# A SPONGE city approach for the water challenges of Kajiado

Kajiado Town in Kenya faces a number of serious water challenges, both in runoff management as well as in water supply.

1. Rainwater runoff (storm water) draining from the increasing number of roofs and roads creates gullies in town and drags rubbish into the small rivers around town.

2. The town lacks a centralized water provision system. Private operators sell water from boreholes in town or truck water into town from sources further away. This water is expensive and not always of good quality.


3. Infiltration from latrine pits and sceptic tanks in town causes nitrate to seep into the groundwater layers, thereby polluting the groundwater reserves, several boreholes show high nitrate concentrations.


## How to create a SPONGE city?

To overcome the water issues in Kajiado Town a number of innovative and sustainable water system interventions can be implemented. These systems absorb precipitation and reduce the storm water flows. Think about:

- Infiltration pits or infiltration galleries
- Flow gardens, parks and wetlands
- Retention structures such as tanks and basins

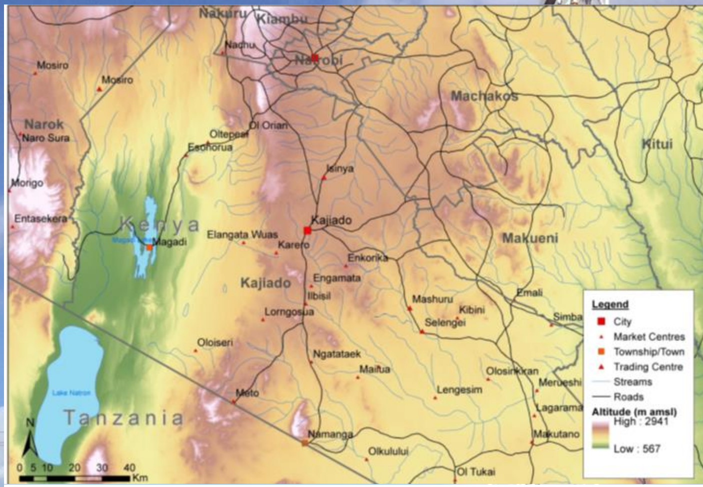


Figure 2 Location of Kajiado town


Figure 1 digging an infiltration pit

These interventions aim to turn Kajiado into a SPONGE city: The outcome of an integrated approach that augments urban infrastructure to retain and recharge groundwater. Interventions in SPONGE city Kajiado boost the underground water system and make it work like a sponge to absorb, store, leak and purify rainwater and release it for re-use when necessary.

## Five step approach towards implementation

The Kajiado SPONGE city consortium – NIA, RAIN, Acacia water, AMREF, MTTI and SASOL - aims to make Kajiado a model town for towns of Arid lands of East Africa

This document shows the steps towards the implementation and roll out of the approach:

1. Defining the problem
2. Testing
3. Planning
4. Implementing
5. Research and dissemination

# 1. Defining the problem: *water challenges of Kajiado town*

To understand the problem, the following activities were carried out by the consortium:

- Water point mapping
- Hydrogeology, surface water runoff and drainage patterns
- Urban sanitation assessment
- Local social and governmental environment assessment

## 1.1 Three root causes of the problem

1. The growth of Kajiado town led to the increased hard impermeable surfaces such as roofs, roads, storm water drains. Increase of hard surfaces negatively impacts groundwater recharge as storm water drains quickly without giving water time to sink into the soil. It also creates a hot and dusty environment.

2. Lack of storm water drainage along roads creates deep uncontrolled gullies and storm water picks up rubbish. Removal of vegetation causes the same problem.

3. There is no sewage system and if people have pit latrines these are unlined and pollution seeps into the underground, pollution from unmanaged pit latrines is not diluted with freshwater recharge, leading to increasing nitrate concentrations in the groundwater.

## 1.2 Increasing SPONGE function to solve challenges

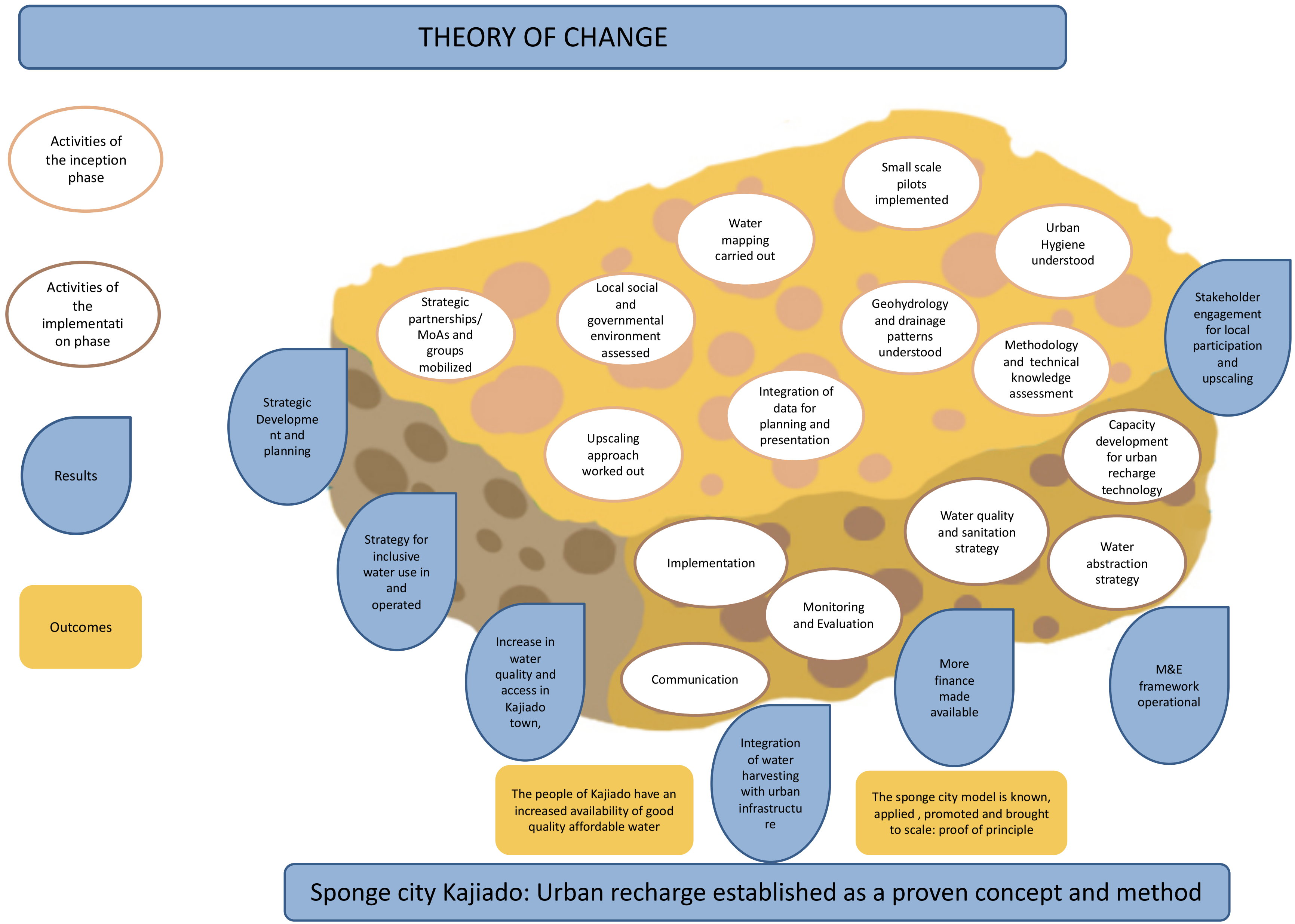
How to reduce the impact of urbanisation on groundwater resources in towns in arid development areas such as Kajiado? Under 'unpaved' or natural conditions there would be more recharge to add to the water table in town, but urban infrastructure and real estate development with more roads, roofs and other hard surfaces prevent water from infiltrating into the ground and replenishing the groundwater.

**SPONGE city Kajiado aims to:**

- **Increase recharge of the urban underground water table;**
- **Reduce nitrate infiltration to limit pollution;**
- **Improve the quality of the urban environment;**
- **Increase resilience to climate change in the context of ongoing urbanisation**

*Figure 2 One of the gullies became a dump site*

To do this a number of activities need to be undertaken, these stand in a particular relation to each other and lead to project outcomes. The next page shows all the activities, results and outcomes in a sponge model that represents the flow of activities from the top of the sponge to the bottom


THEORY OF CHANGE
Activities of the inception phase
Activities of the implementation phase
Results
Outcomes
Strategic partnerships/ MoAs and groups mobilized
Local social and governmental environment assessed
Water mapping carried out
Small scale pilots implemented
Urban Hygiene understood
Geohydrology and drainage patterns understood
Methodology and technical knowledge assessment
Integration of data for planning and presentation
Upscaling approach worked out
Capacity development for urban recharge technology
Water quality and sanitation strategy
Water abstraction strategy
Implementation
Monitoring and Evaluation
Communication
Strategic Development and planning
Strategy for inclusive water use in and operated
Increase in water quality and access in Kajiado town,
Integration of water harvesting with urban infrastructure
More finance made available
M&E framework operational
Stakeholder engagement for local participation and upscaling
The people of Kajiado have an increased availability of good quality affordable water
The sponge city model is known, applied , promoted and brought to scale: proof of principle
Sponge city Kajiado: Urban recharge established as a proven concept and method

## 1.3 Assessments support intermediate findings

The following assessments support the intermediate problem definition presented above.

### 1.3.1 Water point mapping

Kajiado town had a projected population of 16,000 in 2013 (Kenya National Bureau of Statistics). At present the town lacks a central municipal water supply system and several private companies supply drinking water from boreholes. A well field west of Kajiado river also provides another source of water with boreholes drilled in the phonolite aquifers and pumping water to Kajiado through a pipeline. Unfortunately, the water from this scheme is insufficient for town water supply. Several boreholes are located in and around town, that have low to medium yields. Several boreholes closer to the Kajiado river have higher yields (10-15 $m^3$/hour).

*Figure 3 Overview of water points.*

The Scale up of Sustainable Water Access (SUSWA) project already established a great deal of knowledge on the groundwater situation of the project area. In December 2016 and during the February 2017 mission water point mapping of boreholes, shallow wells and river beds and water quality checks were performed. During the kick-off week (6-10 February 2017), several boreholes in town were sampled for chemical analysis in the laboratory, to determine the water quality and to attempt to determine the origin of the water. During the field campaign, measurements were done to determine the electrical conductivity (EC-value), which indicates the salinity of the water, nitrate concentration and pH.

**Result (March 2017):** A complete database of 62 water points in and around Kajiado town is available in Excel and in GIS (see figure 4), with water quality test results and if applicable also the borehole specifications.

### 1.3.2 Hydrogeology, surface water runoff and drainage patterns

To assess the suitability and potential of different water recharge and retention measures in the Kajiado context we studied the hydrogeological situation and the drainage patterns. The team assessed existing databases, remote sensing imagery, GIS-work and existing literature to map hydrogeology and drainage patterns (Figure 5 and 6). Transect walks and field verification took place and the geophysical services from the "Improving Sustainable Groundwater Exploration with Geophysics (ISGEG)" project validated the findings


*Figure 4 Flow direction of road drainage along major roads.*

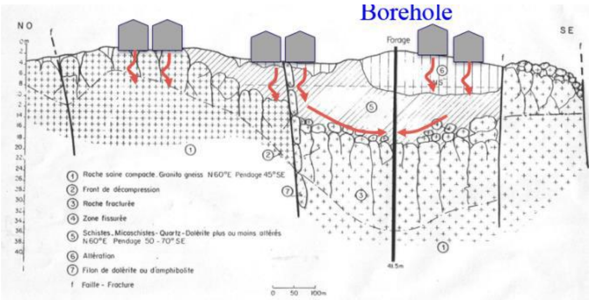



*Figure 5 Concept of shallow (polluted) groundwater flow towards deep aquifers in fractured basement in project area.*

**Result (March 2017):** A report on hydro geological assessment, thematic maps indicating relevant features, such as drainage patterns, surface types and soil characteristics is available (Acacia Water, 2017).

### 1.3.3 Urban sanitation

#### Solid waste

The citizens of Kajiado lack an adequate system for solid waste management. In many parts of town rubbish piles up and either flushes away with the storm water or it is set on fire to smoulder for days, creating toxic fumes. People are not yet encouraged yet to manage their wastes at household level and bring waste to a designated waste dumping site. One registered contracted private company handles solid waste from a number of customers and one other private company has been given a license to collect wastes from individual plot owners. The rubbish is brought to a declared dump site which unfortunately is situated very close to a gully that drains from Kajiado (Figure 7). This poses a risk to water quality of underground aquifers, because the gully brings water to the infiltration zone downstream of the dumping site.

From the disposal site the contracted company collects and disposes waste for transportation towards other disposal sites outside the county territory. The Kajiado County government pays the cost of collection and disposal. At the moment the waste handling companies only deliver a (very) limited portion of the waste from households dumping site. As a consequence, most waste ends up in the environment, sometimes in pits, but often in drainage canals or natural gullies.


*Figure 6 Location of dumping site, directly in front of gully b (presented in red) based on (Ministry of lands, department of physical planning, 2003).*

#### Liquid waste

The Ministry of Water, Irrigation and Sanitation of Kajido county government is mandated to address the issue of liquid waste from sanitation. The Ministry agreed this is a challenge, because there is no disposal site for water and sewerage. The few people who perform pit emptying take the waste to Mavoko Municipality in Machakos County. The ministry recognises the need for assessments to be done for Kajiado town on alternative disposal ways for waste water and sewerage. will be involved in this meeting.

**Result (March 2017)**: Rough overview of sanitation situation is available, sanitation services details, description of waste flows and environmental risks will be further elaborated by AMREF.

### 1.3.4 Local social and governmental environment assessment

The consortium informed and assessed the different line ministries about the project and the county government is open to collaboration, for instance in the form of land designation to the program. In the

next phase the consortium will formalize these relations with the government and include the borehole operators into the program. Also, the need to understand specific gender and social inclusion related problems in the town and the way improved access to water might amend these problems, will be explored. The assumption that improve water available in town will improve livelihoods of the poorer sections of society have to be verified. The same applies for the assumption that women and children now bear the brunt of collecting water. Interviews will be organised to validate existing knowledge and provide insight in the possibilities.


*Figure 7 Launch of the program in February 2017.*

As part of this activity beginning of February a series of meetings with relevant governmental offices and organisations took place. The 8th of February 2017 the SPONGE city Kajiado team launched the program in Kajiado for a group of interested parties and collaborating organisations (Figure 7). Government representatives from the Ministry of Health, the Ministry of Water and Irrigation and the Planning Department of the Kajiado county government attended. The SPONGE city Kwa Vonza team from Kitui was also there to share their ideas as well as NGO's involved in the Dutch funded Watershed program in Kajiado county. Private sector water operators and NGOs such as Welthungerhilfe also attended. All witnessed Dorcas Njoroge of the Ministry of Water and Irrigation of the county government as she blessed the program and vowed the support of the County.

**Result (March 2017)**: Social analysis of water users, instigate formalization of relations with local government.

## 2. Testing solutions: *Augmented infrastructure turns Kajiado into a SPONGE city*

The solution to the water challenges, lies in the augmentation of urban infrastructure, to make roads, houses and parks the catchment area from which water can be redirected for infiltration or stored in retention basins or parks. By using urban infrastructure as water harvesting tools these interventions enhance the sponge function of Kajiado town. Testing of the solutions is needed to verify if solutions work, given the local hydrological, geotechnical, social and other characteristics of the project area.

In the second step of the SPONGE city Kajiado approach several solutions were tested in the field. Based on the successful implementation of three pilots it was concluded that these solutions worked as they were planned. This successful implementation is an important step towards full scale replication of solutions within the project area.

### 2.1 Pilot MTTI dam

A small dam initiated by RAIN and constructed by MTTI and SASOL. This small dam we thought would recharge storm water into the ground, but instead it retained water for almost 8 months of the year. Many people use this water for washing, bathing and watering their cattle, trees have sprouted and become greener around the small reservoir. It thought us that some parts of Kajiado can store surface water and doing more of these small dams would increase water availability around Kajiado. Together with the County government we selected a track of land which now drains storm water but can be designated for retention and urban beautification. We aim to engage the students of MTTI to make a number of these dams in the south gully near the railroad.

*Figure 8 MTTI pilot location shows successful implementation of retention area, serving multiple use water systems.*

### 2.2 Pilot Carwash Infiltration Pit

During the field study, a site was found where concentrated infiltration of water into the subsurface was already implemented. One of the towns 'car wash' facilities uses this infiltration technique to get rid of excess water: the carwash infiltration pit (CIP). The car wash consists of an elevated water tank, a water hose, a shallow channel for draining the water and an infiltration pit of a meter deep.

The open infiltration pit contained silt, soap and oil residue from the car was and was therefore an implausible site for high infiltration rates. Nonetheless, the site could easily be used as a pilot and is in a sense representative for the urban setting. Around 6 PM (7 February 2017), the pit was filled with water from a water truck, up to the level of the bottom of the drainage ditch. There was no visual rapid infiltration, so the site was left 15 minutes after filling it. The following morning around 8.30 AM, the pit was empty. According to the car wash personnel, the pit was empty when they started working earlier that morning. The exact duration to complete infiltration is unknown, but from these observations a minimum infiltration rate of 80 mm/hour is estimated.

*Figure 9: Pilot infiltration pit at a car wash site.*

## 2.3 Pilot SPONGE city Infiltration Pit

The car wash pilot inspired us to develop a controlled infiltration pilot to give insights in the potential for localized recharge through subsurface infiltration. A promising intervention is sub-surface storage of runoff water in a drainage gully, combined with augmented recharge. A pilot design was made for an in-stream infiltration pit, which was baptized a SPONGE Infiltration Pit (SIP). The pilot demonstrated the simplicity of infiltration pits and provide useful information on the hydraulic properties of the sub-surface and the viability of such low-tech solutions.

A hole of 1.2 x 1.2 x 2.0 m (LxWxH) was filled for 2/3 with angular gravel (1-2 cm) and 1/3 with coarse river sand (Figure 10). The gravel maximized infiltration at the level of the most conductive layers. The main problem with infiltration pits is clogging of the wall and this must be prevented or minimized (Bouwer, 2002). With the SIP we filled the top of the pit with sand. Two locally made piezometers were with a length of 1.8 m (2" diameter) were installed of which one was equipped with a data logger for measuring the water level (interval 1 minute). A one meter long pipe was installed for controlled filling of the SIP with water from a water tanker. From the bottom of the pit upward, approximately 0.3 m was weathered gneiss, overlain by 0.5 m highly weathered basement rock, consisting of 1-2 cm gravel in a loamy sand matrix. From this level to the subsurface, the soil consisted of compact red sandy loam.

Approximately 1.2 $m^3$ of water was pumped into the pit (Figure 12) after which infiltration could start. Moderate to rapid infiltration was visible though a quickly subsiding water level. The results from the data logger are show in Figure 13. From the results it can be seen that a drop in water level of 65 cm was realized in one hour, after which the infiltration rate dropped considerably to 3 cm/hour. The infiltration rate is related to the height of the water column. During storms, the pit is assumed to be filled entirely with water. Therefore, high infiltration rates are expected during periods of runoff.

After completing the experiment, the datalogger was reprogrammed to a measurement interval of 15 minutes. The water levels in the SIP are monitored during the rainy season, so that the actual infiltration rates can be estimated and used for upscaling.

*Figure 10: Design and photo of SPONGE Infiltration Pit demo.*

*Figure 11: Filling of the SPONGE Infiltration Pit for testing purposes (left) with borehole water from a truck (right).*

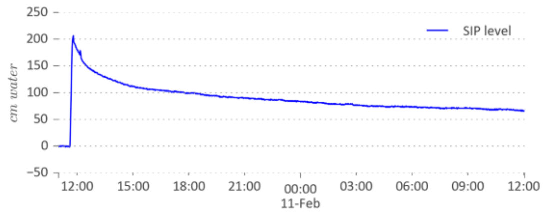



*Figure 12: Water level in the SPONGE Infiltration Pit (SIP) with rapid infiltration in the first hour (65 cm drop in level).*

## 3. Planning solutions

Based on the research and the pilots there are two main conclusions:

***Rainwater runoff needs to slow down.***
The lack of proper storm drainage channels, the dumping at existing drainage channels and the formation of deep gullies around town shows that solutions have to be found for runoff.

***Waste management needs a boost***
Both solid and liquid waste threaten the environment and the drinking water of the people. The presence of nitrate concentrations in the deep groundwater proves that water from the upper layers seeps to the lower aquifers. Reducing the concentration of nitrate can be achieved through improved water infiltration in combination with reduced liquid waste infiltration.

**Principles**
In terms of interventions we adhere to a number of principles which guide the interventions:

1. Low tech low maintenance solutions: Kajiado is a small town with big problems. Solutions which require high investments or ingenuity in implementation and maintenance have a high risk of being forgotten, abandoned or vandalized.

2. Opportunities to recycle or reuse with the private sector need to be explored alongside governance systems: Waste is increasingly seen as a potential resource for recycling. We have the principle that if it can be done by a business without negative impact on the environment then this should at all time be preferable.

Based on the research and the principles we selected eight intervention areas during inception field visit. An overview of all interventions planned is provided in Figure 13. The seven interventions areas in which interventions are proposed are discussed in more detail in the following paragraphs.


*Figure 13 Overview of planned interventions in Kajiado town.*

### 3.1 Namanga road up to the Teacher's bar

#### Erosion and limited infiltration

The area around Teacher's Bar (Figure 15) is characterised by runoff from both sides of the main road which meanders over the small open space and then creates deep gullies. Roads have become inaccessible by cars. Much of the water from Teacher's Bar derives from the main road (the great north road). Water trapped on the south-eastern side of the road passes through a culvert under the road which then flows underneath the Teacher's Bar drainage channel, into the small open area (Figure 16). This site lies in the upper area or the town, uphill from a number of polluted boreholes.

*Figure 14 Current situation Teachers Bar*


*Figure 15 The grounds around Teachers bar, note the gully that runs under the building*

## Storm water buffers, vetiver and shrubs

For this area a combination of options is proposed. The best scenario is to do all of them, but some of them will already make an impact.

On the south-eastern side of the great north road the storage capacity of storm water is limited. The gully directly drains water to the culvert. Here the intervention can include removal of soil to create reservoirs below the level of the culvert. Some of the soil can be deposited on the shoulder of the road to strengthen it and when loose trees can be planted.


*Figure 16 Great north road with the site that can be expanded into reservoirs*

On the North Western side, the runoff can be controlled by extending the small swale that is already found at some places. This is a shallow rolling trench of approximately 1.20 m wide and 40 cm deep. One can see that grass emerges wherever water is slowed down and this will further help to slow the runoff from the road and reduce erosion.

Once the water reaches the open area after the teachers bar a combination of measures can help to prevent further runoff and increase infiltration. The planning map and the physical situation differ considerably with roads going over what appears to be private plots which are perhaps not allocated. The ideal situation would be that water that flows form the teachers bar is spread out by a strip of vetiver grass, 100 m long, in front of which a trench is dug along the contour 1 m wide until the weathered rock is reached or to a maximum of 3 meters and then backfilled with ballast. In this way the flow of the water is spread, led into the ground or at considerably reduced speed and volume continues downward. Behind the vetiver hardy shrubs such as desert date or acacia sp. can be planted to loosen the soil, decrease temperatures and make the area more attractive.

The gully that is formed downhill needs to be reduced by gully plugs made from stacks of filled old gunny bags. Alternatively, the soil removed from the trenching can backfill the gully and should be compacted.

*Figure 17 Great north road with the culvert, crossing the road*

*Figure 18 Location of Teachers Bar with planned options: blue: small lakes to buffer storm water; red line: swale; transparent yellow: infiltration galleries with vetiver and shrubs*

## 3.2 Outer ring gully/road near Jua Kali

### Clogged gully

The issue in this area is the runoff from the outer ring road or Jua Kali road and the gully formation from the lower point of the road and from here discharging water to the gully. Figure 20 shows the area from which water drains through this gully. When it rains this area drains into this one gully and the storm water pushes the solid waste into a one of the lower area where there are residences. Glass, organic waste, flying toilets create a health hazards for citizens who live in this area (Figure 21)).


*Figure 19 Location of outer ring road and gully, leading towards direction of the school.*

*Figure 20 Clogged outer ring gully*

### Gully rehabilitation and infiltration

The storm drain on both sides of the outer ring needs to be lined on the sides, deepened to 1 m. Concrete or masonry work blockages have to be put at intervals of 5 to 20 m depending on the slope to reduce the speed of the water. Unlike normal lined storm drains we propose to leave much of the bottom of these lined storm drains open or perforated and deepen the trench by 1 m deep and 1 m wide, backfilled with ballast. The aim of the storm drain is not only to slow the water down but also to allow it to seep into the ground. Alternatively, gabions can be made that line the gully and still allow infiltration. The trench should be along the main road for about 100 m on each side from the road, seen from the start of the gully. Jacaranda trees can be planted in pits of 1X1, half a meter deep, overflowing into each other to retain soil moisture.

The gully itself poses different challenges. Ideally this site is excavated in the dry season, all the rubbish removed and dumped away from town. Then it can be backfilled with the material from the trench and compacted to prevent erosion. It would be better to fit it with a lined storm drain or even a culvert reaching all the way to the small wetland. However, any measure in the area cannot be sustainable unless some form of garbage collection is initiated (see sanitation chapter) Garbage dumping will clog the culverts and the gully will reappear. Open drainage will pick up rubbish and deposits it in the northern bigger gully to create health hazards there or the storm drain will also get clogged and the water will find another outlet.

*Figure 21 Options: red with white outline, gully rehabilitation; black line: storm drain with perforated bottom and trees*

## 3.3 Mosque near great north road

### Latrines effect ground water quality

The mosque near the great north road is a large area on the upper side of the urban catchment. Runoff from school and the grounds itself sinks into the soil at the north western corner of the grounds, near the school and the latrines. Its highly likely that the sinking groundwater mingles with seepage from the latrines and later finds its way to the boreholes in town.

### Prevent mixing of latrine and rain water

Reduction of runoff can be achieved though several means around the mosque to reduce runoff from reaching the latrines. As with some of the great mosques in Islamic nations the Islamic garden can provide inspiration for improved water handling. Around the mosque, the rainwater from the roofs can be retained in small ponds in plant beds of improved soil. Palm trees can be planted which will reduce the heat in the compound, decrease evaporation, and allow infiltration at places where nitrate pollution is less likely. Additionally, the roof surface is of such a nature that it can provide a good source of additional drinking water or free water to irrigate the garden. The water that can be collected is approximately 200 cubic meter in the long rainy season, which could be 4 times 50 cubic meter tanks or a number of surface water ponds.

The current area where the drainage from the mosque sinks is close to pit latrines of the school. It is not unlikely that this drainage picks up polluted water that then sinks into the same borehole from which the mosque can get its water. It is highly recommended to use lined and improved pit latrines, emptied by exhausters of vacuum trucks. When this proves to be difficult the infiltration of runoff at the mosque compound some 100 meters away from the pit latrines will also help.

## 3.4 The library and the stadium

### Drainage issues in flat area

The new library site and the road that runs south east from the stadium towards Anglican Church of Kenya (ACK) has drainage issues (Figure 22). During the southern side of the road near ACK turns into a bog, spilling into the compound of the new library and creates a small lake there. The building site at the library is excavated to the level of the shallow base rock which appears to be 1 to 2 meters deep in this area. This area has a very small catchment, it is mostly water from the road and from the new stadium.


*Figure 22 Location of the library and the stadium*

The stadium has recently been walled and shows a compacted surface which allow very little infiltration. The total surface is approximately 12000 m2, which would capture approximately 5000 m2 water annually. If this would all recharge into the ground the problems at the library and the road near ACK would be very limited. If all this water ends up on the road and near the library the bog and lake would increase and deteriorate the road and the library compound. In the area of the library the surface water cannot be recharged since the soil is too shallow, neither can a storm drain transport the water since it the site is a natural depression in the upper part of town.

*Figure 23 The new library with on the foreground the dried up lake*

### Re-greening and flow beds

The options foreseen include the beautification of the stadium in combination with the creation of flow beds along the road that runs south east of the stadium and the library.

In the stadium it is proposed to make small drainage channels following the outer lines of the football field which lead into beds along the outside of the wall. These beds need to be as deep as the small drainage channels (say 30/40 cm) they would be good to level out or have small terraces and have loose and fertile top soil. We recommend dense planting of attractive trees such as Bougainvillea with palm trees or other attractive shady trees. The essence of the intervention is to create a grid of small gullies that pick up the runoff from the stadium and lead it to the beds along the edges. Along the grid (but not in the trench itself) lines of trees can function as shade trees. It is proposed to make the roads that enter the stadium a bit higher in order to reduce the potential for water leaving the stadium.

To the south east a series of flow bed should be established to spread the volume of water from the upper side of the road. A road grader should push soil from the wall towards the road to make beds between the wall and the road that are lower than the road and divided into small sections almost levelled out. These beds should be 6 to 8 meters wide and look like small bench terraces. The road should have small offshoots into the beds to lead the road water into the beds. The same should be applied on the southern side of the library and the small lake near the library should be backfilled with soil to a level higher than the flow beds. Because the volumes are small, especially when the stadium is turned into a recharge park, this will reduce the damage to the road and the library.

*Figure 24 The road near ACK where the road water stagnates*

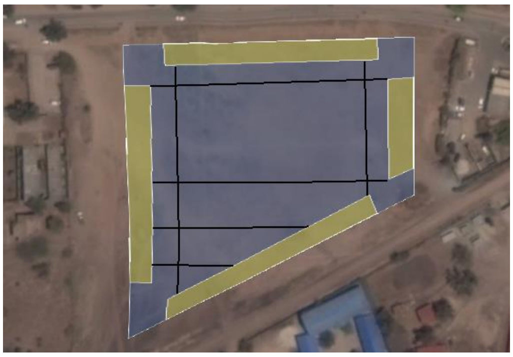


*Figure 25 Location of stadium and ACK with planned planting beds (yellow) and irrigation trenches (black).*

*Figure 26 Flow beds along the southern road (in yellow)*

## 3.5 The southern gully (c)

### Gully with bedrock

A gully running along the southern side of the town but north from the main road drains vast volumes of storm water from the road and the railway towards a tributary of Olkajuado river (Figure 29). Interesting about this gully is that all the soil has been removed and one can look straight at the bedrock of the catchment. No fractures in the rock appear to connect this gully to shallow or deep groundwater, but as such the site is ideal for water retention. On the southern side of the catchment RAIN, NIA and SASOL already developed a small weir implemented by the students of Masai Technical Training Institute (MTTI)(Figure 30). This gully now has water almost 8 months of the year, shows signs of regreening and caters for livestock and domestic use (bathing and washing). In the gully we numbered c a similar sort of interventions would help to create additional water for the animals which would otherwise depend on borehole water.

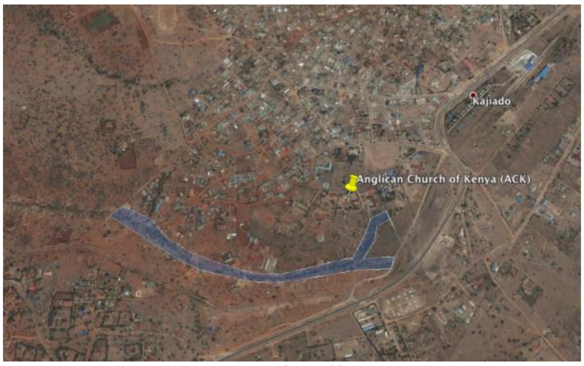


*Figure 27 Location of gully c*


*Figure 28 Impermeable riverbed of gully c*

### No-regret stone weirs

The kind of constructions here could be small masonry check dams up stream followed by larger cemented or masonry weirs to create surface water storage. In this program we propose to engage students of MTTI to work on a project in which students learn basic masonry wall making with natural stones. These are no regret measures, the consortium will see to the right siting and dimensioning and the students can make structures that reduce the surface water flow on the upstream side of the catchment. Thereby the speed of the runoff will be reduced, silt is trapped along with water and vegetation can return in these places. Further downstream a series of surface water ponds will create water for livestock.


*Figure 29 The weir at MTTI storing water*

## 3.6 The middle gully (b) near the showground

### Projected build up area

Shallow groundwater exists close to showgrounds, during the dry season water can be found in this gully which drains a small part of Kajiado town (
Figure 301). Trees remain greener for longer in and around this gully. The upper side is currently used as a dump for soil from plot development but because of the presence of water could be ideal for urban beautification. Currently there are no houses directly into this area but in the next 20 years it can be expected that Kajiado grows towards this direction. To seclude this area from being built up would help to keep more groundwater in Kajiado, cool the new built up areas and prevent the drying of the shallow aquifer that feeds the rest of the gully and provides water for cattle.

*Figure 30 shallow groundwater at gully b*

### Catchment protection with leisure forestry area

The options are simply to make an enclosure in the shape of a trapezoid, level out the dump site, find an alternative dump site downstream from the trapezoid and allow access only to pedestrians. With the soil moisture in the area thick bush will come up quickly and develop into forest. The alternative is to limit the growth of bush, plant high shady trees such as Acacia sp or Fig trees. Together with the forestry department the area could be developed into an arboretum and parking facilities along the road need to be planned for.


*Figure 31 Situations and proposed interventions near the middle gully*

## 3.7 The Northern gully (a) to Haraf

### Rapid runoff

This site can be divided into 4 sections, also shown in Figure 323.

- **A1 The upper part** (transparent green in the figure) is a site with some runoff from the surrounding lands and the dirt road coming from the Great North Road. The small gully is relatively unpronounced and not eroded. Urban development is entering around this area which will increase runoff. The drainage is not well placed and enters back into a built up area.

- **A2 The gully from the school onwards** (transparent red has quite a number of trees but is heavily polluted from open defecation, garbage dumping and garbage flowing from town. There are trees that suggest there is shallow groundwater at least part of the season.

- **A3 Further down** (transparent blue) the tree cover disappears and the gully aligns with a lineament in the deeper base rock. Research showed that infiltration takes place here, the volume of water that gets in is a lot more than what gets out of this stretch of gully.

- **A4 The last stretch** (transparent purple) is a small gully, meandering a bit but definitely not carrying the volumes of water A2 and A3

*Figure 32 sections of gully A.*

*Figure 33 The small channel of A4*

### Stream protection and runoff reduction

Also seen from the upstream area downwards, interventions can aim to reduce rapid runoff. This means that water from A1 and A2 can slow down before it reaches the infiltration zone. Ideal sites to reduce runoff include the upper section from the Presbyterian church which could be improved with bench terraces or Fanya Juu terracing or vetiver strips.

The same goes for the demo farm at A2, this area could be terrace. The added value would be that runoff is delayed, can be used for trees or plants and does not cause problems in the gully. In A1 and A2 itself a reserve should be made whereby cows are not to be grazed and dumping should not take place. Thereby a high canopy will emerge which allows water to pass slowly but at the same time will filter it before it reaches section A3, the infiltration area.

The infiltration area should be protected from rubbish dumping, erosion and flash floods. This site needs further investigation as it might be a good site from which water can be delivered to town. If the upper catchment is protected the water should be clean enough for consumption. Further testing is required.

The lower section (A4) can stay as it is or be blocked a bit further to allow more infiltration.

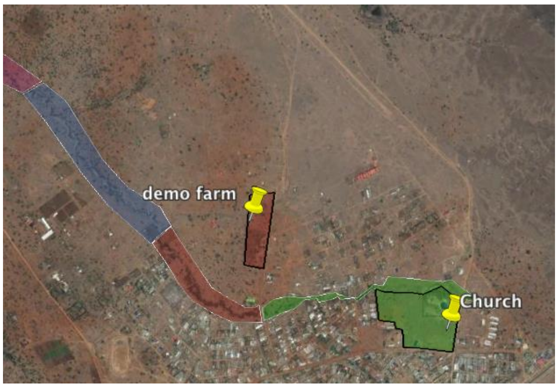



*Figure 34 Optional sites for in situ measures in gully A.*

## 3.8 Downtown Kajiado city

### Waste management

From the initial assessment of waste management in Kajiado city it can be concluded that management of waste can be improved. Although two private companies are already involved in waste collection activities the effectiveness of waste collection is low. Also the infrastructure to manage waste in a proper way is not sufficient (solid waste) or non-existent (liquid waste) yet (Figure 37). Unmanaged liquid waste flows are supposed to effect ground water quality as also described in section 3.3.

*Figure 35 Informal waste dump site and a full overflowing septic tank southwest of gully c, discharging liquid waste into the riverbed.*

### Organise solid and liquid waste management

To improve the current situation, the local government can take the lead in the organisation of waste management. As a minimum condition of waste management waste should be disposed at a designated controlled location.

Relocation of the existing solid waste dumping site and carefully protecting the environment close to the site is one of the important issues that could be addressed at this initial stage. Seepage from the dump will negatively impact the groundwater quality. Also community awareness raising to collect and sort waste in a proper way could help to improve the situation of waste ending up in the river valleys and polluting water resources. Stimulating and extending an (in)formal structure of waste collection activities in town could help the private company to scale up its activities towards re-cycling of waste.

For liquid waste people should be encouraged to empty their septic tanks and pit latrines in time by local entrepreneurs. Designating an official dumping site near the town for liquid waste should be prioritised, also to enhance current liquid waste management practises. After that full scale collection of liquid waste is a first step towards re-cover, recycle and reduce of this liquid waste.

Liquid waste offers business opportunities to create value propositions. Two successful local business initiatives in Kenya include bio-gas and briquette production from liquid waste (Figure 37).

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*Figure 36 Use of feacal matter for briquette making after carbonisation to kill pathogens (Practical Action).*

# 4. Implementing solutions

In the SPONGE city Kajiado program the consortium aims to introduce a number of practical solutions to prevent water losses in town and increase access to good quality water. These solutions include known 3R-technologies such as roof water harvesting, sand dams, gully plugs, but then brought into the urban setting of Kajiado. We also aim to combine this with urban beautification and innovation around design of road drainage. In such a project the focus also on networking and collaboration for sustainability

## 4.1 Strategic partnerships/MoAs and groups mobilized

Throughout the process we seek the compliance, investment and association with a number of strategic partners including the County government, with whom we would like to formalize engagements. This will enhance the sustainability of proposed interventions.
The Ministry of Water and Irritation, The ministry of public health and sanitation and the planning department will be key in project implementation, ownership and sustainability.
The project aims to engage different initiatives in Kajiado to reach scale. At present we hope to involve different projects and mainstream agendas and initiatives. The WASH Alliance Kenya and Welthungerhilfe showed interest in collaboration.
The other part of this activity is the mobilization of community groups to look at the potential for urban sanitation and pooled funding for roof water harvesting. We will work with existing organized community groups to increase their awareness and build their capacity in WASH related interventions to ensure a holistic approach to safe water and improved sanitation and hygiene practices.

## 4.2 Setting an enabling environment

As all solutions have to be financed an important step is to accelerate the implementation phase through local investments. To reach this goal it is important to set an enabling environment, that is needed to make an investment plan feasible. Examples of activities the consortium will do with the aim to enable acceleration of investments in the project area are:

- In cooperation with MTTI we will support the installation and distribution of rain water harvesting tanks in the institution.

*Figure 37 Existing rain water harvesting facilities at a private house in Kajiado town.*

- At individual households we will need to look at substantial contributions from beneficiaries or pooling of resources.

- Through community mobilization and sensitization, we will create demand for improved sanitation among the community and hamlets.

- We will seek to establish discounts or private sector involvement through pooling of resources for tank construction.

### 4.3 Towards a complete investment plan

In this step a complete plan of investments probably exceed the contribution of the initial Via Water proposal. The interventions under the Via Water program will be too few to cover the full extent of the proposed interventions. This means that all exceeding costs have to be covered by contributions of third parties (local and regional governments, other NGO's and private business partners). In this step we aim to show proof of principles of SPONGE city Kajiado to possible financiers, with help of the results of successful implemented pilot interventions. We aim at financiers who can cover full scale implementation of solutions for Kajiado city, but we are also looking for partners who can bring the program to other cities in the region. We will therefor also look at possible financiers who are willing to invest outside Kajiado.

### 4.4 Actual implementation

If all conditions (financial, institutional, environmental, technical and social) for the implementation of solutions in Kajiado town are met, the implementation of solutions can be put into action.

### 4.5 Monitoring and evaluation of solutions

Monitoring and evaluation of implemented solutions in Kajiado city will be an important activity to be able to scale up towards other areas. Success stories have to be documented and disseminated to a broad public. On the other hand important learnings have to be gathered as well, to be able to adapt solutions and to make these more effective.

## 5. Researching and dissemination for scale

After successful implementation of interventions in the project area of Kajiado city, the aim is to scale up the SPONGE city approach towards other cities in the region. The aim of this phase is to make Kajiado a model from which other towns in the arid lands of East Africa (Figure 38) can get inspiration from.

To reach more scale it is needed to continue monitoring and evaluation, best practise gathering and dissemination of these practises towards other donors and actors in the region.

*Figure 38 Kenya city map (mapsofworld.com)*

## The SPONGE city consortium

***Neighbours Initiative Alliance***

Established and registered in 1996, Neighbours Initiative Alliance is a Non-Governmental Organization (NGO) working with pastoralist communities in Kenya. NIA implements community anchored programs in Water, Sanitation and Hygiene (WASH), Health and Nutrition, Food Security, Governance and Economic Development. In the Sponge City Program NIA operates as the lead implementing organization and local partnering institute for county government and the learning agenda

***RAIN***

RAIN specializes in sustainable water programs in a development context. RAIN programs focus on the retention, recharge and reuse of water (3R). We aim to motivate and help as many people as possible to apply these methods in a sustainable and effective way, whether the water is for domestic, productive or environmental purposes. Our focus is on making the concept and practice of rainwater harvesting (RWH) familiar to people in areas that lack sufficient and safe water sources. In the program RAIN will focus on development, coordination of partnership, technical backstopping and learning.

***Acacia water***

Acacia Water provides consultancy services on groundwater exploration, integrated water resources management, development plans and water infrastructure design. In the programme Acacia Water will be responsible for the hydrogeological assessments and the technical evaluation of options to improve water provision.

**Masai Technical Training Institute**

Already part of our initial thinking process on the ways in which urban areas can be adapted using simple infrastructure, the Masai Technical Training College is a tertiary institution based in Kajiado County, Kenya. It is the leading institution in the county which offers full-time, part-time, distance and online learning. In the consortium MTTI will deploy its students and lecturers to train on simple water harvesting infrastructure and facilitate several learning occasions.

***Amref Health Africa in Kenya***

Amref Health Africa is an international African organisation headquartered in Nairobi. Its mission is to improve the health of people in Africa by partnering with and empowering communities, and strengthening health systems. Amref will develop the programs sanitation component by focussing on Urban Community- led total sanitation (UCLTS) thereby developing the water quality and sanitation component. This will also include community mobilization, local networking and upscaling in line with lessons learnt from implementation of urban sanitation project in Nakuru Kenya.

***SASOL Kenya***

Internationally renowned for their sand dam expertise and highly appreciated for any form of technical backstopping on 3R measures, SASOL has been in operating since 1990. Based in Kitui town Kenya, SASOL will assist the consortium with Technical backstopping in infrastructure.


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