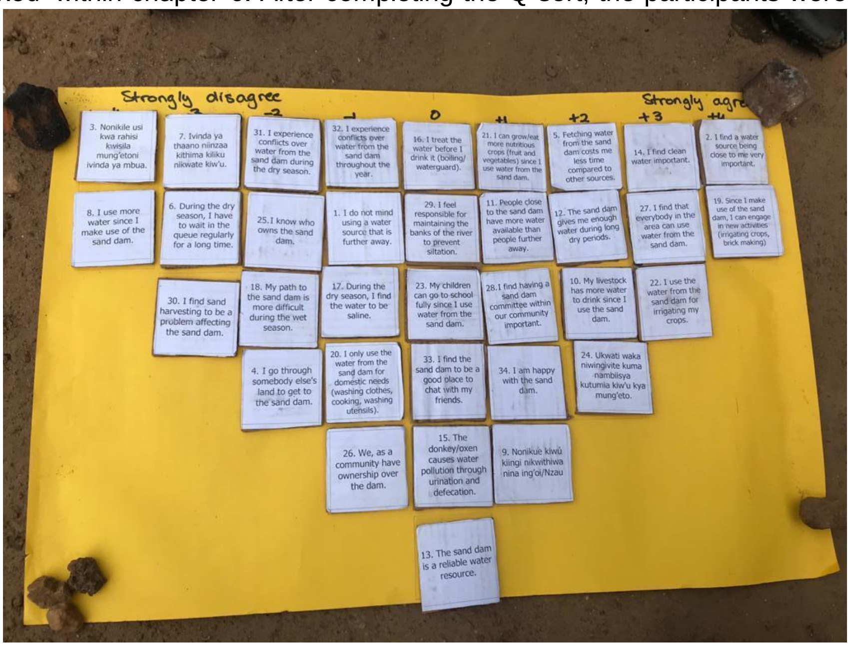

Figure 26 Completed Q-sort.

6. Data analysis results

6.1 Introduction

After conducting a total of 50 Q-sorts (Figures 27 & 28), the data is analysed using KADE software. All the Q-sorts can be found in the Appendix as RAW data (Appendix 5).

To examine the data, at first, the group is analysed as a whole, so the 50 Q-sorts together. However, to see the differences between the two groups, the data is also evaluated separately in the two different regions. This data analysis ends with a comparison between the two regions separately and the group studied as a whole to see what similarities and outliers appear.

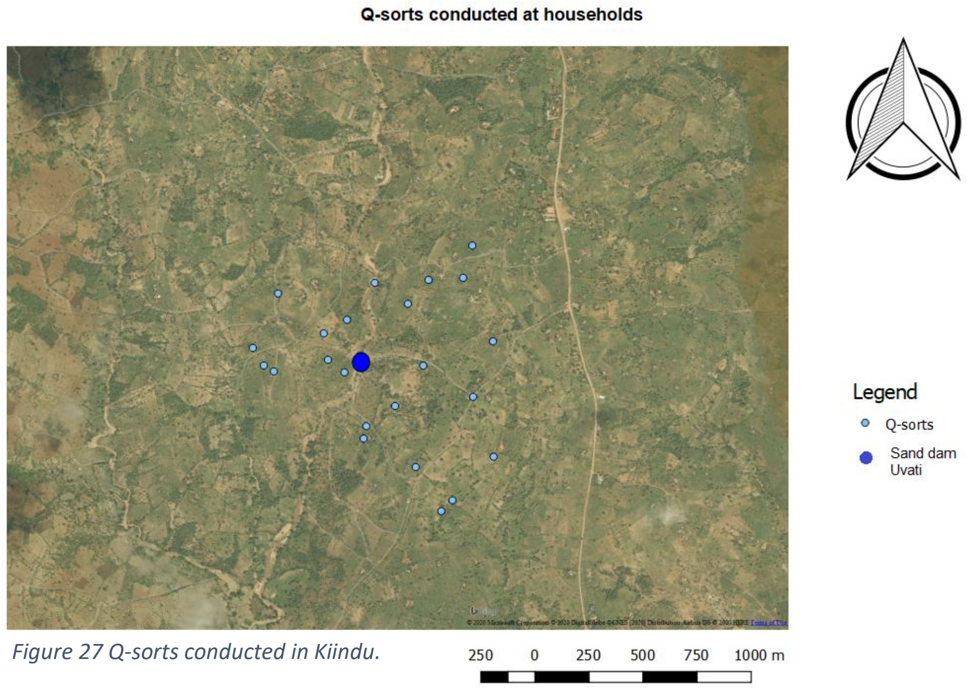

Figure 27 Q-sorts conducted in Kiindu.

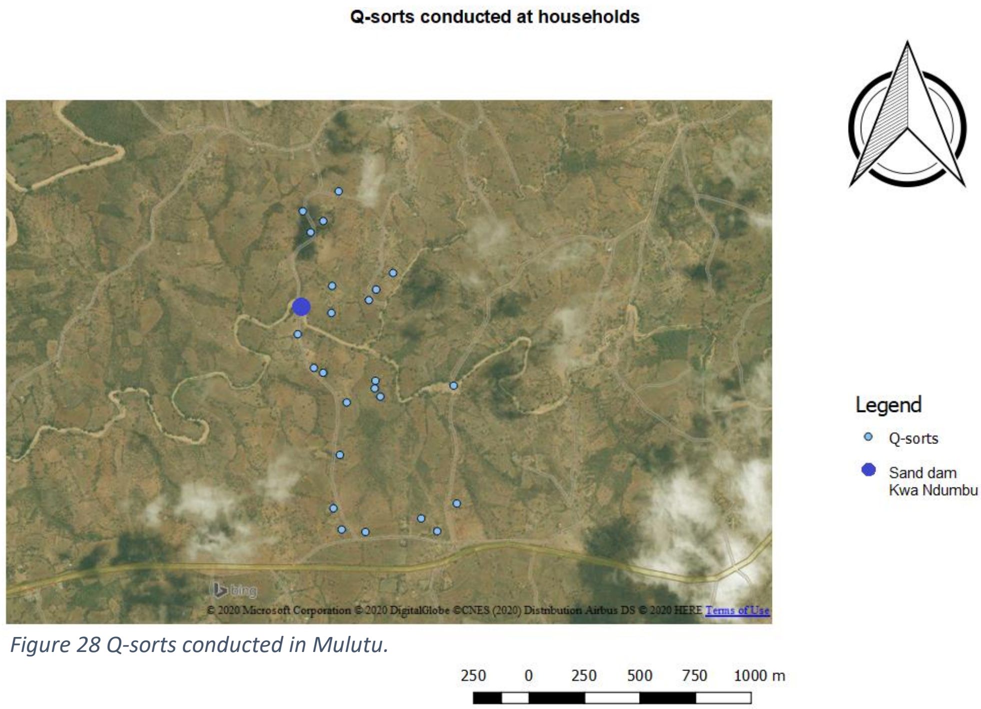

Figure 28 Q-sorts conducted in Mulutu.

Variables and interpretation

When examining the respective factor scores concerning the other factors, we can start to interpret them. It is the relative positions within the entire sort that describe a factor and not just the individual statements themselves. When interpreting the factor it is important to reduce a misinterpretation as a result of the researcher's bias as much as possible. This can affect the validity and reliability of the findings. Next to this, it is also tempting to give an overly detailed factor description however, it opens up the danger of imposing a specific view of the world on the factor. To help the interpretation of the factors, the following variables were used per iteration (2, 3 and 4-factor analysis):

Location: At first the location of the participant can play a role namely being located in Mulutu near the newly built dam or Kiindu within an area of matured sand dams in cascade formation.

Distance: Absolute distance towards the sand dams might also play a role. Based on interviews, a distinction is made between being 'relatively close to the dam', within 500 metres, or being 'relatively far way', beyond 500 metres.

Gender: As fetching water is most of the time a woman's job to do, according to the literature study and interviews, the variable of gender is important to take into account.

Age: According to the interviews done, the variable of age also plays a role, as the adolescents and elderly are most of the time excluded from doing the job of fetching water.

Size of household: 'More people, means more water needed' according to one of the interviewees. An average of 5 people seems to be the standard. Higher demand means, more trips to fetch water and more litres of water per day to fetch.

Another aspect such as marital status, which crops people grow and what kind of livestock people have is available from the 'personal pages' (upon request), which are structured as semi-structured interviews and serve as metadata for this research. Also, variables such as time spent living in the area and income-related information are all used to further interpret the data.

6.2 Factor analysis according to the criteria

To compare the statistical information regarding the different numbers of factors, a 2-, 3-, 4-, 5-, 6-, 7- and 8-factor analysis is generated. The Q-sorts were loaded to a factor using the *automatic flagging* process using a 5% significance level ($P < 0.05$). The statistical data is presented in Table 3.

Table 3 Factor characteristics.

All participants	Flagged	Unflagged	% Flagged	Eigenvalue	Cumulative % Explained Var.	% Explained Variance
2 factors	39	11	78	5.89	30	12
3 factors	42	8	84	3.71	37	7
4 factors	38	12	76	3.07	43	6
5 factors	39	11	78	2.71	48	5
6 factors	33	17	66	2.61	53	5
7 factors	32	18	64	2.31	58	5
8 factors	32	18	64	2.14	62	4

When including all 50 Q-sorts the 8 unrotated factors accounted for 62% of the total variance. When looking at representative scores in Table 3 one can see that as the number of factors increases, the number of unflagged people increases with the number of factors. All factors, however, still load more than 50% of the participants, which gives thus no grounds to discard factors based on the loading on 1 single factor criterion. When evaluating the factors according to the *composite reliability*, it is key to have high 'internal consistency'. According to the previously mentioned reliability composite of 0.94 or higher only a 1, 2, 3, 4 and 5 seem applicable (Figure 29).

Based on literature from other Q-method studies (see methodology) you can see which factors meet the criteria mentioned, such to go forward with 2, 3, 4 or 5 factors. From this point choosing the number of factors to be analysed is a balance between the wanted variance and the number of wanted typologies to define within the pool of participated people. An overview of the factor analysis and brief arguments for interpretation is given below:

2-factor analysis: Too many distinguishing statements and too little variance, too many people loading on one factor.

3-factor analysis: Enough distinguishing statements, enough variance, enough participants loading to one factor (+5).

4-factor analysis: Enough distinguishing statements, enough variance, enough participants loading to one factor (+5).

5-factor analysis: Enough distinguishing statements, enough

2 Factors	factor 1	factor 2
Nr of participant loading to factor	21	18
Composite reliability	0.988	0.986
Distinguishing statements (p < 0.05)	29	29

3 Factors	factor 1	factor 2	factor 3
Nr of participant loading to factor	14	15	13
Composite reliability	0.982	0.984	0.981
Distinguishing statements (p < 0.05)	24	23	18

4 Factors	factor 1	factor 2	factor 3	factor 4
Nr of participant loading to factor	10	10	9	9
Composite reliability	0.976	0.976	0.973	0.973
Distinguishing statements (p < 0.05)	12	12	13	17

5 Factors	factor 1	factor 2	factor 3	factor4	factor 5
Nr of participant loading to factor	9	10	6	8	6
Composite reliability	0.973	0.976	0.96	0.97	0.96
Distinguishing statements (p < 0.05)	6	10	7	7	9

6 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
Nr of participant loading to factor	7	5	3	8	5	5
Composite reliability	0.966	0.952	0.923	0.97	0.952	0.952
Distinguishing statements (p < 0.05)	4	1	4	8	2	3

7 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
Nr of participant loading to factor	6	5	4	7	4	4	2
Composite reliability	0.96	0.952	0.941	0.966	0.941	0.941	0.889
Distinguishing statements (p < 0.05)	2	4	2	9	2	4	1

8 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8
Nr of participant loading to factor	4	5	4	7	3	2	2	5
Composite reliability	0.941	0.952	0.941	0.966	0.923	0.889	0.889	0.952
Distinguishing statements (p < 0.05)	2	3	1	6	1	1	1	0

Figure 29 Factor characteristics and their statistics.

variance, enough participants loading to one factor (+5).
In summary, it was found that a 2-factor analysis gives too little variance according to what it can display. Per factor, many are people are loading to it and therefore showing less variance, also according to Table 3. To interpret the factors in this analysis becomes more difficult as well, as the distinguishing statements are plenty. A three-factor analysis covers already more variance in three factors and makes interpreting the factors easier as the distinguishing statements become less. A four-factor analysis generates already smaller groups of people loading to one factor, capturing even more variance. A five-factor analysis covers more variance and generates smaller groups of people loading to a factor, however, generates less distinguishing statements. A six-factor analysis is not compatible according to the criterion of minimum composite reliability of 0.94 and number of people loading to a factor: which should be at least four and is in this case for factor 3 only three people. A seven-factor analysis does not comply with multiple criteria as multiple factors here have too few people loading to a factor, composite reliability below 0.94 for one factor and too few distinguishing statements to interpret a factor. Same accounts for an 8-factor analysis whereby again these three criteria do not comply with the needed statistical values to 'pass' for interpretation. Then based on interpretability: +5 factor analyses, on a group of 'only' 50 people, can complicate the interpretation as it is then difficult to understand the behaviour of people loading to this factor. Thus according to the statistical criteria and interpretability, a 2, 3 and 4-factor solution is done.

6.3 Q-sort group as a whole

Factor analysis

For the factor analysis of the group as a whole, the following options are, according to the statistical criteria, applicable namely: a 2-, 3- and 4-factor analysis, which have all been applied. An overview of the entire examination can be found in appendix 8, 9 and 10. When looking at a 2-factor analysis the number of people loading to the 2 factor lies at 78%, whereas a 3-factor analysis has respectively 84% and a 4-factor analysis has 76% of the people loading to it. Therefore based on this criterion the 3-factor analysis is most preferred. Based on the content and most interesting factors to be interpreted, we can also see the most differentiating factors within the 3-factor analysis where the difference between the factors can be highlighted. Therefore, it is decided to further interpret the 3-factor analysis, which will be explained later on. In Table 4 an overview is given with several distinguishing statements, with extreme value (e.g. -4 or +4) as this gives a clear idea of the perspective of the typology. Of course, not all distinguishing statements can be of extreme value and thus, according to the output the distinguishing statement can also have a value of 2 or 3 for example, as can be seen in Table 4.

Table 4 Distinguishing statements for the group as a whole, 3-factor analysis.

Group as a whole			
Factor	*Several distinguishing statements*	*Value*	*z-score*
1	During the dry season, I have to wait in the queue regularly for a long time.	4	1.962
	I experience conflicts over water from the sand dam during the dry season.	3	1.118
	I feel responsible for maintaining the banks of the river to prevent siltation.	-4	-2.306
	I know who owns the sand dam.	-3	-1.772
2	I am happy with the sand dam.	3	1.370
	I have a higher income since I started making use of the sand dam.	2	0.950
	During the dry season, I have to wait in the queue regularly for a long time.	-4	-1.953
	During the dry season, I have to dig deeper to fetch water.	-2	-1.181
3	During the dry season, I find water to be saline.	4	1.161
	During the dry season, I have to dig deeper to fetch water from the sand dam.	3	1.064
	I use the water from the sand dam for irrigating my crops.	-4	1.792
	I can more easily cross the river via the sand dam during the wet season.	-3	1.397
Based on iterations done using KADE software			

Factor interpretation

The elements within KADE software will serve as an aid for interpretation, such as the distinguishing statements, the difference between the factors, the z-scores, visualizations of the Q-sorts and Q-sorts loading to it. According to the Q-sorts loading to a factor, the evaluative interviews after conductance of the Q-sort helped as a tool for further interpretation.

What was a factor again? Here a brief reminder of the *definition of a factor*: **a factor is a group of people who similarly sorted the Q-puzzle: thus having the same perspective or viewpoint.** In appendix 7 the visualizations of the three different factors are shown, as well as the complete overview of the correlation between the different Q-sorts (Appendix 6 & 7). For all factors, *infographics* are created to summarize the characteristics of a factor including keywords, a description, an example of the typology, the statistics of the people loading to it, relevant water access elements and a complementing image.

Factor 1

Factor 1 has 14 participants loading to it. A description of the factor is given in the overview below, where briefly the keywords describing the person loading to this factor and the characteristics are also given. As the results are mostly based on quantitative results, it is aimed to give a human perspective to this analysis by giving an example of somebody loading to this factor. This is done according to his or her perspective based on the interviews done.

KEYWORDS

Seek for large water volumes in preferably shortest period of time. Lack of ownership feeling towards the dam and experiencing conflict to be a burden, during dry season.

DESCRIPTION

These people have been living in the area for a long period. They make use of the water for both irrigation and domestic use and make many trips a day fetching a lot of water, which costs a lot of time, typically three times a day with mostly four jerry cans per trip. This frequency corresponds to the above-average household size of 7 people per household. This group also lacks the feeling of ownership towards the dam, possibly because of their long time spent living near it or because it was built before they moved into the area and they do not know who owns the sand dam. The typical person of this group experiences conflict over water from the sand dam, especially during the dry season and mostly about: 'who fetches water first?' when waiting in a long queue.

EXAMPLE OF TYPOLOGY

'A woman living in Kiindu taking care of her disabled'

This person lives within a large family where she has the responsibility of fetching water as her parents are working on the farm. She has to stay at home and take care of her disabled brother. However, fetching water must be done quickly as she does not want to leave her brother alone for a long time. Therefore the time to fetch water must be as short as possible (typically 30 minutes), which can be delayed up to 2 hours due to queuing during the dry season. Also, arguments can arise as people want to fetch water first instead of standing in line awaiting their turn.

STATISTICS

14 people loading

79% of people from ***Kiindu***

64% 29% 7%

60% households > 5 people

50% domestic

50% agricultural

WATER ACCESS ELEMENTS

Time, water quantity, ownership

Figure 30 Factor 1 - Group as a whole

Factor 2
Within this factor, 15 people are loaded. Again a description is given in the figure below. To give an example of somebody loading to this factor, one of the participants is again briefly described within this box.

KEYWORDS

Content over the sand dam as they experience high water quantities to be available throughout the year. Agricultural activities are most important to this factor group as an income-generating activity.

DESCRIPTION

Overall, these people are content over the structure appreciating having a water source close by. People loading to this factor take the opportunity of the water available to grow and eat more nutritious food since they make use of the sand dam. These people earn an income through the water use from the sand dam: through farming and activities like brickmaking or jobs within security, finance or other small businesses. The person relating to this factor feels responsible for maintaining the sand dam, as maintaining the banks of the river seems to be important to them in the long-term to secure water supply.

EXAMPLE OF TYPOLOGY

'A farmer living in Mulutu'

After the construction of the sand dam, this farmer saw the possibility to irrigate her crops and to diversify in crops, thereby expanding from only maize and beans to vegetables, which she sells at the local market close to home. She lives further away from the sand dam, however, her husband owns a plot near the river which eases the job of irrigation. The crops cultivated are not only used as cash crops but also for own consumption as this saves money instead of buying the products at the local market. Overall she is content over the structure as the sand dam gave a reliable supply of water throughout the year which creates the possibility of irrigation and therefore development.

STATISTICS

15 people loading

67% of people from ***Mulutu***

60% 33% 7%

50% between 35 - 50 years

30% domestic

70% agricultural

WATER ACCESS ELEMENTS

Agricultural activity, income, water quantity

Figure 31 Factor 2 - Group as a whole

Factor 3

Within this factor, 13 people are loaded. Again the keywords, characteristics and a human perspective are included.

KEYWORDS

Mainly domestic water users, find terrain and path to be important towards the sand dam. Water quality is important to these people. People have clear ownership over the dam and find having a sand dam committee to be valuable.

DESCRIPTION

Participants in this group mainly use the water from the sand dam for domestic purposes and thus not experience increased income since they make use of the sand dam. Several people also rely on water bought from a shop or pay water according to the water bill and thus not solely rely on the sand dam as only water supply. Closely related to this is the quality of the water, which seems to be sometimes doubtful because of urination and defecation done by the animals. Treatment is often done using water guard to improve quality up to their drinking water standards. Another characteristic is that these people are located further away from the sand dam. Their path towards the sand dam seems to be important in their ease to fetch water.

EXAMPLE OF TYPOLOGY

'Head of a household in Mulutu'

This lady has been living in Mulutu for a long time and finds water quality to be important. During the dry season, salinity seems to be an issue to her. The water table drops and the water that she fetches has a salty taste. When salinity issue appears in the Mutendea river, where the sand dam lies, she rather fetches water in river Kayoo which is further away but supplies cleaner water. She also experiences animals defecating and urinating which changes the characteristics of the water, such as taste and odour. When water quality drops below a certain personal preference she treats the water using water guard or through boiling.

STATISTICS

13 people loading

70% of people from ***Mulutu***

46% 39% 15%

Group of all ages

92% domestic

8% agricultural

WATER ACCESS ELEMENTS

Water quality, terrain, ownership

Figure 32 Factor 3 - Group as a whole

Consensus statements
The factors give a difference in opinion, but there are also commonalities between the different factors and the people loading to it. These are called consensus statements. These statements are the following; *'I find clean water to be important'* & *'I find a water source being close to me very important'.* This results in a consensus opinion towards the '**distance'** and '**water quality**' aspects of water access. A close proximity to the water source and a clean water source seems to be most important by all participants based on these factors and thus direct elements of water access.

The table below gives an overview of the z-scores per statement, per factor to indicate the value of each statement.

Table 5 Overview of statement z-scores per factor.

Nr.	Statement	Factor 1		Factor 2		Factor 3	
		Z-score	Rank	Z-score	Rank	Z-score	Rank
1	I do not mind using a water source that is further away.	-0.62	27	-1.69	32	-1.2	28
2	I find a water source being close to me very important.	1.25	4	1.38	2	1.14	3
3	I can more easily cross the river via the sand dam during the wet season.	-0.58	26	-0.1	20	-1.4	30
4	I go through somebody else's land to get to the sand dam.	-1.96	33	-1.61	31	-1.41	32
5	Fetching water from the sand dam costs me less time compared to other sources.	-0.49	23	0.27	14	0.65	14
6	During the dry season, I have to wait in the queue regularly for a long time.	1.96	9	-1.95	34	0.85	10
7	During dry season, I have to dig deeper to fetch water from the scoop holes.	0.62	1	-1.18	29	1.06	4
8	I use more water since I make use of the sand dam.	-1.04	30	0.09	15	0.98	8
9	I can carry more water since I have a donkey/oxen.	-0.26	21	0.67	11	0.68	13
10	My livestock has more water to drink since I use the sand dam.	-0.54	25	1.36	4	1	7
11	People close to the sand dam have more water available than people further away.	0.54	11	-0.32	22	0.69	12
12	The sand dam gives me enough water during long dry periods.	-1.01	29	0.82	9	-1	27
13	The sand dam is a reliable water resource.	0.78	8	0.78	10	-0.49	23
14	I find clean water important.	1.25	3	1.54	1	1.19	1
15	The donkey/oxen causes water pollution through urination and defecation.	1.26	2	-0.37	23	1.03	6
16	I treat the water before I drink it (boiling/waterguard).	0.5	13	0.04	18	0.9	9
17	During the dry season, I find the water to be saline.	0.48	14	-0.22	21	1.16	2
18	My path to the sand dam is more difficult during the wet season.	0.11	17	-0.49	25	-0.49	22
19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)	0.46	15	1.03	6	-0.36	21
20	I only use the water from the sand dam for domestic needs (e.g. washing clothes, cooking, washing utensils).	1.08	6	0.04	17	0.62	15
21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.	0.94	7	1.33	5	-1.26	29
22	I use the water from the sand dam for irrigating my crops.	0.08	18	0.91	8	-1.79	33
23	My children can go to school fully since I use water from the sand dam.	-1.22	31	-0.42	24	-0.23	20
24	I have a higher income since I started making use of the water from the sand dam.	-0.46	22	0.95	7	-1.4	31
25	I know who owns the sand dam.	-1.77	32	-0.78	27	-0.64	24
26	We, as a community have ownership over the dam.	-0.9	28	0.09	16	0.6	16
27	I find that everybody in the area can use water from the sand dam.	0.01	19	0.6	12	0.1	18
28	I find having a sand dam committee within our community important.	0.57	10	-0.03	19	1.04	5
29	I feel responsible for maintaining the banks of the river to prevent siltation.	-2.31	34	0.49	13	0.09	19
30	I find sand harvesting to be a problem affecting the sand dam.	0.27	16	-0.85	28	0.82	11
31	I experience conflicts over water from the sand dam during the dry season.	1.12	5	-1.29	30	-0.69	25
32	I experience conflicts over water from the sand dam throughout the year.	-0.51	24	-1.8	33	-1.93	34
33	I find the sand dam to be a good place to chat with my friends.	-0.13	20	-0.65	26	-0.82	26
34	I am happy with the sand dam.	0.53	12	1.37	3	0.54	17

Conclusion

This first analysis highlights which elements of water access are being valued by different groups within the overall group of community members from the two districts in Kitui. Different factors (typologies) with differentiating characteristics were distinguished with the use of Q-method, as displayed previously in this chapter.

The first typology relates to the *time* element of water access. The importance of this element to water users could be related to higher water consumption caused by the larger size of the households (or additional water needed for their plots). Many jerry cans per day are needed, corresponding to many trips. When queuing times are long during the dry season, this typology stresses the presence of conflict, mostly focusing on: 'who fetches water first?'. According to the explanatory interviews, this can be related to a lack of ownership over (water from) the sand dam. People just come to fetch water as efficiently and quickly as possible, which could lead to conflict more easily. A relation with the dam could remain important, as people closer to the sand dam feel they have priority over using the water from the sand dam over the ones that come from further away. The observation that people value the element of time is also reflected in the z-scores of several statements (Table 5). A high z-score of 1.96 relates to the statement: 'During the dry season I have to wait regularly for a long time'. The lack of ownership closely relates to a negative z-score of -1.77 of statement 25: 'I know who owns the sand dam'. The latter can be explained by the high percentage of people loading on this factor living in Kiindu (80%), where the sand dam has existed for many years. The ownership may have been forgotten (which could also indicate that lack of ownership has not been a problem).

The second typology characterizes a group (mainly from Mulutu) of farmers (high z-score of 1.37 of statement 34), who do not experience long waiting times to fetch water (z-score of -1.95 of statement 6). These people are content with the water availability from the sand dam throughout the year and use the water to irrigate their plots (highest z-score of statement 22). Within this group of people, the element of development through *agricultural activities* appears to be most valued, which would be related to the element of *large water quantities* readily available. They value these elements of water access as eventually an *income* is generated through the cultivation of vegetables and fruits, which also adds to an improved *healthy* way of living (higher z-score compared to others of the statement: 'I can grow/eat more nutritious crops since I make use of the sand dam'. The succession from water availability to agricultural production, and thereby addressing many elements of water access, give them water security in their daily life. This line of succession is seen in other valued statements like: 'I can engage in new activities…' & 'I have a higher income …'.

A third typology is a group of people, again mainly from Mulutu, who value the sand dam for providing domestic water, used for drinking, washing, etc. *Water quality* is for this group one of the most important elements of water access, as people experience the water to be saline (statement 17, z-score of 1.16) and treat the water using Waterguard filters or boiling it (statement 16, z-score of 0.9). Water use is mainly associated with personal consumption. One can, therefore, argue that the link between drinking water and *health* becomes more clear in this typology, as its members want to prevent water-borne diseases. These elements also appear during the interviews, where two effects are most commonly discussed: 1) an increase in salinity during the dry season, and 2) a change in taste and odour through animals defecating and urinating at the sand dam (difference in z-scores of statement 15 for factor 1 and 3).

The differences between the three factors/typologies relate to the water use purpose of each typology, which range from using the water for both irrigation and domestic purposes to mainly domestic or mainly irrigation use. Overall, it appears that people who earn money from their income-related activities based on water from a sand dam are more content over the dam compared to people who mainly use water for domestic purposes. Another important difference appears to be between those having the sand dam as the only water resource in use, compared to those having multiple options available and thus not fully relying on the sand dam only. The first factor/typology fully relies on the water from the sand dam for domestic purposes and experiences more conflict, whereas the third factor does not experience these conflicts because they have a second water resource as an option. Fully relying on one source can induce both water scarcity and social stress, generally for the poor, who do not have the luxury of also relying on other water sources. It can be suggested that water-related emotional distress is developed as a by-product of this issue, therefore it can easier result in a conflict.

6.4 Q-sort group separate areas

Factor analysis

This research is looking at two different regions. The previous analysis was to see which elements of water access are valued when taking the group as a whole, not looking at the different locations specifically. However, to make a comparison, these regions are separated as well to see which factors roll out of the analysis.

This subsequent analysis is done whereby the raw data is divided into two different regions, analysed separately and then compared. The number of factors is decided according to the same criteria mentioned earlier. For the analysis, a similar number of factor per regions is preferred and thus firstly the criteria were applied to all factors in both regions to decide on the number of factors.

To get to know which factors can be extracted again a criteria analysis is done for both groups within the region of Mulutu and Kiindu. An overview is given in Figure 33.

When applying the previously mentioned criteria to the region of Mulutu, the 8-, 7-, 6-, and 5-factor analysis can be excluded based on the number of people that must at least load to 1 factor. Thus a factor analysis of 2, 3 and 4 factors can only be further used.
When doing the same for the region of Kiindu the 8, 7, 6, 5 and 4-factor analysis can be excluded based on the same criterion as only 3 people are loading on a factor in the 4-factor analysis. Thus, for further evaluation, the 2 and 3-factor analysis is used.
When looking at the 3-factor option of Mulutu you can see that the three groups give an extra diversification compared to the 2-factor analysis. When looking at the 2-factor you can see that is a difference in the percentage of people loading to a factor namely of 81% for the 2-factor and 96% for the 3-factor. For Kiindu region this percentage is quite comparable and thus no reason to choose over or the other based on this criterion. Again, when going from a 2-factor analysis to a 3-factor analysis, it can be seen that the factor give more variance and thus it is decided to also go with the 3-factor analysis for the case of Kiindu. Next to these arguments, this part of the research is also about the comparison between the two regions, which is more reliable when doing this with both the same number of factors.

MULUTU

2 Factors	factor 1	factor 2
Nr of participant loading to factor	12	9
Composite reliability	0.98	0.973
Distinguishing statements ($p < 0.05$)	22	22

3 Factors	factor 1	factor 2	factor 3
Nr of participant loading to factor	12	7	6
Composite reliability	0.98	0.966	0.96
Distinguishing statements ($p < 0.05$)	19	14	16

4 Factors	factor 1	factor 2	factor 3	factor 4
Nr of participant loading to factor	7	4	5	6
Composite reliability	0.966	0.941	0.952	0.96
Distinguishing statements ($p < 0.05$)	7	12	11	7

5 Factors	factor 1	factor 2	factor 3	factor4	factor 5
Nr of participant loading to factor	6	4	4	5	3
Composite reliability	0.96	0.941	0.941	0.952	0.923
Distinguishing statements ($p < 0.05$)	3	5	6	4	5

6 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
Nr of participant loading to factor	3	5	3	3	3	3
Composite reliability	0.923	0.952	0.923	0.923	0.923	0.923
Distinguishing statements ($p < 0.05$)	2	2	4	3	5	3

7 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
Nr of participant loading to factor	3	2	2	2	1	3	4
Composite reliability	0.923	0.889	0.889	0.889	0.8	0.923	0.941
Distinguishing statements ($p < 0.05$)	0	2	2	1	2	1	2

8 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8
Nr of participant loading to factor	1	3	2	2	3	3	1	3
Composite reliability	0.8	0.923	0.889	0.889	0.923	0.923	0.8	0.923
Distinguishing statements ($p < 0.05$)	2	3	1	1	0	1	1	1

KIINDU

2 Factors	factor 1	factor 2
Nr of participant loading to factor	13	10
Composite reliability	0.981	0.976
Distinguishing statements ($p < 0.05$)	28	28

3 Factors	factor 1	factor 2	factor 3
Nr of participant loading to factor	9	7	6
Composite reliability	0.973	0.966	0.96
Distinguishing statements ($p < 0.05$)	18	16	16

4 Factors	factor 1	factor 2	factor 3	factor 4
Nr of participant loading to factor	7	5	8	3
Composite reliability	0.966	0.952	0.97	0.923
Distinguishing statements ($p < 0.05$)	9	13	9	12

5 Factors	factor 1	factor 2	factor 3	factor4	factor 5
Nr of participant loading to factor	7	3	5	3	4
Composite reliability	0.966	0.923	0.952	0.923	0.941
Distinguishing statements ($p < 0.05$)	8	4	8	7	8

6 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6
Nr of participant loading to factor	5	2	5	2	2	2
Composite reliability	0.952	0.889	0.952	0.889	0.889	0.889
Distinguishing statements ($p < 0.05$)	5	2	3	0	1	2

7 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7
Nr of participant loading to factor	2	2	2	4	1	3	2
Composite reliability	0.889	0.889	0.889	0.941	0.8	0.923	0.889
Distinguishing statements ($p < 0.05$)	2	2	1	2	0	0	1

8 Factors	factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	factor 7	factor 8
Nr of participant loading to factor	1	1	2	3	2	3	3	1
Composite reliability	0.8	0.8	0.889	0.923	0.889	0.923	0.923	0.8
Distinguishing statements ($p < 0.05$)	0	2	1	0	0	1	0	2

Figure 33 Factor characteristics and their statistics of two separate areas.

Therefore, to compare both areas in an optimum way, it is decided to work with the three-factor option. Next, an overview is shown including several distinguishing statements of the 3-factor analyses in Table 6 and 7.

Table 6 Distinguishing statements for Mulutu.

Mulutu			
Factor	*Several distinguishing statements*	*Value*	*z-score*
1	I find clean water to be important.	4	1.638
	The sand dam is a reliable resource.	3	1.162
	I experience conflicts over water from the sand dam during the dry season.	-3	-1.35
	During the dry season, I have to wait in a queue for a long time.	-4	-2.025
2	I find sand harvesting to be a problem affecting the sand dam.	4	1.96
	During the dry season, I find the water to be saline.	3	1.301
	I have a higher income since I started making use of the sand dam.	-4	-2.048
	Since I started making use of the sand dam I can engage in new activities.	-1	-0.445
3	I find the sand dam to be a good place to chat with my friends.	4	1.737
	I can carry more water since I have a donkey.	3	1.342
	Since I started making use of the sand dam I can engage in new activities.	-4	-1.731
	My path towards the sand dam is more difficult during the dry season.	-3	-1.567
Based on iterations done using KADE software			

Table 7 Distinguishing statements for Kiindu.

Kiindu			
Factor	*Several distinguishing statements*	*Value*	*z-score*
1	During the dry season, I have to dig deeper to fetch water from the sand dam.	4	1.874
	I find sand harvesting to be a problem affecting the sand dam.	3	1.33
	I feel responsible for maintaining the banks of the river to prevent siltation.	-4	-2.13
	I use more water since I make use of the sand dam.	-3	-1.33
2	I can grow/eat more nutritious food since I started making use of the sand dam.	4	1.778
	I can engage in new activities since I started making use of the sand dam.	4	1.706
	People close to the sand dam have more water available than people further away.	-3	-1.002
	The donkey/oxen cause water pollution through urination and defecation.	-2	-0.953
3	I use more water since I make use of the sand dam.	4	2.277
	During the dry season, I find the water to be saline.	4	1.422
	I find sand harvesting to be a problem affecting the sand dam.	-3	-1.224
	I can grow/eat more nutritious food since I started making use of the sand dam.	-3	-1.124
Based on iterations done using KADE software			

6.4.1 Mulutu

Factor 1

A total of 12 people are loading to this factor. The keywords, description, example, statistics and water access elements are listed again below.

KEYWORDS

These people are content over the sand dam because of its reliability throughout the year. Also find water quality to be important. Feel themselves living in a 'peaceful' surrounding without any conflict and experience short water fetching time and see sand as a valuable asset, for example, their livestock.

DESCRIPTION

Most of the people make use of the dam for domestic purposes, however, sometimes water a small plot to cultivate some nutritious crops such as fruits and vegetables: for own purpose. Or make use of the water for livestock. A fair amount of people do not own a donkey and carry the water on their backs and live further away from the dam: thus they make more trips compared to those who do have a way of transport, however, do experience the ease of fetching water using the handpump. Several people also rely on other water sources such as rainwater harvesting or purchasing water from the water kiosk. This type of person experiences a high reliable water table throughout the year and does not experience long queues (4 feet normally during the dry season and 1 foot during the wet season). Some see the sand dam as a valuable asset, as sand is used as construction material and thus sand harvesting is not a problem when doing it on a small scale for this typology.

EXAMPLE OF TYPOLOGY

'A participant not fully relying on a sand dam'

A community member who is living in Mulutu can be seen as a typical person loading to this factor. He works at a prison in Kitui and uses the water only for domestic purposes and sometimes he takes his cattle to the dam to drink. Overall he finds the dam to be reliable and a valuable asset for the area. Within the picture the homestead of this family can be seen, where an example of sand harvesting for personal use is seen.

STATISTICS

12 people loading

58% 42% 0%

75% living > 500 metres

45% domestic

55% agricultural

WATER ACCESS ELEMENTS

Agricultural activity, reliability

Figure 34 Factor 1 - Mulutu.

Factor 2
A total of 7 people are loading to this factor, where again the characteristics of the factor are shown below.

KEYWORDS

Female majority, in large households, who experience water quality problems, experience queueing during the dry season. Experience reduced water quantities through sand harvesting.

DESCRIPTION

Mostly women are loading to this factor. These women experience water quality issues and therefore treat the water using water guard or boil the water before drinking. This typology does not experience a change in income-generating activities and mostly uses the water for domestic purposes. A geographical aspect of this group, which stands out, is that these people live close by, have not participated in the construction of the dam or some cases do not fully understand how a sand dam works: they expect surface water and not water to be stored underground. These people value having a sand dam committee. The reason is that this prevents conflicts over water and activities like sand harvesting from happening, which is seen as a problem according to this typology.

EXAMPLE OF TYPOLOGY

'Water quality and sand harvesting is a problem'

This female experiences water quality problems, treats her water and stores it then in a buffer tank on their family grounds. She has not participated in the construction and it has not directly impacted her income-wise. During the dry season queueing occurs delaying her water fetching times. She experiences dropping water tables during the dry season, resulting in a shortage of water and increased unwanted salinity. According to her, this is because of sand harvesting problems. When this is done on a large scale the water table drops. The people performing sand harvesting activities should have the right permit from the chief officer, however, this is more formality than done in practice.

STATISTICS

7 people loading

86% living < 500 metres

86% 14% 0%

86% households > 5 people

66% domestic

34% agricultural

WATER ACCESS ELEMENTS

Water quality, water quantity

Figure 35 Factor 2 - Mulutu.

Factor 3

Within this group, 6 people load to this factor. Again a description of the typology is given below.

KEYWORDS

Social interaction to be important and their way of water transport method seems to be of importance to ease the job of reaching the sand dam and fetching water.

DESCRIPTION

This fairly young group of people values the sand dam as a place for social interaction to chat with friends and fetch water in groups. People in this group have possession over a donkey to fetch water and a clear and easy path towards the sand dam as they have a favourable position near the main road to the sand dam. A typical person relating to this factor lives further away and values their clear path and way towards the sand dam.

EXAMPLE OF TYPOLOGY

'A highway to water and a place to for social interaction'

The boys shown in the picture are the youngsters of the household and experience the sand dam to be a good place for social interaction, hang out with their friends and play sports during the dry season when they can walk through the riverbed.

Before the sand dam, the river was to some already a place to meet and during the wet season, the dam gives them the possibility to swim in the water and enjoy themselves.

The boys in this household live further away and see the sand dam therefore as a good place to meet.

STATISTICS

6 people loading

83% > 500 metres

50% 33% 17%

57% between 16 - 34 years

60% domestic

40% agricultural

WATER ACCESS ELEMENTS

Social capital/interaction, terrain

Figure 36 Factor 3 - Mulutu.

Consensus statements

Within this group, the following statements are in consensus: (agreed) *'I find a water source being close to me very important'* & *'Fetching water from the sand dam costs me less time compared to other sources'*. The dimension of **distance** and **time** seemed to be most important to all people which is the direct impact on human life since they make use of the sand dam.

6.4.2 Kiindu

Factor 1

On this factor 9 people loaded. The figure below shows the characteristics of this factor.

KEYWORDS

These (mostly) women experience short fetching times and use more water since they moved into the area, also related to large households. Experience water to be unequally distributed.

DESCRIPTION

Mostly women relate to this factor. They experience short fetching times even though they live further away. Because of this distance, they also rely on other water sources, such as a water point further upstream, making use of a water pond or pay for drinking water. These women find that people living close to the sand dam have water more water readily available and thus also carry the responsibility of maintenance over the dam. Sand harvesting is seen to be a problem as it lowers the water table, giving trouble in water availability during the dry season. A dropping water table results in scooping deeper, sometimes to 1,5 meter according to this group. However, this problem is difficult to tackle because of the absence of a sand dam committee which they need to create the authority to cope with these kinds of problems.

EXAMPLE OF TYPOLOGY

'A problem of authority'

A young lady born in Kiindu experiences sand harvesting to be a problem. The water table already drops during the dry season and sand harvesting makes this problem even worse. However, to react to a problem like this, a sand dam committee could be of use as she said: 'It is not up to me to say anything when I see this. As an individual, you cannot say something about it to another individual. A group of people having the authority to stand up would help the best.' As she lives further away, she supplies herself and family with own grown crops which she supports using water from a point higher up in the ephemeral river, as this is closer. A separate scoop hole is created here, just for irrigation thereby making use of multiple places and sources.

STATISTICS

9 people loading

78% 14% 14%

78% living > 500 metres

44% domestic

55% agricultural

WATER ACCESS ELEMENTS

Time, water quantity, maintenance

Figure 37 Factor 1 - Kiindu.

Factor 2
In total 7 people are loading to this factor. The infographic below gives an overview again of this typology.

KEYWORDS

A content group of people because of the possibility of new activities to grow/eat more nutritious food and experience a higher income. Equal water distribution experienced and value their proximity to the dam.

DESCRIPTION

These fairly young people, living close to the sand dam, have their plots which they cultivate with vegetables and fruits. These activities were mainly supported because of their proximity to the dam which allowed them to explore activities like irrigation and brickmaking. A high water table is experienced all year through, experience no quality issues and do not see sand harvesting as a problem. The high water table and availability of water seem to be equally available for everybody in the region: no difference in living close or far away. Their proximity to the dam does not relate to the responsibility of maintenance according to their opinion. This responsibility lies with the government. This typology regularly pays somebody to fetch water for them as well, as jobs like pastors, farming or other income-related activities are their priority.

EXAMPLE OF TYPOLOGY

‘A young farmer using the SD for irrigational purposes’

This man works on the farm together with his family. They cultivate vegetables using jerry cans filled with water. Perfectly aligned crops and mango and papaya trees are also shown in his plot. He feels blessed to live in this area, compared to other areas, as this region has water readily available. Because of the separation of scoop hole per water use, there is water for everybody. Separate scoop holes are created for livestock, domestic use and irrigation. Therefore no conflicts arise in his view and the water is equally distributed. Because water is equally distributed it is not per se their responsibility to maintain the dam. The capital to do this is simply not there and thus the government’s responsibility to do this.

STATISTICS

7 people loading

57% households > 5 people

43% 43% 14%

50% between 16 - 34 years

14% domestic

86% agricultural

WATER ACCESS ELEMENTS

Agricultural activity, health, income

Figure 38 Factor 2 - Kiindu.

Factor 3
For this factor 6 people loaded. Again, the infographic below shows the characteristics of this typology.

KEYWORDS

Seek for large water volumes per trip in the preferred shortest time. These are mostly domestic water users who experience quality issues. Rely mostly on the sand dam for their water needs.

DESCRIPTION

These people in the area of Kiindu mostly use the water for domestic use only, which they get supplied reliably through the sand dam. They however fully rely on the sand dam and do not have back up options like water ponds or the capability to pay for water. This typology values their way of transportation, mostly using donkeys, and need many jerry cans per trip to support the household water needs. Not only their donkeys but all livestock experience to have more water available as they can easily take them to the sand dam. Salinity issues appear according to this factor, however not in a problematic way: treatment is not necessary. However, animals negatively affect the taste and odour of the water. Lastly, this factor group experiences sand harvesting not to be a problem: only personal use is not affecting the sand dam in a negative way.

EXAMPLE OF TYPOLOGY

'A simple solution to a quality problem'

Only domestic purposes are necessary for this family, as their crops are rain-fed. With a fairly big household, they rotate the job of fetching water and because of their household size, value their donkey. People living close have the responsibility of maintenance as they earn money through irrigation and this family does not. A problem, however, is the quality of the water-related to odour and taste. It is still drinkable, however less pleasant. Separate scoop holes for livestock prevent illness and other health-related issues, however, defecation and urination done by the animals seems to be a problem. People should tie their animals to the tree when fetching water and bring the water to them, so everybody can enjoy the water odourless and of good taste.

STATISTICS

6 people loading

67% households > 5 people

50% (women) 33% (men) 17% (both)

71% living < 500 metres

83% domestic

17% agricultural

WATER ACCESS ELEMENTS

Water quality, water quantity

Figure 39 Factor 3 - Kiindu.

Consensus statements

Within this group the following statements are in consensus: *'I know who owns the sand dam' (disagreed)* & *'I have to go through somebodies land to get to the sand dam' (disagreed).* Ownership and lack of ownership play a key role in this group. Based on interviews held in this region, the individualistic way of living by the people in this area is a characteristic, which became clear when comparing this to the area of Mulutu.

Table 8 gives an overview of the z-scores per statement, per factor to indicate the value of each statement.

Table 8 Statement z-score per factor, per region.

Nr.	Statement	*Mulutu z-scores per factor*			*Kiindu z-scores per factor*		
		Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
1	I do not mind using a water source that is further away.	-1.99	-0.42	-0.73	-0.25	-1.69	-0.84
2	I find a water source being close to me very important.	1.27	1.04	1.22	0.55	1.39	1.02
3	I can more easily cross the river via the sand dam during the wet season.	-0.01	-1.5	-1.94	-0.49	-0.63	-0.67
4	I go through somebody else's land to get to the sand dam.	-1.8	-1.12	-1.43	-1.29	-1.36	-1.14
5	Fetching water from the sand dam costs me less time compared to other sources.	0.68	0.61	0.77	-0.59	-0.41	0.92
6	During the dry season, I have to wait in the queue regularly for a long time.	-2.03	1.24	-0.15	0.65	-0.82	1.25
7	During dry season, I have to dig deeper to fetch water from the scoop holes.	-0.53	0.95	1.47	1.87	-0.05	0.71
8	I use more water since I make use of the sand dam.	-0.21	-0.38	0.63	-1.33	-0.13	2.28
9	I can carry more water since I have a donkey/oxen.	0.33	0.11	1.34	-0.67	-0.43	0.9
10	My livestock has more water to drink since I use the sand dam.	1	-0.4	0.11	-1.09	0.79	0.39
11	People close to the sand dam have more water available than people further away.	-0.11	0.5	0.1	0.85	-1	1.03
12	The sand dam gives me enough water during long dry periods.	0.95	-1.33	-0.39	-1.3	-0.08	-1.1
13	The sand dam is a reliable water resource.	1.16	-0.39	-0.42	0.81	-0.01	-0.67
14	I find clean water important.	1.64	0.28	0.56	0.87	1.35	1.28
15	The donkey/oxen causes water pollution through urination and defecation.	0.32	1.58	0.3	1.41	-0.95	0.58
16	I treat the water before I drink it (boiling/waterguard).	0.11	1.59	0.6	0.77	-0.54	-0.54
17	During the dry season, I find the water to be saline.	0.2	1.3	-1.03	0.3	-0.12	1.42
18	My path to the sand dam is more difficult during the wet season.	-0.08	-0.15	-1.57	0.27	1.06	-0.38
19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)	0.46	-0.45	-1.73	0.22	1.71	-0.3
20	I only use the water from the sand dam for domestic needs (e.g. washing clothes, cooking, washing utensils).	0.37	0.28	0.32	1.44	-0.39	1.23
21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.	1.09	-0.54	0.43	0.44	1.78	-1.12
22	I use the water from the sand dam for irrigating my crops.	-0.18	-1.78	-0.92	-0.07	0.61	-1.02
23	My children can go to school fully since I use water from the sand dam.	-0.8	-0.5	-1.05	-0.67	-0.75	-0.42
24	I have a higher income since I started making use of the water from the sand dam.	-0.12	-2.05	1.17	-0.92	1.44	-1.01
25	I know who owns the sand dam.	-0.21	-0.46	-0.28	-1.48	-1.61	-1.32
26	We, as a community have ownership over the dam.	0.38	0.84	-0.03	-1.17	-0.66	-0.93
27	I find that everybody in the area can use water from the sand dam.	0.12	-0.62	0.83	0.03	1.01	0.85
28	I find having a sand dam committee within our community important.	0.32	0.97	0.92	0.99	0.94	0.13
29	I feel responsible for maintaining the banks of the river to prevent siltation.	0.31	0.28	-1.4	-2.13	-0.06	-0.57
30	I find sand harvesting to be a problem affecting the sand dam.	-0.12	1.96	-0.53	1.33	-0.15	-1.22
31	I experience conflicts over water from the sand dam during the dry season.	-1.35	0.34	1.09	1.29	0.37	0.26
32	I experience conflicts over water from the sand dam throughout the year.	-2.03	-1	-0.68	-0.07	-1.54	-1.49
33	I find the sand dam to be a good place to chat with my friends.	-1.01	-0.82	1.74	-0.57	-0.57	-0.3
34	I am happy with the sand dam.	1.86	0.04	0.69	0.02	1.47	0.8

Conclusion

This second analysis highlights which elements of water access are being valued by different groups within the two districts in Kitui. This time, people were first arranged with regard to their regional location, before different factors (typologies) with differentiating characteristics were distinguished with the use of Q-method, as displayed previously in this chapter. Do different elements of water access appear?

Mulutu

A first typology is a group of people content over the structure, because of its *reliability* in supplying water all year (high z-score of 1.16 for statement 13). Through this reliability, water fetching *times* are experienced to be short. The people see the sand dam as a valuable asset for both domestic and agricultural purposes (45% and 55%). Having livestock, small plots for agriculture for own consumption and activities such as sand harvesting and brickmaking are common to this group. These aspects of water access can be of value to them, because they also rely on other water sources besides the sand dam, such as rainwater harvesting or paying somebody to fetch water for them. People loading on this factor spread their chances by having multiple activities, besides jobs within sectors like security, dairy farms and other jobs.

The second generated factor has a female majority (86%), where the *water quality* element of water access is valued, as people experience dropping water tables drop with associated increased salinity. This drop in the water table is suggested to come from sand harvesting activities (high z-score of 1.96 of statement 30). Therefore, an authority like a sand dam would be needed to *maintain* the dam to keep water tables high on the long-term, as this is mostly the only source this group of people rely on.

The third typology characterizes a group of people who value the *social interaction* of the sand dam. This is the only group that values statement 33 ('I find the sand dam to be a good place to chat with my friends') with a high z-score of 1.73. This can be because of the young age that characterizes this group; the job of fetching water is normally not theirs. Because of their homestead location, situated further from the dam (83% living further than 500m), the sand dam is seen as a good place to socialize and communicate. Living further away also increases the appreciation of easy paths towards the dam and water transportation using a donkey to ease the job of fetching water (high z-score of statement 9, compared to the other factors).

Kiindu

The first typology mostly characterizes woman (78%) who fetch water daily. People value, although being situated further away, their short fetching *times*. Because of their location, *maintenance* of the river banks is not their responsibility according to the interviews, which is also shown in statement 29, z-score of -2.13. Maintenance would be the responsibility of the people bordering the sand dam. Sand harvesting is seen to be affecting water quantities (high z-score of 1.33 for statement nr. 30), but, due to lacking authority, this problem cannot easily be addressed.

The second typology characterizes a group of farmers (86% agricultural water use) with plots close to the river, who can, therefore, perform *agricultural activities,* which gives them directly increased *income* (high z-score of 1.44 for statement 24). They grow more nutritious crops which improve personal health (statement 21, z-score of 1.71).

Thirdly, a group valuing the *water quality aspect* of water access consists mainly of domestic water users (83%). Salinity tends to increase during the dry season (high z-score of 1.42 of statement 17), although not so much that users (have to) treat the water. This group of people stimulate sand harvesting, as this generates *income* (see statement 30 with a z-score of -1.22).

Comparison

Overall, the region of Mulutu seems more content with the dam, in terms of water quantities, decreased fetching times, possibilities that appear such as irrigation or brickmaking, and the social experiences at the dam. The area of Kiindu, being more used to the sand dam, experiences more difficulties with dropping water tables. These differences could explain the intensified agricultural activities in Kiindu compared to Mulutu: more cultivation of vegetables and fruits using irrigation takes place in Kiindu. Understandably, Kiindu community members *value the agricultural activity* element of water access more, and the role of the dam for food security as such. However, water allocated to agriculture cannot be used by domestic residents, which may create distributive inequalities. In Mulutu, the sand dam has only been there for a short time, and thus agricultural activities do not stand out as much as in Kiindu. The distributive question seems less applicable yet. Water quality is valued by both regions, although the different individuals and communities have variable standards of water quality. Perhaps, when the focus is on income-generating activities, the quality water standards decrease – which can be seen in Kiindu. The activity of sand harvesting seems in both regions to be a benefit, as it generates an income. It is a burden as well, affecting the water tables of the sand dams. Overall, it seems that people having access to a dam for a shorter period (Mulutu) value slightly *different* elements of water access, such as the social benefits of the dam to get together. The people in Kiindu appear may have stronger individualistic values and focus on their income-generating activities within agriculture.

6.5 Comparison of the group as a whole and areas separately

Factor analysis

When going from the group as a whole to the two regions apart, several differences were highlighted. In other words, the groups change when forcing them into groups of the region. Within this section, a comparison is made between the group as a whole and the two regions apart.

At first, an overview is given of who relates to which factor in Table 9. When taking a look at the group as whole compared to Mulutu (3-factor vs 3-factor) it is first evaluated who stayed in the factor, switched to another factor or who does not relate to it at all: thereby creating a different factor.

Table 9 Q-sorts loading per factor iteration.

Q-sorts loading per factor iteration			
Iteration	*Description*	*Factor*	*Q-sorts loading to it*
2	The group as a whole: 4-factor analysis	Factor 1	42, 30, 31, 50, 48, 35, 41, 36, 14, 29, 24, 18, 22, 8
		Factor 2	39, 28, 12, 2, 23, 34, 7, 33, 13, 49, 9, 11, 27, 45, 1
		Factor 3	38, 17, 44, 46, 10, 47, 43, 40, 4, 26, 16, 3, 37
5	Mulutu: 3 factor analysis	Factor 1	11, 34, 12, 33, 39, 9, 27, 26, 45 * relates to factor 2 group as a whole
		Factor 2	38, 10, 46, 2, 4, 1, 37 * relates to factor 3 group as a whole
		Factor 3	18, 3, 47, 20, 32, 21 * relates to factor … not at all!
7	Kiindu: 3-factor analysis	Factor 1	48, 42, 30, 7, 50, 22, 31, 14, 24 * relates to factor 1 group as a whole
		Factor 2	49, 23, 8, 28, 15, 25, 6 * relates partly to factor 2 group as a whole
		Factor 3	43, 16, 17, 5, 13, 29 * relates partly to factor 3 group as a whole
Red = person NOT relating to factor in 'group as a whole'			

At first, factor 1 from the Mulutu analysis relates quite well with factor 2 of the group as a whole, except for one person (highlighted in red). The second factor of the Mulutu analysis closely relates to factor 3 of the group as a whole, however, two people do not appear in this factor and end up in factor 2. Lastly, Mulutu factor 3 does not relate to one of the factors at all, when looking at the group as a whole. This is thus very characteristic for this region.

When doing the same for the region of Kiindu, similar transitions appear. Factor 1 of the Kiindu analysis relates to factor 1 of 'the group as a whole' except for 2 people. The second factor only partly relates to factor 2 of the group as a whole. More than half of the people switch to a different factor when not being forced according to region. The people who switch do not appear in a factor when looking at the group as a whole. Therefore factor 2 is a region-specific factor. Lastly, Kiindu factor 3 partly relates to factor 3 of the 3-factor analysis of the group as a whole. One person ends up in factor 2 and one in factor 1 when going from region forced to the group as a whole and the third transition does not end up in one of the three factors at all. So again, this factor says more about the region specific perspectives of the group.

A visual overview is given of all factor analyses together on the next page (Figure 40).

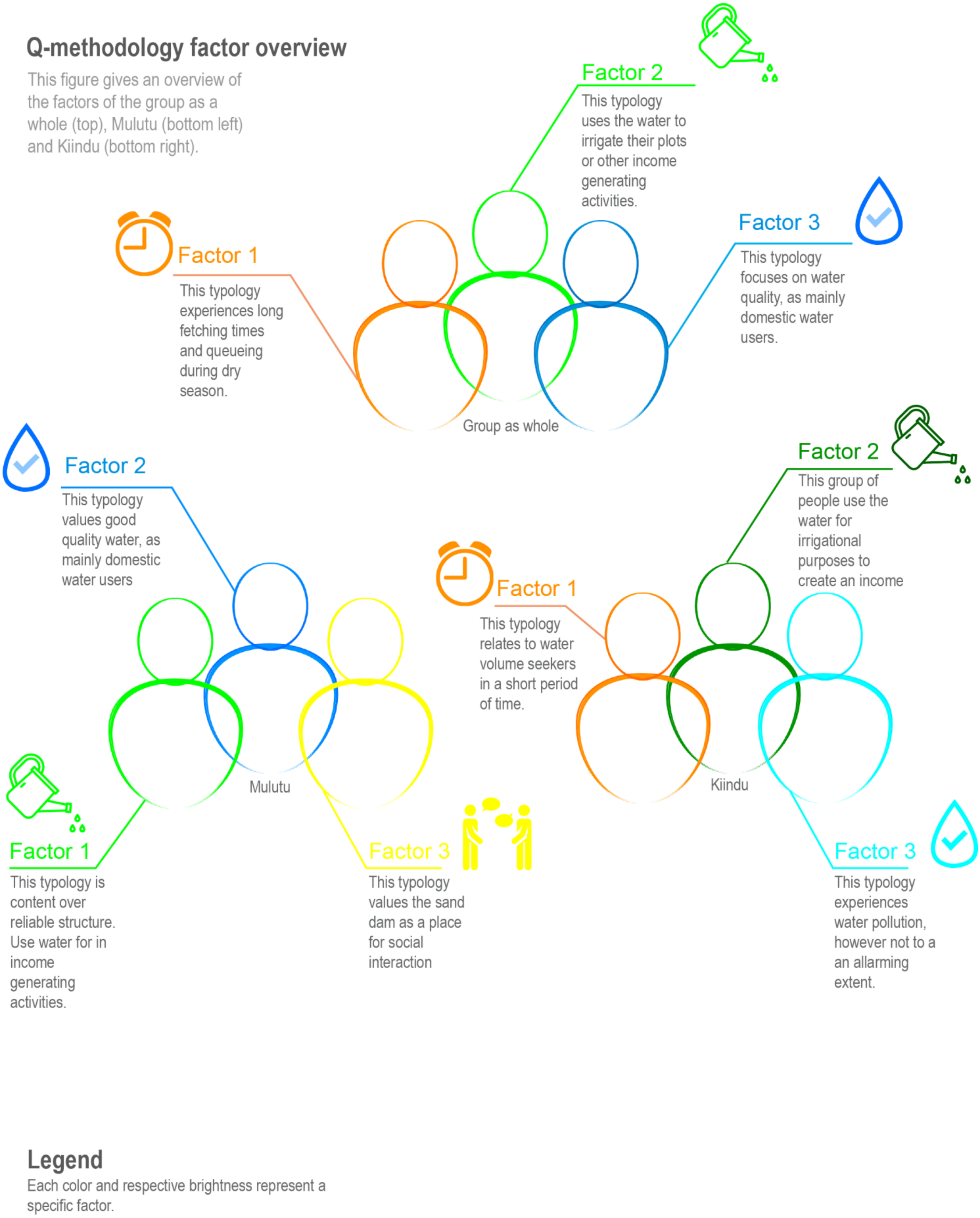

Figure 40 Q-methodology factor overview.

7. Discussion

The research objective is to evaluate how communities in Kitui assess the change in water access. The main interest is to see which elements of water access are valued by the people and why. To do so, at first, an overview was created, based on both literature and interviews, about the definition of water access, where both direct elements like distance, time and reliability were applicable, and indirect elements like ownership and agricultural activities were described. The people's opinions were evaluated regarding these different elements of water access: what is their consensus and what not? The latter resulted in differentiating factors, highlighting the various characteristics of both communities. In this discussion, we explore further the meaning, importance and relevance of the findings. It focuses on the evaluation of findings and how this relates to the research question. This in support of the overall conclusion, which is addressed in the next chapter.

First: *What do the results mean?* Communities are dynamic: there is consensus, however, the findings also show sensitivities highlighted in the different factors. On average, people value their short walking distance to the water resource, in both regions. The difference between those regions lies in the agricultural activity and pressure on the water resource, which seems higher in Kiindu. This is logical because of the age of the sand dam, through which development took place. The different water use purposes such as agriculture, drinking water, livestock and brickmaking, for example, are shown to be of importance, highlighted in the different factors. An example can be seen in a higher z-scores of the statement 'I have a higher income since I started making use of the sand dam.' which relates to the factor where people perform intensive agricultural activity, most of the time income-related. Location towards the sand dam also plays a role in the diversification between factors. People living close, have their water source readily available, compared to people living further away, who expand their working activities towards livestock keeping, brickmaking and other jobs, sometimes not related to water as well. This difference in location also leads to a difference in dependency on the water source. People living further away make use of other water resources such as rainwater harvesting, or tapped water bought from the water kiosk. This difference in dependency leads to a different appreciation of the sand dam. People fully depending on the source tend to be more critical on the sources compared to people who are not fully dependent.

Did the Q-set and the factors allow you to answer the research question of which 'elements of water access' are valued? The analysis of the different factors was based on the outcomes of KADE software and personal interpretation. Based on the *distinguishing statements, people loading to a factor, z-scores of the statements* and *differences between the factors,* the outcomes were analysed. An example list of distinguishing statements was shown in chapter 6. Most convenient to interpret were those with extreme values, like +4 or -4. Those statements already give a strong view on a person's viewpoint. For most of the factors extreme values were included in the distinguishing statements, however, distinguishing statements can also have a less extreme value, like +1 or -1. These values need a different interpretation as people 'slightly agree' or 'slightly disagree'. These differences were taken into account carefully when formulating the factors. Next to those distinguishing statements are the people loading to a factor. How many people load to a factor is shown as the 'sort weight'. For the interpretation of the factors, people with the highest weights are taken more into account than people with a lower weight. Another indicator of Q is the z-score of a distinguishing statement. These values indicate how far off the statement is from the 'average'. The z-score can have a positive and negative value and indicate a higher or lower than average, which again helped to interpret the factors. However, sometimes the differences were so small, e.g., -1.224 and -1.124, that the z-scores were mostly used to compare which statement weighs more *between* factors instead of *within* a factor. Lastly, KADE gives another outcome which indicates the differences between the factors and shows the z-score difference between two factors, which is exactly how the z-scores were used to interpret the factors and how they are different from each other. Overall, it was useful to run multiple iterations, extracting various factors, to see the different outcomes. Sometimes one factor analysis can be easier to interpret than the other. For example in the analysis for the 'group as a whole,' the three-factor analysis clearly showed different typologies compared to a four-factor analysis where factors were more blend into each other. Running those iterations and seeing which iterations gives you the most interesting information, is thus a suggestion for the future researcher using Q-method. Overall, based on these different indicators the factors analysis clearly assisted in answering the research question.

The 'messiness' and a broad sense of water access, was highlighted through the findings. As found in the concourse development not only a distinction can be made between international standards of water access but also local indicators of the definition. Next to this, a clear distinction can be seen in the factor outcomes as well as in the literature, between people who value elements of *agricultural water access* and *domestic water access*. According to the analysis of the group as a whole, conflicts occur over water which is more likely to occur at this local level, between individuals than on community scale. According to Doorn, 2019, when different water users compete, conflict is more likely to happen, as *domestic* water users experience more conflict over water compared to the farmers, who experience water to be equally distributed according to the findings. Water users do compete with each other and competing demands may pose a distribution problem, as suggested especially in the region of Kiindu were pressures are higher through intensified agriculture. That means that the people who benefit from water used in the 'water-intensive activities' are often not the same as those who suffer the negative consequences of this water. The commitments that people have towards their water-related activities are usually met best by those who have an interest in the situation being brought about: in this case, intensified and income-generating agricultural activities. The results according to the different factor analysis show that access involves matters that range from a discussion of fundamental individual rights to community rights over water. Access leading to water security implies social decision-making on competing water use priorities of household, agricultural or other income-generating demands: it, therefore, goes beyond just water availability.

Overall it can be seen that the researcher has the power of forcing people into groups. Different factor summaries appear when going from the group as a whole to the two regions apart. Based on previous research we knew how communities appreciate a sand storage dam in general, however, it is important not to only know how effective and efficient the structure can be, but also how the burdens and benefits are distributed. We should, therefore, aim for a 'difference friendly world' where the dominant typology of farmers, who follow the succession stream of access to water, is no longer the standard. The use of water from the sand storage dam rests largely on the subjectivity behind consumer's, feelings, values and perceptions. The findings of the factor analyses add depth to the already existing research database: it suggests that individuals can play a role in addressing challenges and benefits regarding sand storage dams in their role as a member of a community.

Why do the results matter? When comparing Mulutu and Kiindu it can be seen that sand storage dams overall are a proven design over a longer period. In both regions the elements of reduced water fetching times and close proximities are valued. The appreciation of the people, who participated in this Q-sorting, towards their proximity and short fetching times is an example of this field-proven Q-method. Although the dam in Kiindu dates from decades ago, it still serves the local community and created a development in irrigational practices. The area of Mulutu has the advantage of a hand pump, which eases the job of fetching water, compared to the destroyed one in Kiindu forcing people to the only scoop for water. The overall ageing effect of the dam itself is not necessarily seen as having an impact. As long as constructed well, the dam can be seen as a sustainable, cost-effective structure for access to water, hence being a durable solution.

Furthermore, *what can't the results tell us?* The outcomes of this research are specific for this study area, as expected. For example, the gender balance of 75% women and 25% of men are characteristic of this research, however, might *not* be representative when zooming out to county or even country scale. The gender imbalance *does* represent the current situation of a woman's job to fetch water for this region, however, might not be the same ratio if researched from a different angle than access to water. The same argument counts for the variability of residence time, which has seen not to be of influence for the results and therefore not included in the factors. People move out, move in and are drivers of community dynamics. These changes over time, are again not comparable to other regions with differences in variables like these. Also, this research took place in two different areas where Mulutu contained a single isolated dam and Kiindu a cascade of dams: the latter surrounded by dams in worse state compared to Uvati and thus adding pressure on the water source. When taking this Q-method to another sand dam, different opinions and perspectives might be observed.

How is Q-methodology tool to be appreciated in this study? The strength of Q-methodology is to go beyond the obvious: it highlights the unique characteristics of a community. Implementing the methodology into this research diversified the research toolbox and provided the opportunity to explore the perspectives related to diverse sand storage dam users and their ability to access the water. It can be seen that Q-methodology has much to offer for the researcher because the identification of the participants' viewpoints in a reliable way has the potential to formulate and deliver community dynamics and open up the dialogue to create awareness not only within the different typologies but also between them. Several studies related to sand storage dams have been published over the years, however, no studies citing Q-methodology as the research design were found within this field. Researchers, governmental institutions and others often seek consumers' perspectives related to the impact of these dams and the truth behind feelings, behaviour, attitudes and perspectives. It is hard to find adequate numbers to study these aspects using quantitative research however, Q-methodology can be used to gain valuable insights from a water user group in a fairly short amount of time. What needs to be said though is that the tool is not free of influence. Performing Q-sorting and asking questions afterwards always influences the research. However, accurate concourse development is a procedure to deal with this. The same accounts for choosing a software of choice. Any other software might give you different results, however, the principle of the different software tools for Q-method are the same. Settings and visualizations are where you might end up with different results. The software tool comes up with the statistics of the factors: in that sense, you have less influence on those outcomes, however, it is still up to the researcher to believe them or not. Lastly, the choice made by the researcher to force people into groups is an influence, in this case into the region. However, those decisions are made to go into depth, generating other kinds of outcomes which are of interest when comparing, in this case, different regions.

8. Conclusion summary

This study aimed to define which elements of water access are valued by people who use water from sand storage dams in two sub-regions in Kitui - Kenya? The overall answer is that people value their proximity towards the dam and short fetching times, which are the obvious consequences of structures like sand storage dams. This appreciation is shown in the consensus statements of the group of respondents as a whole. However, differentiating factors appeared as well. Some seek large water volumes in domestic water use, mainly because of their large households. These members experience conflict as well, mainly during the dry season, over 'who fetches the water first?', specifically when queueing occurs. Another group of people, benefitting from water availability, managed to convert their surplus water into more intensive irrigation practices, leading to increased income. Next to this, water quality is important. More water with good quality being available, means more people making use of it for themselves and their livestock, even though the latter negatively influences water quality, according to the people in the respective typology. Even though the consensus statement 'I find clean water to be important' applies to all, water quality appears to be seen as a problem by few.

When 'forcing' the people into different regions, slightly different factors appear. A fairly group of people satisfied with the reliability of the water supply appears in Mulutu. Next to this is a group of mainly females, who value the aspect of quality and find the change in taste and odour to be a disadvantage. They are, contrary to the previous factor, less content with the dam itself. Thirdly, there is a group of mainly youngsters, who do value their decreased fetching times, but even more, the social interaction which takes place near the dam and the interpersonal aspects of fetching water, like networking and social support.

Kiindu is showing different factors, starting with a typology that values shorter fetching times. However, members do find the water source unreliable and find sand harvesting to be a problem, which cannot be tackled because of a lack of authority to act on it. Secondly, there is a typology which makes the most of the water from a sand dam through irrigated plots with vegetables and fruits, which increases the capital of water users. Lastly, a group of people, solely relying on the dam for domestic purposes and livestock, value their clean water supply and experience water quality issues related to odour and taste. Over time, Kiindu people may have become more individualistic and value this. This may challenge issues of ownership and a reduced sense of Harambee, as people do not see the water as being equally available and used among the community.

The community values, interrelationships and groups that have been brought up with the Q-method are different compared to the evident outcomes from previous research. For example, the differences in opinion between water users when fully relying on a sand dam, or the difference in age and its interlinked social interactive value of a dam, are new aspects. In general, the findings of the Q-method highlight the diverse and broad perspective of water access: different elements of water seem to be important to different kind of people varying from water quality, to time to agricultural activities. A distinction between domestic and agricultural water access was found as well, with different users value other elements of water access. Limited access because of distance/location affects choices in activities such as livestock keeping or irrigational activities. People closer to the sand dam have a more protected supply of water and can build prosperity from that in the cultivation of cash crops. It is important to stress this diversity of water access. These are, among other things, site and situation-specific. Water access does not have a 'shopping list' of elements. A 'customized list of elements' was created for this study, but other elements might appear when doing this type of research in other areas, with different people, environments and technologies.

This research stressed the broad definition of water access, specifically when zooming in to local sand dam use. This use has multiple faces: different users and values of water illustrate how the current water consumptions may lead to competing use and pose a distribution problem. The elements of water access showed clear intra-community and local variations. An example can be found in the terrain and thus physical access. A sand dam structure can become less efficient when easy access via roads is not taken into account in the design. Good pathways can eventually ease the job of fetching water, as community members can use their donkeys all year round or even 'upgrade' to carts and oxen, thereby doubling the load of water fetched in one trip.

Q-method provides people with a voice, open up the dialogue and create room for bottom-up community input to safeguard maximum community benefit, in its total 'bandwidth' of variance, from a properly designed and constructed sand storage dam. Strong debates occur among local, regional and national audiences. These debates are often time-consuming and may be less related to research findings than desirable. Then, what scientific studies or practical actions should follow? Future research can be expanded to explore the role of additional community characteristics, such as class, ethnicity and others like disability. Q-method can be used as a teaching practice and research tool for policymakers to perform similar research in other areas. This can enhance learning and encourage participation, which eventually will lead to a better understanding and enriched feedback on how individual sand dams are appreciated by people. According to an interview held at the NaBWIG workshop, Q-method could be used as a reflection tool encouraging the researchers to learn about water supply and demand dynamics of different communities. Structures like sand storage dams highly depend on human experience and thus subjectivity of access water for domestic and irrigation purposes. Understanding the various perspectives, gathered through a Q method study, can assist water communicators with research-based information to the diverse audiences. Knowing the characteristics of each perspective would benefit the communication process because the audiences could receive specific information relevant to their needs. All these options remain based on a better understanding of the interplay of multiple factors regarding water access, which is the basis for a more thorough understanding of how communities value their access to water regarding a sand storage dam.

Thoughts on future development & NaBWIG

This last part of the report builds on the results from this thesis, which combined a basic understanding of different typologies and local knowledge related to water access, based on data and analysis from the Q-method and the results from semi-structured interviews and observations, and links it to the NaBWIG project. Its objective to co-create a portfolio of water storage options with local stakeholders, combining a basic understanding of hydrological behaviour of ephemeral rivers and their aquifers, socio-economic drivers for water use *and* local knowledge, is a recognition of the desirability of common ground. The project applies adaptation pathways approaches to support long-term planning in uncertain times and develop systematic ways to make future adaptation decisions, in recognition of the desired long-term learning process between multiple players to monitor development and changes (Hermans, 2016). To specify and evaluate the interplay between environment and society, specific contexts are needed to explore the opportunities and threats of change at relevant (often local) scales. The tool of *adaptive investment pathways* that is used by NaBWIG to explore sustainable water storage, is influenced by uncertain socio-economic circumstances, climate variability and changing stakeholder demands. When addressing the challenges of adaptation of water resources under changing conditions, people can support flexible and resilient solutions coupled with *on-going monitoring and evaluation*. It is key to understand the linkages between biophysical and social aspects to anticipate the possible future of a society or community. When starting the dialogue it is easier for governments, funding agencies and other stakeholders to take action (Savenije, 2016). When utilizing a technique like sand storage dams up to its potential for all users, it is important to seek common ground between those users, as this is required to define a basis for compromise, cooperation and management of the resource. This common ground is closely linked to issues of water ethics, including values like equity and communal management. A definition of water ethics relates to how individuals and societies view and interact with water from different perspectives, which can be sometimes complementary and sometimes contradictory (Doorn, 2019). As such, as a project interested in creating resilience and food security using ephemeral rivers, NaBWIG also links to water ethics: one could argue it is an ethical project.

One of the possible water storage options for the portfolio of NaBWIG is a sand dam. This research showed how people value water access created by these dams by looking at two different regions with different experiences from sand dams: Mulutu has little experience with the sand dam, whereas Kiindu has gathered more experience with this structure over time. The region of Mulutu consists of an isolated dam where the focus lies on short fetching times, the opportunity for agricultural improvement and the sand dam is seen as a social meeting point. Kiindu, on the other hand, is now part of a cascade of sand dams where people are used to the benefits of the sand dam and transformed their lands into cultivated plots with more irrigation activities occurring. As stated earlier: the NaBWIG project aims to understand the linkages between biophysical and social aspects to anticipate the possible future of a society or *community*. However, the concept of a 'community' is rather challenging. Both regions suggest that 'one community' does not exist in either of the regions. The results from the Q-method show different perspectives within both communities on both domestic and agricultural water use, with specifics of perspectives depending on whether one takes the respondents as a whole or analyses them per community. In both regions, comparable elements arise, but different groups appear too. These two 'communities' are diverse in perspectives and one must look at both regions with different 'lenses' as their position is different from each other. The researcher may force these people into groups, which then are called a community, but in reality, is still a group of people with different interests. Nevertheless, it seems to be possible to indicate certain elements regarding ideas of water access that appear as relevant issues to consider. The perspectives on these elements may change *over time*, which would relate to the available experience with water from sand dams – as suggested by the results from the two communities that have been discussed. Next, some examples from the field are elaborated, highlighting its *opportunities* and *threats*. Typology results related to *agricultural activities* and *water quality* are explained to give an example of the locally relevant trade-offs and how they can enrich the adaptive pathway context, from a diverse communal perspective.

One typology values the sand dam as people can do irrigation. People bordering the sand dam exploit the water for crop cultivation to create an income. The sand dam gives them the certainty to do so. Mulutu farmers value the sand dam's possibilities to follow the succession line of agriculture, however, do experience risk on flooding, as they are close to the dam. The people in the region of Kiindu cultivate their crops more intensively. However, dropping water tables are seen as a threat as this can eventually lead to an insufficiency of the water source: affecting not only the farmers but domestic water users as well. This can be an explanation for an increase in conflict over the water source, as pressures increase over time. There is a difference between people who live close and people who live further away from the sand dam. Farmers living close can have both benefits and hurdles of the source as it can be insufficient for irrigation and only enough for potable and livestock use when water tables drop. Or, it can offer them security and more time as they do not have to go far to fetch water. When riding along the agricultural succession line or to get a 'kick-start' into it, the government can invest in distribution pipelines or pumps. At the individual level, people can invest in storage facilities, including water tanks. The outcomes of the report suggest that people who live further away, depending on multiple sources of water, were more content over the structure than people fully relying on it. This suggests diversification in additional water sources, such as rainwater harvesting using simple materials like iron sheet roofs linked to water tanks.

The element of *water quality* is stressed by a different typology. A group of domestic water users values the sand dam for its water availability and clean water supply. Compared to other water users they value their quality water more than others. They experience that, although the water supply has increased, the potential danger of pollution has increased with it: through defecation and urination or salinization. Their balance is between certainty in quantity versus uncertainty in quality over time. To ensure quality water and less contamination, a hand pump can be of use. However, these come for a high cost, though its benefits are of high impact as well. In Mulutu the hand pump was installed right after construction of the sand dam. SASOL placed one in Kiindu in the '90s. Violence and destruction can be seen as a threat in the area of Kiindu, as its materials are of value at the market. The hand pump got stolen in Kiindu and has not been replaced. A less costly measure, also with beneficiary outcomes, can be enhancing *by-laws.* By-laws are informal verbal rules, set up by local inhabitants to regulate themselves. Think about tying animals to trees to decrease the risk of pollution through defecation or urination *or* separating scoop holes for different water purposes. These laws are valued by locals to local people. Another example relates to the possibility for community members to earn an extra income. This through fetching other household's water for a small price, or by mobilizing community members to create a scoop hole, where other community members can make use of, again for a small price.

Another outcome of this research highlighted the dynamics around the activity of sand harvesting: both an opportunity and threat. People value the activity as it generates an income or because the sand can be of use in construction, but the activity also deteriorates the performance of the sand dam over a longer period. It is a biophysical uncertainty, but it also closely relates to social dynamics. When rules are not obeyed or different opinions result in conflict, it can polarize a group of people thereby losing its social cohesion. This can be seen in the area of Kiindu. One way to make sure these dynamics are in balance is through a body of authority: *sand dam committees.* Field experiences show that both communities value the presence of a sand dam committee, although only in Mulutu one is active, in Kiindu they are keen on having one. These committees are groups of people from one area that have the authority to speak up when for example pollution rates increase, water tables drop because of intensified agricultural activities or sand harvesting activities are done without a permit. This authority can also assist in regulating rules regarding river bank maintenance for example. This to prevent siltation in the long run which can decrease the performance of the sand dam. Next to these aspects, sensitivities and issues, like conflict over scoop holes and queueing, can be captured in organizations like these. It is key to lower the risk towards conflict, which in Kiindu shows to become more present over time. It is, however, difficult to speak up as an individual when conflict arises. Through an authority like a sand dam committee, it becomes easier to mitigate during a conflict. Not only a dialogue can be stimulated through a sand dam committee, but education can also be supported. Education can assist local people in better-informed investment options like diversifying in crops, small livestock or other income-related activities.

These examples show some of the 'community' dynamics that enable or hinder optimum use of sand storage dam. Here it is suggested to open up the dialogue to monitor key elements like *agricultural activity* and *water quality*. Local inhabitants can act like *'living monitors'*, expanding their knowledge on water use from sand dams when pressures like climate change or a change in water use can result in different needs and redistribution of water priorities in the region. By taking into account typologies and how they value their water, you can cover the many needs of a 'community'. This way, not only one group of favourably located farmers end up in the succession line of development, while others drop down and experience negative changes from the extraction of water from sand dams.

This 'community diversity' stresses the need *for ground realities to be checked* when working with adaptive pathways. By incorporating management structures like *sand dam committees* and the self-regulating ability through *by-laws*, you can create more participation in decision-making, including the possibility for people to intervene in their relation to sand storage dams. Members of local communities can articulate their interest and show their concerns and needs through sand dam committees and by enhancing the by-laws of a community you can make sure the neediest people will not experience negative consequences versus the people on the 'agricultural succession line'. Policies can address these ethical and traditional management systems concerning access and use of water resources, to prevent conflicts from occurring. These conflicts will not only be about access to and withdrawal of the water, but also the control over its management. Overall, it is found to be important to cover the community dynamics and to support cohesion between different groups. Inclusion of community ethics, self-management capabilities and values in decision-making processes can support the development of sand storage dams making the most out of it. A key factor is to open up the dialogue between stakeholders, community members and policymakers, to create awareness of what is happening within a group of people and explore where improvement can take place, based on *their* local knowledge. Common interest groups within the local communities can be formed to express their values, cultural and ethical perceptions towards it. This can create people's awareness of the impact their activities have on the vital water resource.

Final remarks

A sand storage dam is one of the water storage options that can be included in a portfolio to cope with uncertainties and increase resilience. So, is this technique a valuable one to include within NaBWIG's portfolio of storage options? Based on this study, sand dams are seen as valuable structures for development. It gives both regions more security in water supply and gives them the opportunity through reduced water fetching times to spend their time on other activities. These activities might not result in a higher income through agriculture right away (Mulutu) but *can* flourish over time when people have more experience in using a sand storage dam (Kiindu). It must be said that Mulutu is a different region compared to Kiindu. Kiindu has transformed into a cascade of sand dams, some of them work (Uvati), some don't (upstream and downstream), with increased pressure on both the resource and social dynamics as a result. Nonetheless, sand dams can be seen as a cost-effective, long-term solution to increasing water security for local inhabitants. Through Q-method, the different characteristics of a community appear, with each its different water access priority. When planning adaptive, you, therefore, do not need to focus on the 'overarching community' or 'community' in general, but by taking different characteristics into account. This way you can make sure a structure like sand storage dams can be effective for all in a sustainable way. To make national-scale characteristics more relevant at a local scale and the other way around, it is key to enrich the 'adaptive pathway' context with locally relevant details, such as their threats and opportunities, thereby checking a pathway with ground realities. These can give relevant insights into the conditions under which problems occur and make trade-offs transparent.

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Appendix

1. Instructions letter

Dear sir/madam,

My name is Judith Brummelkamp and I am currently working on a thesis for the Technical University of Delft and IHE Delft, Institute of Technology for research, in the Netherlands.

I am evaluating how communities assess the change in water access since they make use of a sand dam.

I would appreciate it if you could share your thoughts and opinions on the change in access to water since you make use of the water from the sand dam. Therefore it would help me if you could fill in this Q-sort which won't take longer than 30 minutes. All the information you provide is confidential, your results will be used anonymously and your name will not be disclosed anywhere.

Also, I would like to stress that participating is voluntary so if you do not want to participate in this research; that is perfectly fine. So what to do if you want to participate? **Please arrange the statements in your preferred order of agreement varying from most disagreeable to most agreeable**. Which statement cards regarding water access are most applicable to you and what do you value most, that is what you should take in mind.

For questions about the research, results from the research or other questions, do not hesitate to contact me at J.M.Brummelkamp@student.tudelft.nl or via phone at +31612101241 or +254740770791

Kind regards,

Judith Brummelkamp

Nitawa Judith Brummelkamp,

nisomea Technical University of Delft and IHE Delft, Institute of Technology for research, in the Netherlands. Niendeye kusoma undu andu masenzetye kukwata kwa kiw'u kumana na kutumia ming'eto.

Ni muyo kwakwa ethiwa ukanengane mawoni maku undu kukwata kwa kiw'u kusenzetye kuma wambiya kutumia mung'eto.

Ngatetheka muno ila nukusuisya Q-sort ino ila itamina ndatika 30. Maovoo ala unengane nimasuviiku na makatumika kwanzia yaile na isyitwa yaku yitikawetwa vandu.

Nikwa kwiyumya kwaku kusuisya , na ila ndukwenda kuusuisya vayi undu.
Ethiwa niwiyumitye **vanga misoa yino kwianana na undu we ukwitikilana nayo kuma ula uleana na w'o muno muvaka ula ukwitikilana naw'o muno**.

Kwa maukulyo mbee no ugwatwe kwisila : J.M.Brummelkamp@student.tudelft.nl kana namba ya simu : +31612101241 / +254740770791.

Nimuvea,

Judith Brummelkamp

2. Example of a personal page

This table was used to summarize the evaluative interview per Q-sort conducted. The database of personal pages is available upon request to value participants privacy.

Personal page – participant information

Date: /01/20
Time:

Questions	*Answers*	*Notes*
1. What is your name?		
2. Male/female		
3. How old are you?		
4. What is your occupation?		
5. How long have you lived here?		
6. What is your status? (single, married, etc.)		
7. How many people does your household contain in total?		
8. What do you use the water for?	Irrigation ☐ Drinking water ☐ Livestock ☐ Household duties ☐ Other, namely ……………… ☐	
9. How much water do you use?	*Ask for the number of trips, the number of jerry cans used and way of transportation*	
10. If agreed with statement 19, explain.		
11. If agreed with statement 24, explain.		
12. If agreed with statement 25, explain.		
13. If agreed with statement 31/32, explain.		
14. +4 statements + explanation		
15. +3 statements + explanation		
16. -4 statements + explanation		
17. -3 statements + explanation		
18. Anything they would like to add?	*Get the story per person*	

3. Q-statement database

Here an overview of all statements formulated based on the concourse development. This set of statements was used as a trial in the field to eventually select the 34 statements that were used for the final Q-sort as was stated in chapter 4.

Statement	Nr.	Statement in Kamba
I find the walking distance towards and from the sand dam very short.	1	Nona kitambo kya kuthi munge'toni kikikuvi
I don't mind using another water source which is further away.	2	Ndyonaa ve vata wakutumia kiw'o kuma kundu kungi kwi kuseo
I find a water source being close to me being very important.	3	Nonaa vala nitavaa kiw'o vakuvi ve vata muno
Fetching water from the sand dam costs me less time compared to other sources.	4	Kutava kiw'o kuma munge'etoni ni laisi kwi kuma kunduni kungi
During the dry season, it can get very busy, I have to wait in the queue for a long time.	5	Yila kwina munyao kwithaa kukwatanu netelaa musitali kwa kilungu kiingi
During the dry season, I have to dig deeper to fetch water from scoop holes.	6	Yila kwi munya ninzaa kithima kiliku kutava kiw'u
I can fetch water within an hour during the dry season.	7	Nonitave kiw'u kwa kilungu kya isaa imwe kwina munyao
The sand dams give me enough water during the dry spell (August - October).	8	Mung'eto unengae kiw'o kianu ivinda ya munyao(mwai wa nyaa -mwai we ikumi)
On average, I use more water since I make use of the sand dam.	9	Ngitala nitumiaa kiw'u kiingi nundu nitumia kiw
I can carry more water since I have a donkey.	10	Nikuaa kiw'u kingi nundu nithaa na ing'oi
My livestock has more water to drink since I use the sand dam.	11	Indo syakwa yu syina kiw'u kingi kyaunya nundu nitumia mung'eto
I find clean water to be more important.	12	Nonaa kiwu'u kitheun ki kyavata muno
I find safe water to be more important	13	Nionaa kiw'u kitheu kimaana muno
I treat the water with chlorine/water guard before I drink it.	14	Nikiaa kiw'u dawa ndanamba kunywa
During the dry season, I find the water to be saline.	15	Ivinda ya munyao kiw'u kithiwa munyu
I find the sand dam to be a reliable water resource.	16	Nonaa kiw'u mung'etoni kikyakwikwatwa
I only use water from the sand dam for domestic needs	17	Ndumiaa kiw'u kya mung'eto mavatani ma musyi
I only use water from the sand dam for livestock water needs	18	Ndumiaa kiw'u kya mung'eto kunyithya indo
I only use water from the sand dam for crop irrigation needs	19	Ndumiaa kiw'u kya mung'eto kunyitya mimea
I find the sand dam easily accessible in the dry season only.	20	Nionaa mung'eto nelaisi kuthi ivinda ya Thaano
I find the sand dam easily accessible wet season only.	21	Nionaa mung'eto nelaisi kuthi ivinda ya mbua
I find the sand dam easily accessible in both dry and wet seasons.	22	Kiw'u kuma mung'etoni kikwatikana mituki kwi mbua na kwi munyao
My path to the sand dam is more difficult during the dry season.	23	Nzia yakuthi mung'etoni ni laisi ivinda ya thaano
My path to the sand dam is more difficult during the wet season.	24	Nzia ya kuthi mung'etoni ithiwa na mathina kwi mbua
I like it that I can more easily cross the river via the sand dam during the wet season.	25	Niniendete mungeto nundu no nikile usi kwisila mungetoni ivinda ya mbua
I can now grow more crops since I use water from the sand dam.	26	Nonivande mimea mbingi nundu nitumiaa kiw'u kuma mung'etoni
I can now diversify my livestock since I use water from the sand dam.	27	No niithye indo mbulenwe nundu nitumia kiw'u kya mung'eto

I can now engage in other social activities since I use water from the sand dam	28	Oyu no nike maundu angi nundu nitumia kiw'u kya mung'eto
my children can engage in fulltime schooling since I use water from the sand dam.	29	Syana syakwa nosisome masaa monze nundu nitumiaa mung'eto
Since I make use of the sand dam, I feel freer to do other activities.	30	Nundu ndumiaa mung'eto niwaa nina saa sya kwika maundu angi
I have a higher income since I started making use of the water from the sand dam.	31	Nina ukwati munene kuma nambiya utumia kiw'u kya mung'eto
I experience conflicts over water from the sand dam during the dry season.	32	Ninonie ithokaa ivinda ya thaano nundu wa kiw'u kya mung'eto
I experience conflicts over water from the sand dam during wet and dry seasons.	33	Ninonaa ithokaa ivinda ya thaano na ya mbua nundu wa kiw'u kya mung'eto
I experienced discussion sometimes over water from the sand dam during the dry season.	34	Ni veethiwe na ithokoo ivanda imwe vaa mung'etoni ivinda ya munyao
I go through somebody else's land to get to the sand dam.	35	Nisilaa kithekani kyene kuthi mung'etoni
I find that everybody in the area can use the water from the sand dam.	36	Kila mundu vaa no atumie kiw'u kuma mung'etoni
I find the sand dam to be a good place to chat with my friends.	37	Mungeto nionaa ne vandu vaseo vo kueya ngewa na anyanyawa
The sand dam is owned by an NGO.	38	Mung'eto niwa kikundi
the sand dam is owned by the Government.	39	Mung'eto ni wa serikali
We, as a community have ownership over the dam.	40	Ithye ta kikundu mungeto uno ni witu
I find having a sand dam committee within our community important.	41	Nonaa kwitha na kamitii ta kikundi kwi vata
I feel responsible for maintaining the buffer zone around the dam.	42	Niwa niwia wakwa kuseuvya ndee sya mung'eto
Because of siltation, I can only use water from the centre of the sand dam.	43	Nundu wa kulindika ndonya utumia kiw'u kuma katikati wa mung'eto
I find sand harvesting to be a problem affecting the sand dam.	44	Kutavwa kwa kithangathi ni muisyo vaa mung'etoni
I am happy with the sand dam.	45	Nimutaanu ni mung'eto
I can go to school later in the morning as my time to fetch water is short.	46	Nonithi sukulu kioko tene nundu ivinda ya kutava kiw'u ni yoleku
Some plots are too close to the river, this stimulates siltation.	47	Miunda imwe ivakuvi na usi na nitumaa usi ung'ala
Life is more simple since we make use of the sand dam.	48	Maisha nimololo nundu nitumiaa kiw'u kya mung'eto
People living further away from the sand dam have more water available.	49	Andu ala mevaasa na mung'eto mena kiw'u kianu
So many people use the sand dam, the water is being exploited too much.	50	Andu aingi matumiaa mung'eto kwou kiw'u kiingi nikitavwa
I sometimes sell the water at the market.	51	Mavinda amwe nonithooasya kiw'u soko

4. Interviews

This appendix gives an overview of the people interviewed to create the concourse of this research. Also, the evaluative interviews after conductance of the Q-sorts are shown which were of help for the interpretation of the factors. The interviews are available as recorded files, transcription into a Q&A format and summarized in 'personal pages' which were created per Q-sort conducted. These are available on request to value participants privacy.

Interviewee	*Description*	*Date*	*Notes/topic of the interview*
Benade	Engineer at SASOL	5/12/2019	General information about sand dams in the area + the history of SASOL and study area suggestions. Concourse development
Mutinda Munguti	Executive chief of SASOL	5/12/2019	General information of sand dams, the vision of SASOL, opinion on improved water access since the construction of dams. Concourse development
Community members of Mulutu area	Community members and participants of the sand dam committee	6/12/2019	Concourse development
Community members of Kiindu area	Community member	7/12/2019	Concourse development
Moses Mwangi	South Eastern Kenyan University	9/12/2019	Concourse development + guidance within narrowing down the scope of research
Community member of Mulutu area	Community member	10/12/2019	Concourse development
Community member of Mulutu area	Community member	10/12/2019	Concourse development
Community member of Mulutu area	Community member	10/12/2019	Concourse development
Community member of Mulutu area	Community member	10/12/2019	Concourse development
Community member of Kiindu area	Community member	11/12/2019	Concourse development
Community members of Kiindu area	Community members	11/12/2019	Concourse development
Community members of Kiindu area	Community members	11/12/2019	Concourse development
Community member of Kiindu area	Community member	11/12/2019	Concourse development
Fred	Director of Environment and Natural resources, Kitui county. Previously working for SASOL	16/12/2019	Concourse development. Current challenges regarding sand storage dams.
Matthew	Engineer at SASOL	18/12/2019	Concourse development. Study area specification.
Community members of Mulutu area	Q-sort evaluation of trial run	20/12/2019	Evaluation of the trial run of Q-method
Community members of Kiindu area	Q-sort evaluation of trial run	20/12/2019	Evaluation of the trial run of Q-method.
Community members of Mulutu (**26x**)	Q-sort evaluation interviews	14/01/2020 – 11/02/2020	Evaluation of the Q-sorts done in the field
Community members of Kiindu (**24x**)	Q-sort evaluation interviews	14/01/2020 – 11/02/2020	Evaluation of the Q-sorts done in the field
Kisengau	Department of water and agriculture	14/02/2020	Evaluation of findings in the field
Members of the agricultural department	Extension officer & finance	20/02/2020	Evaluation of findings in the field
Leah Mukiite	Water Resources Authority Resources Mobilization & Partnership	25/02/2020	Implications of the findings within NaBWIG and policymakers.

5. Q-sorts conducted (RAW data)

Here an overview is given of the raw data showing each statement value per Q-sort.

participants	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17	s18	s19	s20	s21	s22	s23	s24	s25	s26	s27	s28	s29	s30	s31	s32	s33	s34
QSORT1	-1	0	3	-3	3	-1	-1	2	2	-3	0	2	1	1	-2	-2	1	-1	0	-4	0	4	0	4	-1	0	-4	1	1	-2	-2	-3	3	2
QSORT2	0	0	2	-2	-2	-3	-3	3	3	4	-1	2	3	0	-2	0	-1	-1	0	1	1	1	1	4	-4	2	2	-1	-1	-3	-4	-2	1	0
QSORT3	-2	4	-4	-3	0	0	0	2	1	-1	1	-3	-3	3	0	3	-2	-4	-1	-1	-1	-2	2	3	0	1	2	1	-1	-2	0	1	2	4
QSORT4	-3	-1	-2	-3	0	0	1	-1	0	4	1	-1	0	-1	2	4	2	-4	2	1	1	-1	0	-2	0	2	-3	1	-2	3	3	-4	-2	3
QSORT9	-2	3	0	-2	1	-3	-3	1	-1	4	1	2	1	2	0	2	0	-2	-2	1	-1	0	0	0	-1	-4	2	4	-1	3	-3	-4	-1	3
QSORT10	-1	2	-3	-2	3	4	1	0	4	0	1	-4	-2	0	0	2	3	1	0	-1	1	-3	-1	-1	-4	1	0	2	2	3	-2	-2	-1	-3
QSORT11	-3	0	1	-3	1	-3	-2	-1	2	0	1	1	3	0	-1	-2	2	4	0	3	4	-1	-1	0	1	2	-2	0	-2	2	-4	-4	-1	3
QSORT12	-3	2	1	-1	2	-4	-2	0	0	3	1	-1	0	4	-4	0	0	-2	3	-2	3	1	-1	-1	0	1	-2	2	4	1	-1	-3	-3	2
QSORT18	-1	1	-3	-1	3	-1	3	0	2	0	0	0	0	0	1	1	-1	-2	-4	2	2	-1	-3	2	-3	-2	1	3	-4	-2	4	-2	4	1
QSORT19	-2	1	1	3	2	-3	0	-4	1	-1	0	-2	-3	3	-2	4	0	-4	-1	1	-1	0	-2	-1	2	0	4	0	1	2	-3	-1	2	3
QSORT20	1	2	-3	-4	3	-3	4	2	0	2	-4	-1	0	-2	0	-1	0	1	-2	3	-1	-1	-2	-1	2	0	3	-2	-3	0	1	1	4	1
QSORT21	-2	1	-1	-3	-2	3	3	3	1	0	-1	1	-4	2	1	0	0	-3	-1	-3	2	2	-4	0	2	4	-2	-2	-1	0	4	1	0	-1
QSORT26	-2	1	-3	-4	4	-3	3	2	0	3	-3	1	1	0	0	2	-1	-1	0	-2	-1	-1	0	0	1	2	3	1	-1	4	-4	-2	-2	2
QSORT27	-4	0	-4	-2	-1	-2	-1	2	1	2	1	3	3	1	3	0	2	-2	1	2	4	-1	-3	0	0	0	-3	4	1	-1	-2	-1	-3	0
QSORT32	-1	1	0	-2	-1	0	0	-1	4	-3	1	1	2	0	0	-2	-2	-3	-4	-1	4	-2	-3	2	3	3	2	1	-1	2	1	-4	3	0
QSORT33	-2	2	0	-3	3	-3	-3	-1	0	-1	-2	2	1	1	3	-1	0	4	1	-4	1	0	-2	-1	0	2	1	3	2	-2	-1	-4	0	4
QSORT34	-4	3	3	-1	1	-4	1	-3	1	0	-3	1	2	4	0	0	-1	-1	0	3	2	-2	1	-1	0	2	0	-2	2	-3	-1	-2	-2	4
QSORT35	0	1	-1	-4	-1	1	4	-1	-2	-2	-1	1	2	2	4	0	3	0	2	0	2	-2	-3	0	-3	0	1	1	-1	-4	-3	-2	3	3
QSORT36	-2	3	3	-3	-1	-3	2	-1	0	-1	4	0	1	4	2	1	1	3	2	-3	0	-2	-4	0	-1	-1	1	-2	-4	0	2	-2	0	1
QSORT37	0	1	0	1	1	-2	2	0	-2	-1	3	-4	2	4	3	1	2	4	0	0	-4	-1	0	-3	3	2	-3	-2	-3	-1	-1	-2	-1	1
QSORT38	1	2	-3	-3	2	2	1	0	0	-2	1	-1	0	0	3	4	2	-1	-3	0	-2	-4	-1	-4	-1	3	-2	3	0	4	1	-2	-1	1
QSORT39	-2	2	-2	-4	0	-4	-1	0	1	1	0	2	2	4	0	1	-3	-2	1	3	1	4	-1	3	-1	0	2	-3	0	-3	-1	-2	-1	3
QSORT44	-3	0	1	-2	-1	2	3	2	-1	4	1	1	0	3	0	-2	2	0	-1	1	-4	-2	0	-2	0	3	4	-1	1	-1	-3	-4	-3	2
QSORT45	-3	3	-2	-2	0	-1	-3	-1	2	4	0	3	2	1	4	3	1	-4	1	1	2	1	-2	0	-2	-3	-1	-4	0	2	0	-1	-1	0
QSORT46	-4	4	-1	-4	-2	2	2	0	1	0	-1	-2	0	2	4	1	3	-1	1	2	0	-2	-1	-3	-3	0	1	1	3	3	-2	-3	-1	0
QSORT47	-1	1	-4	-1	0	2	3	1	4	4	3	0	1	2	0	2	-4	-2	-1	0	-3	-3	0	2	-1	-2	0	3	1	1	-3	-2	-1	-2
QSORT5	-1	2	-1	-3	3	4	1	4	1	-2	1	-2	0	0	2	-3	3	-3	0	-1	-4	1	-2	0	-1	-4	3	-1	1	-2	2	0	0	2
QSORT6	0	3	2	-1	-1	-1	-2	1	-3	-4	0	0	1	1	-1	-2	-3	0	2	-1	3	0	-3	3	0	-4	1	2	2	-2	4	-2	1	4
QSORT7	-2	3	1	-1	0	0	-3	2	3	4	-3	1	0	-2	-1	-1	0	-2	3	-3	2	2	0	1	2	1	4	-4	0	-2	-4	-1	-1	1
QSORT8	-2	2	-2	-1	1	0	1	-3	0	3	0	-1	-2	2	-4	-1	-2	1	4	-1	3	1	-1	0	-4	0	1	2	-3	0	4	2	-3	3
QSORT13	-1	1	-1	-4	0	-1	0	3	2	3	4	-3	-2	4	-1	0	-2	-3	2	1	2	-1	1	1	-2	0	3	0	2	-4	0	-3	-2	1
QSORT14	3	3	-1	-3	-1	2	2	-2	1	0	4	0	3	4	1	-1	1	-4	0	-1	1	-3	-2	-2	-2	1	0	2	-4	0	2	-3	0	-1

QSORT15	-2	2	-2	-4	-3	0	2	2	1	1	0	-3	1	2	-1	-1	0	4	-1	3	1	-3	-1	3	-2	0	1	-1	0	-2	0	-4	3	4
QSORT16	-4	3	1	0	0	4	2	2	0	-1	3	0	-3	3	0	-1	4	1	-1	1	-2	-3	-1	-2	-4	-2	2	-1	-3	0	1	-2	1	2
QSORT17	-2	0	-3	-1	1	2	3	4	0	3	0	-2	-4	2	0	0	2	1	1	4	-1	-2	1	-2	-1	2	-1	1	3	-3	-3	-4	-1	0
QSORT22	-3	1	-1	2	0	1	1	0	1	-4	2	-2	0	0	1	4	3	3	-1	-1	-2	4	-3	-3	-4	-2	-1	2	-2	3	2	-1	0	0
QSORT23	-4	2	3	0	-3	-3	-1	-1	-1	1	-2	1	1	3	-2	0	0	4	3	-2	4	0	-1	2	-2	-1	1	2	0	2	-3	-4	0	1
QSORT24	4	1	-1	-4	0	3	3	-3	-1	0	-3	-1	1	2	-2	1	2	-2	2	4	3	1	2	0	-2	-3	1	0	-4	0	0	-1	-2	-1
QSORT25	-1	-1	-1	-3	0	2	2	2	0	-2	-4	1	1	0	1	-3	-2	2	3	-1	3	-2	1	1	-1	0	4	4	-2	3	0	-3	-4	0
QSORT28	-1	4	-4	-2	2	-3	-3	-4	1	2	1	2	0	3	0	0	-1	-2	4	-1	1	3	0	2	-2	-1	3	1	0	-3	-2	-1	0	1
QSORT29	0	2	-1	-2	2	1	4	3	4	-3	2	-4	3	2	-1	1	1	0	-1	3	-2	-2	-3	-1	-3	-2	1	0	-4	0	0	-1	0	1
QSORT30	-1	4	1	-3	-4	0	4	-3	-2	-1	-1	-1	2	-1	1	3	0	0	2	3	1	-2	-4	3	-3	-2	0	2	-2	1	1	2	0	0
QSORT31	-2	2	-1	-4	-1	1	3	-1	-3	3	-1	-2	0	4	4	-4	2	1	0	1	1	2	-1	-2	-3	0	-2	2	-3	0	3	0	0	1
QSORT40	-1	2	0	1	1	-4	-2	0	1	0	3	-3	0	3	1	0	2	-3	1	0	-4	-2	-2	-3	4	-2	-1	4	-1	3	2	-1	-1	2
QSORT41	-2	1	-3	-3	-1	4	4	-1	1	-1	0	-3	2	3	1	3	-2	0	1	2	3	2	0	2	-1	0	-4	0	-1	-2	0	-4	-2	1
QSORT42	-4	2	0	-3	-2	0	3	-3	0	-1	3	-2	-3	1	3	1	4	-1	-1	2	2	1	0	-2	-2	-1	1	1	-4	2	4	-1	0	0
QSORT43	1	1	-1	-1	2	0	-3	4	2	3	0	0	1	1	4	-1	3	0	-3	3	-2	-2	0	-4	-1	-2	0	2	-4	-2	2	-3	-1	1
QSORT48	0	-1	-1	-1	0	1	4	-2	-1	-3	2	-4	3	1	3	2	-2	1	1	3	0	-2	0	-2	-1	-3	2	2	-4	4	1	0	-3	0
QSORT49	-4	1	-2	-3	0	-1	1	3	-2	3	-4	-1	-1	1	-1	0	4	1	1	0	2	4	-2	3	-3	-1	0	0	2	0	2	-3	-2	2
QSORT50	0	1	-2	-4	0	2	-1	-1	-1	-1	0	0	3	1	4	0	-2	2	2	3	3	4	-2	-3	-3	-2	-1	-3	-4	1	1	1	0	2

6. Correlation table

Here an overview is given of the total number of Q-sorts correlating with each other. This is one of the KADE outputs realized during data analysis.

Correlations between Q-sorts

Participant	QSORT1	QSORT2	QSORT3	QSORT4	QSORT9	QSORT10	QSORT11	QSORT12	QSORT18	QSORT19	QSORT20	QSORT21	QSORT26	QSORT27	QSORT32	QSORT33	QSORT34	QSORT35	QSORT36	QSORT37	QSORT38	QSORT39	QSORT44	QSORT45	QSORT46	QSORT47	QSORT5	QSORT6	QSORT7	QSORT8	QSORT13	QSORT14	QSORT15	QSORT16	QSORT17	QSORT22	QSORT23	QSORT24	QSORT25	QSORT28	QSORT29	QSORT30	QSORT31	QSORT40	QSORT41	QSORT42	QSORT43	QSORT48	QSORT49	QSORT50
QSORT1	100	35	8	-14	11	-7	26	31	8	-6	-16	9	4	7	23	40	11	18	9	-10	-19	26	-10	-3	-15	-9	20	32	19	-12	8	-4	9	-5	-9	1	24	-16	-4	21	1	-21	-6	-9	12	-21	-12	-47	24	-9
QSORT2	35	100	9	-10	32	-14	31	19	5	-9	3	-18	19	21	13	13	26	10	-1	-29	-40	54	20	24	-7	16	-16	-1	54	-3	39	-4	33	-14	5	-36	36	1	3	35	0	-3	-16	-34	-1	-31	9	-40	21	-5
QSORT3	8	9	100	17	24	17	-19	9	37	33	21	25	28	3	19	6	15	19	10	0	24	36	9	8	20	36	31	17	11	19	53	19	39	24	21	-7	-11	1	-3	35	28	12	5	19	27	19	5	1	9	-8
QSORT4	-14	-10	17	100	31	24	23	31	20	8	3	25	35	42	8	5	14	11	15	14	51	11	19	46	41	18	-4	-18	-4	24	21	33	9	11	24	16	-1	18	8	4	9	18	33	34	39	49	27	26	30	19
QSORT9	11	32	24	31	100	5	32	43	21	33	4	-31	50	38	7	31	22	6	16	-4	19	38	29	45	31	38	6	14	16	8	28	16	16	18	9	8	40	6	11	41	11	8	10	43	-3	13	41	9	26	3
QSORT10	-7	-14	17	24	5	100	8	14	14	6	-4	8	23	14	8	5	-16	12	2	-1	57	-27	13	9	60	43	21	-31	-6	11	23	27	17	34	45	36	1	14	21	1	40	8	8	4	28	26	12	21	15	-6
QSORT11	26	31	-19	23	32	8	100	36	-1	1	6	-22	27	44	32	45	44	20	27	21	5	28	18	17	19	-10	-29	2	16	3	4	4	39	3	10	-3	51	1	22	11	13	2	9	7	18	9	15	4	17	23
QSORT12	31	19	9	31	43	14	36	100	-17	30	-28	1	30	39	3	40	46	-9	15	0	-4	35	17	24	20	9	-14	24	28	38	48	6	4	-10	21	-8	52	-9	3	43	-14	-14	6	36	13	-6	-11	-23	41	-15
QSORT18	8	5	37	20	21	14	-1	-17	100	11	46	16	11	18	41	5	3	33	19	-14	22	22	-16	15	4	26	23	21	-26	23	17	38	37	28	1	22	-11	19	6	16	49	31	28	6	28	39	36	21	16	17
QSORT19	-6	-9	33	8	33	6	1	30	11	100	6	-13	24	-16	18	4	34	-4	6	6	8	19	9	9	13	7	-7	-2	9	1	10	-6	-7	9	-1	11	13	-8	-28	26	8	-1	-28	41	-13	13	-19	4	-11	-26
QSORT20	-16	3	21	3	4	-4	6	-28	46	6	100	13	45	-10	13	3	7	21	6	8	11	18	9	0	4	-2	22	-9	9	1	-3	-1	36	6	12	-14	-22	18	6	-3	35	16	22	-1	-8	9	26	8	16	18
QSORT21	9	-18	25	25	-31	8	-22	1	16	-13	13	100	4	11	31	-8	-9	8	16	-8	16	6	8	13	13	-3	20	-1	11	14	11	21	2	14	9	5	-18	-5	3	-14	0	4	31	-8	26	29	-9	-21	26	9
QSORT26	4	19	28	35	50	23	27	30	11	24	45	4	100	24	13	34	22	14	7	4	32	29	40	21	30	37	3	-23	33	10	16	1	12	-7	22	-11	19	5	41	24	14	0	3	12	6	-6	7	12	29	-5
QSORT27	7	21	3	42	38	14	44	39	18	-16	-10	11	24	100	16	29	23	32	6	-5	18	33	13	50	38	29	-4	4	8	5	25	21	14	-6	28	-1	23	-3	19	29	4	17	25	19	31	12	29	1	33	17
QSORT32	23	13	19	8	7	8	32	3	41	18	13	31	13	16	100	19	14	13	18	-19	18	14	-3	6	8	13	-3	24	9	-14	8	41	24	-3	-24	-12	11	-11	21	1	16	5	-10	7	12	14	-4	0	-16	-7
QSORT33	40	13	6	5	31	5	45	40	5	4	3	-8	34	29	19	100	40	39	33	14	15	28	15	8	21	-15	4	36	24	10	9	0	21	-3	4	4	46	-28	29	41	-13	-11	16	12	1	-8	16	-19	28	10
QSORT34	11	26	15	14	22	-16	44	46	3	34	7	-9	22	23	14	40	100	27	24	16	-6	55	32	25	29	-8	-16	18	23	15	29	3	30	4	16	-26	38	7	3	30	4	12	13	6	23	6	1	-6	17	5
QSORT35	18	10	19	11	6	12	20	-9	33	-4	21	8	14	32	13	39	27	100	41	16	19	24	25	12	46	0	25	23	-3	1	15	42	48	33	23	5	23	31	23	24	31	46	44	-15	38	26	11	18	22	34
QSORT36	9	-1	10	15	16	2	27	15	19	6	6	16	7	6	18	33	24	41	100	46	10	24	18	21	24	-2	12	29	-4	24	19	46	34	46	-16	31	41	-1	7	18	38	39	34	29	16	46	10	30	9	28
QSORT37	-10	-29	0	14	-4	-1	21	0	-14	6	8	-8	4	-5	-19	14	16	16	46	100	31	-5	28	-14	11	-4	0	-21	-29	-18	-6	19	15	23	22	27	-6	-11	-22	-17	32	-7	26	42	19	16	27	32	-15	12
QSORT38	-19	-40	24	51	19	57	5	-4	22	8	11	16	32	18	18	15	-6	19	10	31	100	-26	15	9	53	26	14	-24	-43	-12	-7	45	4	26	24	38	-28	5	9	-21	36	14	19	36	19	34	36	38	-9	8
QSORT39	26	54	36	11	38	-27	28	35	22	19	18	6	29	33	14	28	55	24	24	-5	-26	100	18	50	10	14	7	28	38	23	53	6	38	-9	5	-19	26	17	0	68	12	13	12	-7	37	2	2	-9	38	36
QSORT44	-10	20	9	19	29	13	18	17	-16	9	9	8	40	13	-3	15	32	25	18	28	15	18	100	0	45	29	26	-24	23	-5	39	18	34	47	59	-14	12	-3	19	-1	17	-13	23	6	6	8	27	-1	22	-17
QSORT45	-3	24	8	46	45	9	17	24	15	9	0	13	21	50	6	8	25	12	21	-14	9	50	0	100	40	21	9	-4	34	8	18	19	1	6	-8	7	14	13	-13	45	1	20	16	11	20	24	24	-2	29	43
QSORT46	-15	-7	20	41	31	60	19	20	4	13	4	13	30	38	8	21	29	46	24	11	53	10	45	40	100	29	29	-8	3	0	28	32	36	46	48	29	24	20	28	9	33	38	43	19	36	49	22	31	34	22
QSORT47	-9	16	36	18	38	43	-10	9	26	7	-2	-3	37	29	13	-15	-8	0	-2	-4	26	14	29	21	29	100	10	-23	-4	2	41	31	21	11	35	-3	-4	2	11	19	34	10	-6	14	33	-6	13	22	-8	-18
QSORT5	20	-16	31	-4	6	21	-29	-14	23	-7	22	20	3	-4	-3	4	-16	25	12	0	14	7	26	9	29	10	100	23	11	-4	26	18	16	50	17	20	-36	6	6	6	48	-2	22	19	4	18	35	6	25	13
QSORT6	32	-1	17	-18	14	-31	2	24	21	-2	-9	-1	-23	4	24	36	18	23	29	-21	-24	28	-24	-4	-8	-23	23	100	-1	24	20	7	29	4	-28	-3	36	-2	21	22	1	28	7	10	10	-3	-12	-1	24	14
QSORT7	19	54	11	-4	16	-6	16	28	-26	9	9	11	33	8	9	24	23	-3	-4	-29	-43	38	23	34	3	-4	11	-1	100	6	28	-21	3	-13	2	-39	27	-6	10	41	-23	-23	-23	-21	-12	-29	-6	-49	24	-5
QSORT8	-12	-3	19	24	8	11	3	38	23	1	1	14	10	5	-14	10	15	1	24	-18	-12	23	-5	8	0	2	-4	24	6	100	31	19	14	16	-3	11	29	31	28	44	8	28	41	2	23	30	-11	17	35	28
QSORT13	8	39	53	21	28	23	4	48	17	10	-3	11	16	25	8	9	29	15	19	-6	-7	53	39	18	28	41	26	20	28	31	100	29	44	21	49	-26	11	13	11	44	24	-5	13	9	33	13	17	-2	28	-3
QSORT14	-4	-4	19	33	16	27	4	6	38	-6	-1	21	1	21	41	0	3	42	46	19	45	6	18	19	32	31	18	7	-21	19	29	100	16	34	-1	9	-5	40	14	18	46	29	41	29	32	42	33	36	-16	23
QSORT15	9	33	39	9	16	17	39	4	37	-7	36	2	12	14	24	21	30	48	34	15	4	38	34	1	36	21	16	29	3	14	44	16	100	39	41	-3	34	12	18	8	44	32	31	-11	44	19	18	8	40	16
QSORT16	-5	-14	24	11	18	34	3	-10	28	9	6	14	-7	-6	-3	-3	4	33	46	23	26	-9	47	6	46	11	50	4	-13	16	21	34	39	100	36	43	8	9	6	-8	53	16	36	16	9	54	38	20	16	11
QSORT17	-9	5	21	24	9	45	10	21	1	-1	12	9	22	28	-24	4	16	23	-16	22	24	5	59	-8	48	35	17	-28	2	-3	49	-1	41	36	100	-6	-3	6	8	-2	20	-16	21	-1	33	6	29	-8	34	-16
QSORT22	1	-36	-7	16	8	36	-3	-8	22	11	-14	5	-11	-1	-12	4	-26	5	31	27	38	-19	-14	7	29	-3	20	-3	-39	11	-26	9	-3	43	-6	100	7	-4	-6	-12	43	21	21	24	19	50	14	39	18	29
QSORT23	24	36	-11	-1	40	1	51	52	-11	13	-22	-18	19	23	11	46	38	23	41	-6	-28	26	12	14	24	-4	-36	36	27	29	11	-5	34	8	-3	7	100	1	37	31	-13	26	13	-4	12	5	-22	-4	41	3
QSORT24	-16	1	1	18	6	14	1	-9	19	-8	18	-5	5	-3	-11	-28	7	31	-1	-11	5	17	-3	13	20	2	6	-2	-6	31	13	40	12	9	6	-4	1	100	31	18	30	41	34	-19	45	32	8	41	18	40
QSORT25	-4	3	-3	8	11	21	22	3	6	-28	6	3	41	19	21	29	3	23	7	-22	9	0	19	-13	28	11	6	21	10	28	11	14	18	6	8	-6	37	31	100	2	11	17	21	-15	21	6	4	39	24	15
QSORT28	21	35	35	4	41	1	11	43	16	26	-3	-14	24	29	1	41	30	24	18	-17	-21	68	-1	45	9	19	6	22	41	44	44	18	8	-8	-2	-12	31	18	2	100	-9	6	11	7	14	4	-3	-16	23	19
QSORT29	1	0	28	9	11	40	13	-14	49	8	35	0	14	4	16	-13	4	31	38	32	36	12	17	1	33	34	48	1	-23	8	24	46	44	53	20	43	-13	30	11	-9	100	33	19	24	36	31	39	54	2	26
QSORT30	-21	-3	12	18	8	8	2	-14	31	-1	16	4	0	17	5	-11	12	46	39	-7	14	13	-13	20	38	10	-2	28	-23	28	-5	29	32	16	-16	21	26	41	17	6	33	100	34	-3	35	43	-16	48	18	32
QSORT31	-6	-16	5	33	10	8	9	6	28	-28	22	31	3	25	-10	16	13	44	34	26	19	12	23	16	43	-6	22	7	-23	41	13	41	31	36	21	21	13	34	21	11	19	34	100	11	37	59	34	28	44	51
QSORT40	-9	-34	19	34	43	4	7	36	6	41	-1	-8	12	19	7	12	6	-15	29	42	36	-7	6	11	19	14	19	10	-21	2	9	29	-11	16	-1	24	-4	-19	-15	7	24	-3	11	100	-16	25	38	26	-11	-15
QSORT41	12	-1	27	39	-3	28	18	13	28	-13	-8	26	6	31	12	1	23	38	16	19	19	37	6	20	36	33	4	10	-12	23	33	32	44	9	33	19	12	45	21	14	36	35	37	-16	100	29	-3	36	32	42
QSORT42	-21	-31	19	49	13	26	9	-6	39	13	9	29	-6	12	14	-8	6	26	46	16	34	2	8	24	49	-6	18	-3	-29	30	13	42	19	54	6	50	5	32	6	4	31	43	59	25	29	100	21	46	22	34
QSORT43	-12	9	5	27	41	12	15	-11	36	-19	26	-9	7	29	-4	16	1	11	10	27	36	2	27	24	22	13	35	-12	-6	-11	17	33	18	38	29	14	-22	8	4	-3	39	-16	34	38	-3	21	100	13	7	20
QSORT48	-47	-40	1	26	9	21	4	-23	21	4	8	-21	12	1	0	-19	-6	18	30	32	38	-9	-1	-2	31	22	6	-1	-49	17	-2	36	8	20	-8	39	-4	41	39	-16	54	48	28	26	36	46	13	100	-18	43
QSORT49	24	21	9	30	26	15	17	41	16	-11	16	26	29	33	-16	28	17	22	9	-15	-9	38	22	29	34	-8	25	24	24	35	28	-16	40	16	34	18	41	18	24	23	2	18	44	-11	32	22	7	-18	100	14
QSORT50	-9	-5	-8	19	3	-6	23	-15	17	-26	18	9	-5	17	-7	10	5	34	28	12	8	36	-17	43	22	-18	13	14	-5	28	-3	23	16	11	-16	29	3	40	15	19	26	32	51	-15	42	34	20	43	14	100

7. KADE factor characteristics

Within this appendix, an overview is given of the Q-method data used for the interpretation of the factors. The Q-sorts loading to the factor, distinguishing statements and their z-scores and values and visualization were used to create the infographics given in chapter 6.

Factor 1 – group as a whole

Q-sort	*Weight*
QSORT42	10.00
QSORT30	9.54
QSORT31	9.15
QSORT50	8.69
QSORT48	7.18
QSORT35	5.90
QSORT41	5.85
QSORT36	5.65
QSORT14	5.60
QSORT29	5.42
QSORT24	5.23
QSORT18	4.99
QSORT22	3.96
QSORT8	3.51

Z scr.	Q Sort Value	State. No.	Statement
-2.31	-4	29	I feel responsible for maintaining the banks of the river to prevent siltation.
-1.77	-3	25	I know who owns the sand dam.
-1.22	-3	23	My children can go to school fully since I use water from the sand dam.
-1.04	-3	8	I use more water since I make use of the sand dam.
-0.9	-2	26	We, as a community have ownership over the dam.
-0.54	-1	10	My livestock has more water to drink since I use the sand dam.
-0.51	-1	32	I experience conflicts over water from the sand dam throughout the year.
-0.49	-1	5	Fetching water from the sand dam costs me less time compared to other sources.
-0.46	-1	24	I have a higher income since I started making use of the water from the sand dam.
-0.26	-1	9	I can carry more water since I have a donkey/oxen.
0.08	0	22	I use the water from the sand dam for irrigating my crops.
1.12	3	31	I experience conflicts over water from the sand dam during the dry season.
1.96	4	7	During dry season, I have to dig deeper to fetch water from the scoop holes.

Composite Q sort for Factor 1

-4	-3	-2	-1	0	1	2	3	4
I go through somebody else's land to get to the sand dam.	I use more water since I make use of the sand dam.	I can more easily cross the river via the sand dam during the wet	I can carry more water since I have a donkey/oxen.	Since I make use of the sand dam, I can engage in new activities	I find having a sand dam committee within our community	I only use the water from the sand dam for domestic needs (e.g. washing	I find clean water important.	During dry season, I have to dig deeper to fetch water from the scoop
I feel responsible for maintaining the banks of the river to	My children can go to school fully since I use water from the sand dam.	I do not mind using a water source that is further away.	I have a higher income since I started making use of the water from the	I find sand harvesting to be a problem affecting the sand dam.	People close to the sand dam have more water available than people further	I can grow/eat more nutritious crops (fruit and vegetables) since I use	I find a water source being close to me very important.	The donkey/oxen causes water pollution through urination and
	I know who owns the sand dam.	We, as a community have ownership over the dam.	Fetching water from the sand dam costs me less time compared to	My path to the sand dam is more difficult during the wet season.	I am happy with the sand dam.	The sand dam is a reliable water resource.	I experience conflicts over water from the sand dam during the dry season.	
		The sand dam gives me enough water during long dry periods.	I experience conflicts over water from the sand dam throughout the	I use the water from the sand dam for irrigating my crops.	I treat the water before I drink it ng/waterguard).	During the dry season, I have to wait in the queue regularly for a long		
			My livestock has more water to drink since I use the sand dam.	I find that everybody in the area can use water from the sand dam.	During the dry season, I find the water to be saline.			
				I find the sand dam to be a good place to chat with my friends.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- ► z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus statement

Factor 2 – group as a whole

Q-sort	*Weight*
QSORT39	13.21
QSORT28	8.80
QSORT12	8.24
QSORT2	7.87
QSORT23	7.59
QSORT34	6.61
QSORT7	6.60
QSORT33	5.77
QSORT13	5.45
QSORT49	5.16
QSORT9	4.98
QSORT11	4.57
QSORT27	4.14
QSORT45	3.69
QSORT1	3.57

Z scr.	Q Sort Value	State. No.	Statement
-1.95	-4	6	During the dry season, I have to wait in the queue regularly for a long time.
-1.18	-2	7	During dry season, I have to dig deeper to fetch water from the scoop holes.
-0.85	-2	30	I find sand harvesting to be a problem affecting the sand dam.
-0.37	-1	15	The donkey/oxen causes water pollution through urination and defecation.
-0.32	-1	11	People close to the sand dam have more water available than people further away.
0.09	0	8	I use more water since I make use of the sand dam.
0.82	2	12	The sand dam gives me enough water during long dry periods.
0.91	2	22	I use the water from the sand dam for irrigating my crops.
0.95	2	24	I have a higher income since I started making use of the water from the sand dam.
1.37	3	34	I am happy with the sand dam.

Composite Q sort for Factor 2

-4	-3	-2	-1	0	1	2	3	4
I experience conflicts over water from the sand dam throughout the	I experience conflicts over water from the sand dam during the dry season.	I find the sand dam to be a good place to chat with my friends.	During the dry season, I find the water to be saline.	I use more water since I make use of the sand dam.	The sand dam is a reliable water resource.	Since I make use of the sand dam, I can engage in new activities	I am happy with the sand dam.	I find clean water important.
During the dry season, I have to wait in the queue regularly for a long	I go through somebody else's land to get to the sand dam.	I know who owns the sand dam.	People close to the sand dam have more water available than people further	We, as a community have ownership over the dam.	I can carry more water since I have a donkey/oxen.	I have a higher income since I started making use of the water from the	My livestock has more water to drink since I use the sand dam.	I find a water source being close to me very important.
	I do not mind using a water source that is further away.	I find sand harvesting to be a problem affecting the sand dam.	The donkey/oxen causes water pollution through urination and	I only use the water from the sand dam for domestic needs (e.g. washing	I find that everybody in the area can use water from the sand dam.	I use the water from the sand dam for irrigating my crops.	I can grow/eat more nutritious crops (fruit and vegetables) since I use	
		During dry season, I have to dig deeper to fetch water from the scoop	My children can go to school fully since I use water from the sand dam.	I treat the water before I drink it ng/waterguard).	I feel responsible for maintaining the banks of the river to	The sand dam gives me enough water during long dry periods.		
			My path to the sand dam is more difficult during the wet season.	I find having a sand dam committee within our community	Fetching water from the sand dam costs me less time compared to			
				I can more easily cross the river via the sand dam during the wet				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- ► z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus statement

Factor 3 – group as a whole

Q-sort	*Weight*
QSORT38	8.57
QSORT17	7.76
QSORT44	6.57
QSORT46	6.49
QSORT10	6.38
QSORT47	5.98
QSORT43	4.86
QSORT40	4.53
QSORT4	4.24
QSORT26	4.15
QSORT16	4.08
QSORT3	3.01
QSORT37	2.85

Z scr.	Q Sort Value	State. No.	Statement
-1.79	-4	22	I use the water from the sand dam for irrigating my crops.
-1.4	-3	3	I can more easily cross the river via the sand dam during the wet season.
-1.4	-3	24	I have a higher income since I started making use of the water from the sand dam.
-1.26	-2	21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.
-0.49	-1	13	The sand dam is a reliable water resource.
-0.36	-1	19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)
0.98	2	8	I use more water since I make use of the sand dam.
1.06	3	7	During dry season, I have to dig deeper to fetch water from the scoop holes.

Composite Q sort for Factor 3

-4	-3	-2	-1	0	1	2	3	4
I use the water from the sand dam for irrigating my crops.	I can more easily cross the river via the sand dam during the wet	I find the sand dam to be a good place to chat with my friends.	Since I make use of the sand dam, I can engage in new activities	I only use the water from the sand dam for domestic needs (e.g. washing	During the dry season, I have to wait in the queue regularly for a long	The donkey/oxen causes water pollution through urination and	I find a water source being close to me very important.	I find clean water important.
I experience conflicts over water from the sand dam throughout the	I have a higher income since I started making use of the water from the	The sand dam gives me enough water during long dry periods.	The sand dam is a reliable water resource.	We, as a community have ownership over the dam.	I find sand harvesting to be a problem affecting the sand dam.	My livestock has more water to drink since I use the sand dam.	During dry season, I have to dig deeper to fetch water from the scoop	During the dry season, I find the water to be saline.
	I go through somebody else's land to get to the sand dam.	I do not mind using a water source that is further away.	My path to the sand dam is more difficult during the wet season.	I am happy with the sand dam.	People close to the sand dam have more water available than people further	I use more water since I make use of the sand dam.	I find having a sand dam committee within our community	
		I can grow/eat more nutritious crops (fruit and vegetables) since I use	I know who owns the sand dam.	I find that everybody in the area can use water from the sand dam.	I can carry more water since I have a donkey/oxen.	I treat the water before I drink it ng/waterguard).		
			I experience conflicts over water from the sand dam during the dry season.	I feel responsible for maintaining the banks of the river to	Fetching water from the sand dam costs me less time compared to			
				My children can go to school fully since I use water from the sand dam.				

Legend

- Distinguishing statement at P< 0.05
- Distinguishing statement at P< 0.01
- ► z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus statement

Factor 1 – Mulutu

Q-sort	*Weight*
QSORT11	10.00
QSORT34	9.83
QSORT12	9.07
QSORT33	8.10
QSORT39	7.34
QSORT9	7.30
QSORT27	6.07
QSORT26	4.57
QSORT45	4.30
QSORT44	3.91
QSORT36	3.65
QSORT35	3.22

Z scr.	Q Sort Value	State. No.	Statement
-2.03	-4	32	I experience conflicts over water from the sand dam throughout the year.
-2.03	-4	6	During the dry season, I have to wait in the queue regularly for a long time.
-1.99	-3	1	I do not mind using a water source that is further away.
-1.35	-3	31	I experience conflicts over water from the sand dam during the dry season.
-0.53	-2	7	During dry season, I have to dig deeper to fetch water from the scoop holes.
-0.12	-1	24	I have a higher income since I started making use of the water from the sand dam.
-0.01	0	3	I can more easily cross the river via the sand dam during the wet season.
0.2	0	17	During the dry season, I find the water to be saline.
0.46	2	19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)
0.95	2	12	The sand dam gives me enough water during long dry periods.
1.16	3	13	The sand dam is a reliable water resource.
1.64	4	14	I find clean water important.
1.86	4	34	I am happy with the sand dam.

Factor 2 – Mulutu

Q-sort	*Weight*
QSORT38	18.04
QSORT10	8.47
QSORT46	8.19
QSORT2	-5.97
QSORT4	4.93
QSORT1	-3.94
QSORT37	3.79

Z scr.	Q Sort Value	State. No.	Statement
-2.05	-4	24	I have a higher income since I started making use of the water from the sand dam.
-0.45	-1	19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)
1.24	3	6	During the dry season, I have to wait in the queue regularly for a long time.
1.3	3	17	During the dry season, I find the water to be saline.
1.58	3	15	The donkey/oxen causes water pollution through urination and defecation.
1.96	4	30	I find sand harvesting to be a problem affecting the sand dam.

Factor 3 – Mulutu

Q-sort	*Weight*
QSORT18	13.32
QSORT3	8.25
QSORT47	4.69
QSORT20	4.58
QSORT32	4.54
QSORT21	3.17

Z scr.	Q Sort Value	State. No.	Statement
-1.73	-4	19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)
-1.57	-3	18	My path to the sand dam is more difficult during the wet season.
-1.4	-3	29	I feel responsible for maintaining the banks of the river to prevent siltation.
-1.03	-2	17	During the dry season, I find the water to be saline.
-0.15	0	6	During the dry season, I have to wait in the queue regularly for a long time.
1.17	3	24	I have a higher income since I started making use of the water from the sand dam.
1.34	3	9	I can carry more water since I have a donkey/oxen.
1.74	4	33	I find the sand dam to be a good place to chat with my friends.

Factor 1 – Kiindu

Q-sort	*Weight*
QSORT48	10.00
QSORT42	4.90
QSORT30	4.42
QSORT7	-3.40
QSORT50	3.38
QSORT22	3.30
QSORT31	2.90
QSORT14	2.81
QSORT24	2.61

Z scr.	Q Sort Value	State. No.	Statement
-2.13	-4	29	I feel responsible for maintaining the banks of the river to prevent siltation.
-1.33	-3	8	I use more water since I make use of the sand dam.
-1.09	-2	10	My livestock has more water to drink since I use the sand dam.
-0.07	0	32	I experience conflicts over water from the sand dam throughout the year.
0.44	1	21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.
0.77	1	16	I treat the water before I drink it (boiling/waterguard).
1.33	3	30	I find sand harvesting to be a problem affecting the sand dam.
1.87	4	7	During dry season, I have to dig deeper to fetch water from the scoop holes.

Factor 2 – Kiindu

Q-sort	*Weight*
QSORT49	4.36
QSORT23	4.36
QSORT8	3.53
QSORT28	3.43
QSORT15	2.62
QSORT25	2.14
QSORT6	2.12

Z scr.	Q Sort Value	State. No.	Statement
-1	-3	11	People close to the sand dam have more water available than people further away.
-0.95	-2	15	The donkey/oxen causes water pollution through urination and defecation.
-0.82	-2	6	During the dry season, I have to wait in the queue regularly for a long time.
-0.39	0	20	I only use the water from the sand dam for domestic needs (e.g. washing clothes, cooking, washing utensils).
-0.15	0	30	I find sand harvesting to be a problem affecting the sand dam.
-0.13	0	8	I use more water since I make use of the sand dam.
1.44	3	24	I have a higher income since I started making use of the water from the sand dam.
1.71	4	19	Since I make use of the sand dam, I can engage in new activities (e.g. irrigating crops, brick making)
1.78	4	21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.

Factor 3 – Kiindu

Q-sort	*Weight*
QSORT43	4.74
QSORT16	4.73
QSORT17	4.62
QSORT5	4.55
QSORT13	3.25
QSORT29	3.21

Z scr.	Q Sort Value	State. No.	Statement
-1.22	-3	30	I find sand harvesting to be a problem affecting the sand dam.
-1.12	-3	21	I can grow/eat more nutritious crops (fruit and vegetables) since I use water from the sand dam.
0.9	2	9	I can carry more water since I have a donkey/oxen.
0.92	2	5	Fetching water from the sand dam costs me less time compared to other sources.
1.42	4	17	During the dry season, I find the water to be saline.
2.28	4	8	I use more water since I make use of the sand dam.

8. Analysis: group as a whole

Group as a whole: 50 participants

Iteration	Settings		Variables 1 Location	2 Distance	3 Gender	4 Age	5 Size of household	Characteristics of factor: Distinguishing statements	v.	Aspects of water access	Q-sorts loading to it	Conclusion for further interpretation	Interpretation of factors *Also based on interviews done*
		2 factor analysis									78% of 50 participants		
1	PCA Varimax Auto-flag	Factor 1	38% in Mulutu 62% in Kiindu	48 % <500 meters 52 % >500 meters	71% female 19% male 10% mixed	41% b'twn 16-34 yrs 33% b'twn 35-50 yrs 26% b'twn 51-70 yrs	24% < 5 p. 24% = 5 p. 52% > 5 p.	During dry season, I have to dig deeper to fetch water from the scoop holes. The donkey/oxen causes water pollution through urination and defecation. I feel responsible for maintaining the banks of the river to prevent siltation.	4 -4	Time aspect to be important Experience pollution No responsibility for maintenance No change in water availability for livestock	21	Size of household seems to paly a role in factor 1 and 2 with 52% in 1 and 61% in 2 above an average of 5 people per household	Mostly women with domestic water use purposes and experience long waiting times during dry season. Can be related to big size of household or big part of the group is fairly young; seen to be inpatient.
		Factor 2	61% in Mulutu 39% in Kiindu	50 % <500 meters 50 % >500 meters	67% female 28% male 5% mixed	30 % b'twn 16-34 yrs 55% b'twn 35-50 yrs 15% b'twn 51-70 yrs	28% < 5 p. 11% = 5 p. 61% > 5 p.	I find clean water to be important My livestock has more water since I make use of the sand dam During the dry season, I have to wait in the queue regularly for a long time. I experience conflicts over water from the sand dam throughout the year.	4 3 -4	Water quality to be important Water availability for livestock Content over performance of structure	18		Make use of the sand dam for income related activities and fairly content, probably also because it is a new structure for them.
		3 factor analysis									84% of 50 participants		
2	PCA Varimax Auto-flag	Factor 1	21% in Mulutu 79% in Kiindu	36 % <500 meters 64 % >500 meters	64% female 29% male 7% mixed	56% b'twn 16-34 yrs 13% b'twn 35-50 yrs 31% b'twn 51-70 yrs	27% < 5 p. 13% = 5 p. 60% > 5 p.	During the dry season, I have to wait in the queue regularly for a long time. I experience conflicts over water from the sand dam throughout the year. I feel responsible for maintaining the banks of the river to prevent siltation. I know who owns the sand dam.	4 3 -4 -3	Time aspect to be important Experience conflicts over water. Lack of ownership and thus no feeling of responsibility for maintenance	14	3 clearly different factors, highlighting difference in income as a difference compared to the 2 factor analysis. This group mainly consists of people between 35-50 years. Most people are loading to a factor in this analysis. Also location Mul vs Kiindu has big differences in within this factor analysis.	Mostly people with domestic water use purposes and experience long waiting times during dry season. No feeling of ownership or for maintenance which can be related to experience of conflicts.
		Factor 2	67% in Mulutu 33% in Kiindu	40 % <500 meters 60% >500 meters	60% female 33% male 7% mixed	38% b'twn 16-34 yrs 50% b'twn 35-50 yrs 12% b'twn 51-70 yrs	36% < 5 p. 21% = 5 p. 43% > 5 p.	I am happy with the sand dam I have a higher income since I started making use of the sand dam During the dry season, I have to wait in the queue regularly for a long time. During the dry season, I have to dig deeper to fetch water.	3 2 -4 -2	Content over performance of structure High business impact since use of the sand dam Do not experience long waiting times Enough water available	15		This group makes use of the sand dam for income related activies and are contant ofer the structure. Mostly people within the age group of 35 to 50 years, most of the time responsible for the income generated.
		Factor 3	70% in Mulutu 30% in Kiindu	46% <500 meters 54% >500 meters	46% female 39% male 15% mixed	28% b'twn 16-34 yrs 39% b'twn 35-50 yrs 33% b'twn 51-70 yrs	23% < 5 p. 23% = 5 p. 54% > 5 p.	During the dry season, I find water to be saline. During the dry season, I have to dig deeper to fetch water from the sand dam. I use the water from the sand dam for irrigating my crops I can more easilily cross the river via the sand dam during the wet season.	4 3 -4 -3	Water quality to be important Water table lowers, problem Domestic water use purposes Find terrain aspect to be important	13		Water quality to be important (more important in Mulutu than Kiindu), can be related to mostly domestic water use purposes of this group.
		4 factor analysis									76% of 50 participants		
3	PCA Varimax Auto-flag	Factor 1	20% in Mulutu 80% in Kiindu	50%< 500 m 50%> 500 m	60% female 40% male	70% b'twn 16-34 yrs 10% b'twn 35-50 yrs 20% b'twn 51-70 yrs	30% < 5 p. 10% = 5 p. 60% > 5 p.	I experience conflict over water using the sand dam My livestock has more water to drink since I make use of the sand dam I go through somebody else's land to get to the sand dam I know who owns the sand dam	1 0 -4	Experience little conflict but not as problematic. No change in water availability for livestock. Clear path No clear ownership over the dam	10	Difference in location becomes clear in factor 1 and 2 Variable of size of household plays a role in factor 4 Age plays a role in factor 1 Fairly low percentage of people loading to the factors	Most of them live in Kiindu, fairly young group of people experiencing only conflict over fetching water.
		Factor 2	80% in Mulutu 20% in Kiindu	30%< 500 m 70%> 500 m	50% female 50% male	50% b'twn 16-34 yrs 50% b'twn 35-50 yrs	30% < 5 p. 20% = 5 p. 50% > 5 p.	The sand dam gives me enough water during the dry season I can more easily cross the river via the sand dam during the wet season During the dry season I have to wait in a queue for a long time I do not mind using a water source that is further away	2 0 -4 -3	Content over water availability Neutral over terrain and path Short fetching times of water Value short distance to sand dam	10		People live far from the sand dam and value the water availability the sand dam gives them in a fairly short time.
		Factor 3	56% in Mulutu 44% in Kiindu	56%< 500 m 44%> 500 m	45% female 33% male 22% mixed	40% b'twn 16-34 yrs 27% b'twn 35-50 yrs 33% b'twn 51-70 yrs	33% < 5 p. 11% = 5 p. 56% > 5 p.	I use more water since I make use of the sand dam I find that everybody in the area can make use of the sand dam The sand dam is a reliable resource My path towards the sand dam is more difficult during wet season	4 2 -3 -1	More water available and more use of water. Social cohesion and ownership feeling (harambee) Reliability is a negative aspect of the sand dam Clear path and easy to walk terrain to sand dam.	9		A group of young people with fairly big households who value the sand dam as a place for social interaction.
		Factor 4	44% in Mulutu 56% in Kiindu	67%< 500 m 33%> 500 m	67% female 22% male 11% mixed	27% b'twn 16-34 yrs 46% b'twn 35-50 yrs 27% b'twn 51-70 yrs	11% < 5 p. 11% = 5 p. 78% > 5 p.	I find sand harvesting to be a problem affecting the sand dam I experience conflicts over water from the sand dam during the dry season I have a higher income since I make use of the sand dam I feel responsible over maintaining the banks of the river to prevent siltation	4 3 -4 -3	Sand harvesting problems affecting water table + resulting in conflicts No change in activities and thus no change in income No clear responsibility over maintenance	9		These people live in big households and experience conficts over fetching water as they make many trips a day and need a lot of water.

9. Analysis group separately (Mulutu)

Mulutu 26 participants			Variables				Characteristics of factor				Conclusion for further interpretation	Interpretation of factors
			1	2	3	4						
Iteration	Settings		*Distance*	*Gender*	*Age*	Size of household	*Distinguishing statements*	*v.*	*Aspects of water access*	*Q-sorts loading to it*		*Also based on interviews done*
		2 factor analysis								81% of 26 participants		
4	PCA Varima x Auto-flag	Factor 1	42% <500 meters 58% >500 meters	67% female 33% male	42% b'twn 16-34 yrs **50% b'twn 35-50 yrs** 8% b'twn 51-70 yrs	25% < 5 p. 17% = 5 p. **58% > 5 p.**	I find clean water to be important The sand dam is a reliable resource During the dry season, I have to wait in a queue for a long time. I experience conflicts over water during the dry season	4 3 -4 -3	Water quality to be important Sand dam is a reliable resource Do not experience long queues Value the close proximity to the water source	12	Sand dam committee importance pops up in separate analysis Slight disbalance in age in factor 1 as well as size of household	These people find clean water to be most important and experience the sand dam to be a reliable resource. Also have other options of fetching water.
		Factor 2	33% <500 meters 67% >500 meters	56% female 22% male 11% mixed	33% b'twn 16-34 yrs 33% b'twn 35-50 yrs 33% b'twn 51-70 yrs	44% < 5 p. 11% = 5 p. 44% > 5 p.	I find sand harvesting to be a problem affecting the sand dam I find having a sand dam committee wihtin our community important I use water from the sand dam to irrigate my crops I have a higher income since I make use of the sand dam	4 3 -4 -3	Sand harvesting to be a problem (environment + maintenance) Community feeling + maintenance important Mainly domestic water users No change in income	9		These peole value a sand dam committee (some of them are in it within this group) as they see it as an authority to take good care of the SD.
		3 factor analysis								**96% of 26 participants**		
		Factor 1	25% <500 meters **75% >500 meters**	58% female 42% male	39% b'twn 16-34 yrs 46% b'twn 35-50 yrs 15% b'twn 51-70 yrs	33% < 5 p. 17% = 5 p. 50% > 5 p.	I find clean water to be important The sand dam is a reliable resource I experience conflicts over water from the sand dam during the dry season During the dry season I have to wait in a queue for a long time.	4 3 -3 -4	Water quality to be important Sand dam is a reliable resource Community lives in harmony over fetching water Experience a change in queueing, no long waiting times	12		These people, mostly living further away, find clean water to be most important. Also have other options fetching water besides the sd.
5	PCA Varima x Auto-flag	Factor 2	**86% <500 meters** 14% >500 meters	**86% female** 14% male	25% b'twn 16-34 yrs **63% b'twn 35-50 yrs** 12% b'twn 51-70 yrs	0% < 5 p. 14% = 5 p. **86% > 5 p.**	I find sand harvesting to be a problem affecting the sand dam During the dry season I find the water to be saline I have a higher inocme since I started making use of the sand dam Since I started making use of the sand dam I can engage in new activities	4 3 -4 -1	Water quality issues Maintenance and environmental issues No change in income and not really any changes in new activities	7	High percentage of big households loading to factor 2 Location difference high percentages Clear age group loading to factor 2 More participants are related to a factor; high percentage! Therefore, preference of this analysis over 2 factor analysis	(mostly) women who experience water quality issues and see sand harvesting to be as a problem lowering the water table; fully relying on the sand dam; no other sources of water.
		Factor 3	17% <500 meters **83% >500 meters**	50% female 33% male 17% mixed	57% b'twn 16-34 yrs 0% b'twn 35-50 yrs 43% b'twn 51-70 yrs	**67% < 5 p.** 0% = 5 p. 33% > 5 p.	I find the sand dam to be a good place to chat with my friends I can carry more water since I have a donkey Since I started making use of the sand dam I can engage in new activities My path towards the sand dam is more difficult during the dry season	4 3 -4 -3	Social interaction to be important Transportation of water to be important No change in activities Clear path and no difficulties in terrain towards sand dam	6		These people, living further away, not only fetch water at the sand dam but value the place to interact with other community members. Because they live further away, value their transportation using a donkey

10. Analysis group separately (Kiindu)

Kiindu 24 participants			Variables				Characteristics of factor				Conclusion for further interpretation	Interpretation of factors *Also based on interviews done*
			1	*2*	*3*	*4*						
Iteration	Settings		*Distance*	Gender	*Age*	Size of household	*Distinguishing statements (a few selected)*	*v.*	*Aspects of water access*	*Q-sorts loading to it*		
		2 factor analysis								**96% of 24 participants**		
6	PCA Varimax Auto-flag	Factor 1	31% <500 meters **69% >500 meters**	62% female 23% male 15% mixed	39% b'twn 16-34 yrs 33% b'twn 35-50 yrs 28% b'twn 51-70 yrs	15% < 5 p. 31% = 5 p. 54% > 5 p.	During the dry season I have to dig deeper to fetch water from the scoopholes People close to the sand dam have more water available than people further away. I feel responsible for maintaining the banks of the river to prevent siltation I have a higher income since I started making use of the sand dam	4 4 -4 -3	Time aspect to be important and dropping water table during dry season (water availability) Wateravailability is unequally distributed according to this group No responsibility feeling for maintenance No change in income	13	High percentage of people relating to a factor. Inequality of water availability pops up in this factor People living close to river can do new activities such as irrigated farming resulting in higher income	People who live further away who value short water fetching times, however find that water is inequally distributed. Find the job of maintance to be for the people living close to the river.
		Factor 2	**70% <500 meters** 30% >500 meters	60% female 30% male 10% mixed	**55% b'twn 16-34 yrs** 18% b'twn 35-50 yrs 27% b'twn 51-70 yrs	30% < 5 p. 10% = 5 p. **60% > 5 p.**	I can grow more nutritious foods since I use water from the sand dam Since I make use of the sand dam, I can engage in new activities. The donkey/oxen causes water pollution through urination and defecation I find sand harvesting to be a problem affecting the sand dam	4 3 -2 -2	Change in diet and activities resulting in higher income No worries about pollution and see a business potential in sand harvesting	10		Fairly young people living close to the dam seeing the potential of the water available to do irrigation both for income and for own purpose instead of buying at the market as this is cheaper when living in bigger households.
		3 factor analysis								92% of 24 participants		
7	PCA Varimax Auto-flag	Factor 1	22% <500 meters **78% >500 meters**	**78% female** 14% male 14% mixed	55% b'twn 16-34 yrs 27% b'twn 35-50 yrs 18% b'twn 51-70 yrs	33% < 5 p. 33% = 5 p. 33% > 5 p.	During the dry season I have to dig deeper to fetch water from the sand dam I find sand harvesting to be a problem affecting the sand dam I feel responsible for maintaining the banks of the river to prevent siltation I use more water since I make use of the sand dam	4 3 -4 -3	Time aspect to be important and dropping water table during dry season (water availability) Sand harvesting affecting this. No clear responsibility feeling for maintenance and no change in water use.	9		These (mostly) females find short fetching time to be important, also because they live further away. Find the job of maintenance to be fort he people living close to the river.
		Factor 2	**71% <500 meters** 29% >500 meters	43% female 43% male 14% mixed	**50% b'twn 16-34 yrs** 25% b'twn 35-50 yrs 25% b'twn 51-70 yrs	29% < 5 p. 14% = 5 p. **57% > 5 p.**	I can grow/eat more nutritious food since I started making use of the sand dam. I can engage in new actitivites since I started making use of the sand dam. People close to the sand dam have more water availble than people further away The donkey/oxen cause water pollution through urination and defecation	4 4 -3 -2	New activities which lead to change in diet. Water distribution to be equal in the area. No effects of animals on water pollution.	7	Clear female group outweighing in factor 1 Big difference in distance towards the sand dam Also here, high percentage of people loading to a factor.	These fairly young people living close to the sand dam have to possiblitiy to irrigate their plots to grow nutritious crops; or for their own consumption or as cash crop. Find the water to be equally distributed whtin the area.
		Factor 3	**67% <500 meters** 33% >500 meters	50% female 33% male 17% mixed	45% b'twn 16-34 yrs 33% b'twn 35-50 yrs 22% b'twn 51-70 yrs	0% < 5 p. 33% = 5 p. **67% > 5 p.**	I use more water since I make use of the sand dam During the dry season, I find the water to be saline. I find sand harvesting to be a problem affecting the sand dam I can grow/eat more nutritious food since I started making use of the sand dam .	4 4 -3 -3	More water use, however more saline (water quality) See sand harvesting not to be a problem (small scale, own purpose). No change in diet or crop choice.	6		More water use, as they have big households. A change in taste during the dry season however not to a point where people get sick from the water. See sand harvesting as a valuable income or resoruce for