In opdracht van enkele ZBA leden waaronder Stichting Neerlandia Foundation heeft Practica onderzoek gedaan naar de beschikbaarheid van grondwater. Rond de rivier is wel voldoende water beschikbaar. Verder onderzoek moet uitwijzen of het water ook verder vanaf de rivier beschikbaar is. Boren is kostbaar en geeft geen garantie op succes.

Stichting Maleja heeft deze activiteit gecoördineerd. Kosten ca. € 10.000

Practica heeft ook een nieuw sproei systeem getest de Vipot, speciaal ontwikkeld om zuinig met water om te gaan. Helaas was de test nog geen succes, wordt verder aan gewerkt.

IRRIGATION ASSESSMENT IN AMUDAT

PRACTICA

IRRIGATION ASSESMENT IN AMUDAT

Field mission report

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INTRODUCTION

Amudat is a small district in North-Eastern Uganda with the lowest development indicators compared to other districts in Uganda. Amudat district is located in the Karamoja and has a semi-arid climate. The Nomadic pastoralist lifestyle of the ethnic Pokot is frequently disrupted due to migration, cattle raiding and armed conflict. ZOA has active programs in this area in the fields of education, WASH (water, sanitation and hygiene) and agriculture. The ZOA business advisors (ZBA) form a cluster of Dutch companies that support the work of ZOA both financially and strategically. In Amudat the advice focuses on the development of improved agriculture, food security, income generation and system sustainability. Within this framework the ZBA have supported the establishment of seven irrigation gardens in the Amudat district, see the overview in Table 1 and location in Figure 1.

The ZOA business advisors have contracted Practica Foundation to assess the current irrigation systems in place and the opportunities for improvement. Ideas for improvement included the use of larger solar pumps, as well as shallow wells to reduce dependency on temporal streams. The introduction of new technologies needs to be configured with the technical and socio-economic reality. To this end, PRACTICA has been engaged to the assignment to support the irrigation garden project in the design, technological and economic choices while assuring system sustainability.

In October 2019, Practica conducted a field assessment to understand the current setting and technology in place. The main objective of the mission was to assess the potential for improving small scale irrigation in the region of Amudat. More specifically, the field visits have informed recommendations on potential pump types and water source development. The assessment provides insights on the sustainability and scalability, linkages with markets, finance and service models. Next to this, the possibility of school gardens has been evaluated. This report presents the findings of the mission and the recommendations for further work in the region.

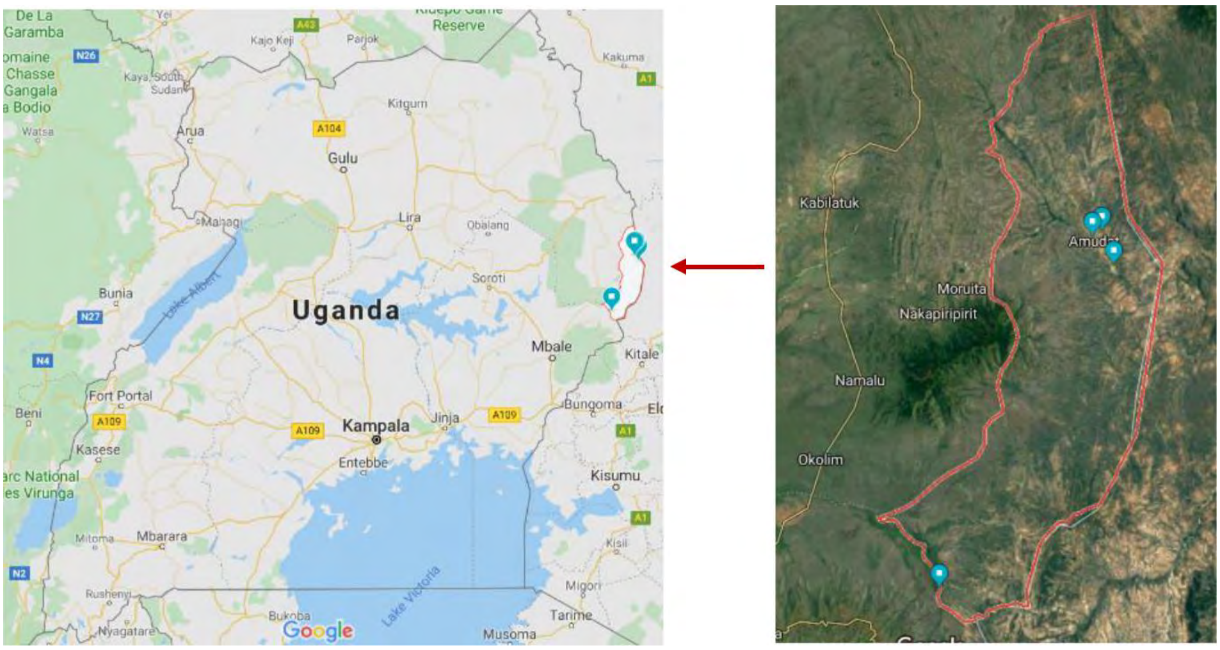


Figure 1 Location of Amudat district and ZOA irrigation gardens

METHODOLOGY

Desk research

Prior to the mission, PRACTICA has requested ZOA to share relevant studies and data related to groundwater and irrigation. The following information has been assessed: Drill log and pump test data from five water points in schools and the Soil and Water conservation measures assessment prepared by We Consult (2010). Unfortunately, the drill log GPS coordinates were missing, however five locations could be retrieved through cross-checking with the overview of schools. The results of the desk study are integrated in chapter 2: Access to water.

Field assessment

A field assessment was executed by a solar pumping expert from Practica and a local agriculture and hydrogeology expert from 13-20 October 2019. Irrigated production in the region is limited to the seven irrigation groups supported by ZOA. From the seven groups a selection of four was made with the local ZOA team, based on the water source, geology and logistics. Table 1 shows the sites that were visited:

Table 1 Overview ZOA irrigation groups

Group Name	# of members		Sub county	Parishe	Village	Water source status	Site visited	Number of test drills
	Male	Female						
Abenezer Self Reliance	14	6	Amudat	Amudat	Alakas	Temporal	Yes	1
Lokales Women Group	6	20	Karita	Lokales	Lokales B	Permanent	Yes	1
Inua Group	8	20	Karita	Lokales	Iwakai	Temporal	No	
Lokales Green Havest	9	15	Karita	Lokales	Iwakai	Temporal	No	
Louta	10	15	Amudat	Amudat	Nabokotom	Temporal	No	
Kokoroi	5	17	Amudat	Amudat	Nabokotom	Temporal	Yes	3
Kanyangareng	9	18	Amudat	Jumbe	Kakres	Temporal	Yes	3

The field visits aimed at assessing the technical and socio-economic situation in the irrigation gardens. To this end, farmers have been interviewed about the following components:

- Farmer group characteristics
- Irrigated production system
- Produce market
- Water source capacity and variation
- Pumps and irrigation technology

This information was cross-checked by field observations, and complemented by measurements on distances, field sizes, water depths and field elevation.

Groundwater availability was explored using a hand augering kit up to 7 meters depth. Several shallow hand-drilling tests were made in each visited sites in order to understand the depth to the water table, the permeability of the soil formations and expected yield for irrigation purposes. The resulting drill log can be found in Appendix A.

Figure 2 From left to right: Augering kit in use ; Soil sample analysis ; Test drill report Alakas

The mission itinerary is summarised in Table 2

Table 2 Mission itinerary

Date	Day	Activity
13-Oct	Sunday	Travel
14-Oct	Monday	Briefing at ZOA office – joint selection of sites for field visit
15-Oct	Tuesday	Visit Lokales site
16-Oct	Wednesday	Visit Alakas site (observations, interviews, test drilling) Visit Kanyangareng site (observations, interviews test drilling)
17-Oct	Thursday	Visit Primary School Katikit (observations, interviews) Re-visit Kanyangareng site (test drilling) Visit Nabokotom site (observations, interviews)
18-Oct	Friday	Re-visit Nabokotom site (test drilling and mini pivot trial) ZBA arrival
19-Oct	Saturday	Visit Nabokotom and Kanyagareng sites with ZBA and mini-pivot demo, Debriefing
20-Oct	Sunday	Church and field visit with ZBA
21-Oct	Monday	Travel

ACCESS TO WATER

Hydrology and surface water

The Amudat district consists of three main river catchments: The Kanyangareng in the North, the Kunyao in the central part and the Greek river in the South (see Figure 4). The three rivers can be divided into 30 sub catchments and over a hundred tributary streams. Apart from the main Greek river, all rivers and streams are seasonal (We Consult, 2010)[1]. Figure 3 shows that the dominant soil type in Amudat district is sandy clay loam.

Figure 4 River catchments in Amudat

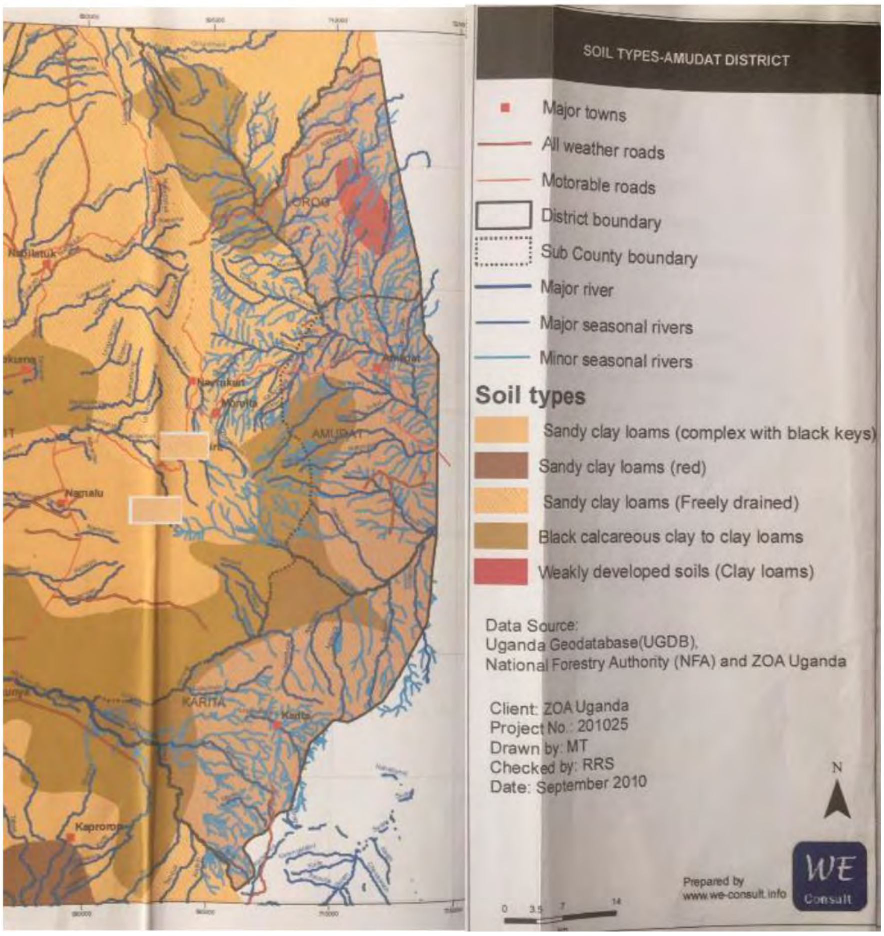


Figure 3 Soil types in Amudat

The main rivers have created large valleys with a flat area of about 400 – 800 wide (see Figure 5. These plains, which are often flooded during the rainy season constitute a large potential for farming and irrigation. Figure 7 shows the downstream Kanyangarang plain from Amudat town up to the Kenyan border, which has a size of over 1100 ha. The plain near the gardens in Lokales is about 240 ha (see Figure 6).

[1] We Consult (2010) Soil and Water Conservation Measures Assessment Amudat District, Uganda.

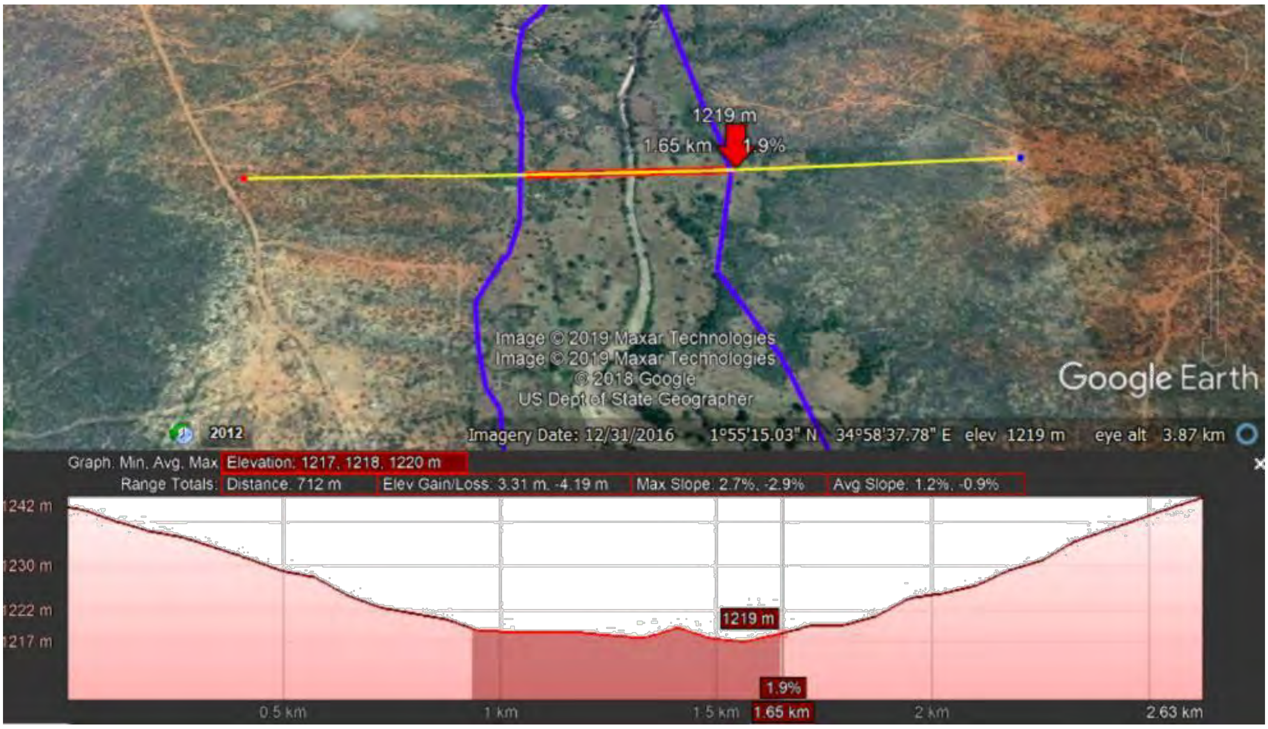


Figure 5 : Elevation profile of Kanyangareng river valley near Kokoroi

Figure 7 Downstream Kanyangareng plain (>1100 ha) and ZOA irrigation gardens

Figure 6 Greek river plain (240 ha) and ZOA irrigation gardens

Shallow groundwater

Except from Greek River, surface water availability is limited to the rainy season. However, the sandy riverbed of the Kanyangareng makes a large water storage reservoir that is accessible throughout the year. In the Kanyangareng site near Amudat, farmers dig holes into the riverbed and find water between 0.5 to 1 meter depth during the dry season. About 8 km downstream in Nabokotom, farmers also manage to dig for water in the riverbed throughout the year. The smaller streams dry up more quickly however. Near Alakas, farmers reported to dig 3 meters into the riverbed to get water. As a result, these farmers stop irrigating after one season since the water gets too deep.

Apart from the riverbed, groundwater can be found at limited depth in the identified flatlands. No open hand-dug wells have been encountered. Eight test drillings done in the ZOA irrigation gardens show that groundwater levels ranged from 1 to 3 meters in the sites near the Kanyangareng river (Alakas, Nabokotom and Kakres) and up to 5.5 meters in Lokales (Greek river catchment). It is expected that water levels will drop during the dry season. Water level monitoring during the dry season is necessary to assess the extent of the annual groundwater level variability.

The soils in the alluvial plains are characterised by a top layer of clay with occasional presence of sandy clay and stones. Four out of eight times the test drilling had to be relocated due to the presence of stones. Sandy aquifers, which are a prerequisite for positive drilled wells, were found during two test drills. The presence of stones can vary considerably within a short distance, as is shown by the three test drills in Nabokotom that are only 25m apart (Figure 8Figure 9 Test drill reports Nabokotom T1, 2, 3 and Figure 9). Nevertheless, the main lithological profile is the same, even for the different locations (See Appendix A).

Figure 8 Test drill locations Nabokotom T1, T2, T3

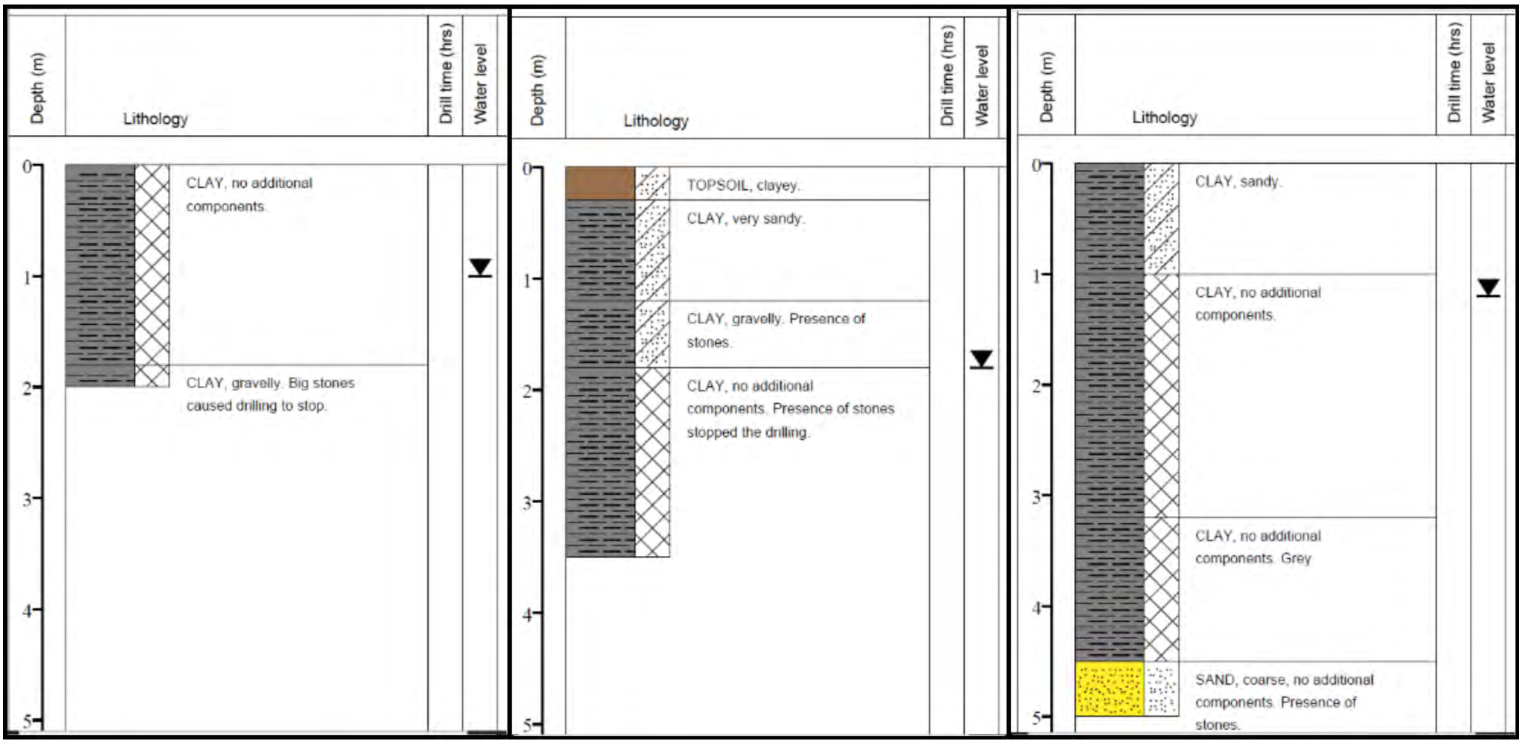


Figure 9 Test drill reports Nabokotom T1, 2, 3

The availability of surface water and the success rate of manual drilling per site is summarised in Table 3.

Table 3 Overview of water availability per site

Group Name	Village	Water availability in riverbed	Success rate drilling in garden
Abenezer Self Reliance	Alakas	Over 3m deep	1 / 1
Lokales Women Group	Lokales B	Permanent surface water	1 / 1
Kokoroi	Nabokotom	Max 1m deep	1 / 3 (low yield)
Kanyangareng	Kakres	Max 1m deep	1 / 3 (medium/low yield)

Deep groundwater

Drill logs from five machine drilled wells in schools (see map in Figure 10) show a typical lithology of top soil or clay ranging from 1 up to 10 meters deep. Going down, the unconsolidated layer is followed by weathered sedimentary rock and ultimately leading to weathered bedrock which is found starting at 6 to 25 meters depth (see overview in Error! Reference source not found.). The static groundwater levels are reported to be within 15 to 28 meters depth and thus always located in the weathered rock zone. The feasibility of manual drilling in weathered rock is very limited. Schools however are usually located in the higher areas to avoid inundations. The water depths are therefore not representative for the river plains and irrigation sites. The logs do show that the presence of productive sandy aquifers in the area is not widespread. In fact, it is limited to the rivers and its deposits in the alluvial plains.

Figure 10 Location of drill logs school wells and assessed river plains in blue and green

Table 4 Overview drill log data school wells

School	Static Water Table (m)	Dynamic water level (m)	Depth drilled (m)	Depth equipped (m)	Start depth weathered granite (m)	Yield (m3/h)
Motany	16	38	72	28	25	1.2
Nakipom	28	49	76	43	16	1.2
Namodo	27	40	82	54	18	0.8
Cheptuis	24		122	55	6	2.4
Kapetawoi	15		99	33	19	1.0

The studied drill logs show that for the five machine drilled wells, only half to a third of the drilled depth is actually equipped. At the same time the yields are low, as shown by the large drop in dynamic water levels while pumping with a hand pump. In two cases the dynamic water levels even dropped below the reported installation depth (!). The yields could have been higher if the drilled holes were equipped up to the reported water strikes in the fracture zones. Positioning the filter screen in the most productive layers would also have led to increased yields. However, even though improvements are possible, the logs and yield tests show that the weathered rock layers are of relatively poor water-yielding capacity.

FARMING AND IRRIGATION SYSTEMS

The irrigated flatlands are fertile and widely available. Despite the limited experience in vegetable production and irrigation in the district, farmers have managed to produce a marketable surplus. About 80-90% of the produce is sold at the local market in Amudat, as well as in Moroto and to traders in Kenya. Nevertheless, production is not organised according to the needs of the market. As a result, at times a part of the harvest is left in the field because of the lack of opportunities to sell it.

The four visited gardens are irrigated using solar pumps (SF1 and SF2), treadle pumps (Moneymaker) and petrol pumps. Farmers indicated that solar pumps are the preferred option, however the petrol pumps and treadle pump are also being used. Pipes from ¾ up to 1 1/4 inch are used to transport the water from the riverbeds to the fields. Water application is done by drip systems (connected to a tank), as well as hoses and water cans. During the mission one mini-pivot (see picture on front page) was installed on the field in the Kanyangareng garden. This system can be used with low-pressure pumps and allows to irrigate areas up to 1500m2.

Figure 11 Pipes used for irrigation

The main problem reported by farmers was the breakdown of solar pumps, and the long time it takes to have these repaired by the distributor in Kampala (up to two weeks). Farmers use a petrol or treadle pump as a back-up in order to prevent harvest losses. Minor maintenance issues can be done by farmers, but some groups refuse to do so due to the fear of losing the right to warranty (5 years). As for the irrigation systems no major problems were reported.

Because of the low irrigation density, it is difficult to acquire materials locally. On the regional markets, pumps and application systems for irrigation are available at reasonable prices.

RECOMMENDATIONS FOR IRRIGATION SITES

Access to Water

The overview in Table 3 shows that in three out of four sites water for irrigation is available throughout the year. A point of attention raised prior to the mission was that the distance may be too long and causing excessive pipe friction losses and reduced flow rates. It was observed that most farmers use pipes that are larger than 1 inch. With an average distance of 50m between the river and the irrigated plot, a 1 inch pipe would cause 4.1 m additional pressure (assuming a flow of 0.5 L/s). This friction head could reduce the SF2 pump output by 30% (!). Using a 1 1/4 inch pipe instead would reduce the pipe friction to 1.2m which causes less than 5% reduction in water flow. Hence, for those sites with large distances from the river to the field it is recommended to shift to 1 ¼ pipes. These pipes are available locally and in this scenario there is no significant negative effect on the water flow.

Creating access to shallow groundwater could be a solution for those sites without year-round access to water in the river, as was the case in Alakas. In order to capture the shallow groundwater either hand-dug wells or shallow boreholes can be constructed. In clay formations hand-dug wells are the only option as the low permeability of clay requires a large volume of water in the well. Drilling hand dug wells in clay formations is a low-cost but labour-intensive activity. In a floodplain, hand dug wells often collapse due to flooding, which implies that new wells need to be dug after every rain season.

Shallow manually drilled boreholes are a more durable alternative, especially when not installed in the main riverbed. However, a permeable and productive aquifer needs to be reached to assure sufficient water inflow. A productive aquifer was found in Alakas and Lokales. After two attempts, wells could also be made in Nabokotom and Kanyangareng, however the yield in these locations was low. In all cases the groundwater was within the reach of suction pumps during the time of testing. Out of eight test drills, two were positive, two were low-yielding and four were negative due to a predominance of clay and stones.

In short, access to water for irrigation can be improved by introducing shallow drilled wells in Alakas. In the other three sites water availability throughout the year is already assured. The groundwater level in Alakas (3m) is within suction depth at the moment, monitoring at the end of the dry season is needed to confirm the potential of a shallow borehole to provide year-round access to water.

Pumps and irrigation technology

The idea to introduce large solar pumps is not recommended, as it will increase the risk of harvest loss in case of pump failure. Using a number of small solar pumps instead reduces this risk. Small solar pumps are also a good combination with low-yielding shallow wells. Treadle pumps could also be a good back-up option; however, the workload is high since two persons are required for its operation.

Water efficiency is relatively high with the irrigation systems used, in combination with the low permeability of the clay soils. Yet, bucket and hose-pipe irrigation can be a time-consuming activity. The installed mini pivot could reduce the workload, however piloting is necessary to assess whether it matches the technical and social needs of the farmers. The use of large diameter pipes (at least 1 1/4 inch) is recommended to reduce friction losses.

Another potential issue regarding the current irrigation systems is the durability of drip technology. Drip systems, although very efficient, require sound maintenance skills and considerable financial resources for replacement. Hose-pipes, buckets, but also the mini pivots have a longer life span, require limited maintenance and have a lower cost. Therefore, these technologies are expected to be more sustainable and easier to scale up.

Business approach

Apart from the gardens supported by ZOA there is little farmer-led irrigation development in Amudat district. As a result, supply chains for pumps, irrigation equipment, as well as agricultural inputs, are largely absent. The possibility of supporting an agro-vet store in Amudat town should be explored, in order to improve the availability of irrigation materials and agricultural inputs.

For individual small-scale farmers, solar pumps and irrigation technologies are still expensive and a finance solution will be required for upscaling. Farmers structured in Village Savings and Loans Associations (VSLA) are common and seem functional. Saving systems organised by these groups of farmers could be useful in the process of acquisition and maintenance of irrigation technologies. VSLA groups could be established for the acquisition of agricultural inputs. For irrigation equipment however the required funds are too large and the pay-back time loo long for VSLA solutions.

In order to increase sustainability, it is advised to use a business approach for future interventions. Building a private supply chain has the advantage that spares and technical know-how are available and that solutions can be scaled up after a project. The ZBA could possibly support a stock of small solar irrigation pumps to be sold by the Agrovet store or another entrepreneur to identify in Amudat. As part of the deal, the enterprise can provide the technologies to farmers through a pay-back solution over a two-years period. Mobile money transfers are common in the area and can facilitate rent-to-own solutions. The entrepreneur will be responsible for the maintenance and reparations.

Reducing the initial investment and the risk of pump failure will lower the barrier for farmers to pay for irrigation technologies. At the same time, it will allow external farmers to also start irrigation activities. Especially in Nabokotom, new farmer groups have started around the ZOA irrigation garden. These groups can then make use of a solar irrigation pump solutions on a rent-to-own basis. It is recommended that new gardens are started in areas with permanent water availability, as for the moment the market is too small to establish a drilling business. Once the sector has grown, a critical mass may be achieved that justifies the opening of a shallow well drilling business.

Lastly, increased coordination or the establishment of a farmer association could help to respond better to the market and avoid the production of crops that cannot be sold. At the same time increased collaboration will facilitate knowledge sharing between farmers.

RECOMMENDATIONS FOR SCHOOL GARDENS

Unlike the farmer fields in the river plains, schools are usually located in the higher situated sites where surface water or shallow groundwater are not available. Table 4 in the chapter on access to water shows that the capacity of deep boreholes in the region is limited. Except for one school in Cheptuis, the yields are just sufficient for a hand pump. If continuous manual pumping were to be done for 8 hours a day at 1 m3/h, one could irrigate maximum 1000 m2 of vegetables. According to Santos et al.[2] this is sufficient area to produce vegetables for daily consumption for 40 persons. At the same time, deep groundwater is reported to be contaminated by corrosive minerals, which can be detrimental to irrigation pumps.

Most likely, a hand pump will not be operated all the time, which reduces the potential irrigated surface considerably. Alternatively, a low yield solar submersible pump could be installed on a borehole for about 1500 euro. The cost of mechanised borehole drilling including geological survey and water quality testing is 23.5 M UGX (about 5340 euro) per well, see Table 5 for the full cost set-up.

Table 5 Borehole drilling costs for 5 schools in Amudat

Well drilling cost	UGX contract	Estimated %	UGX per component	UGX per well	EUR per well
Geological survey	117504400	15%	17625660	3525132	801
Drilling		75%	88128300	17625660	4006
Water quality testing		10%	11750440	2350088	534
Sub total drilling				**23500880**	**5341**
O&M Toolkit	15000000	50%	7500000	1500000	341
Training of Water use committee		50%	7500000	1500000	341
TOTAL COST				**26500880**	**6023**

Besides the borehole and solar pump, an irrigation system would be required. The cheapest option is to use a hosepipe for direct irrigation. However, the availability of fulltime labour for irrigation may be unlikely in the case of a school garden. Therefore, it would be recommended to combine a solar pump for a 1000 m2 garden with 3 basins of 2m3 and spray cans. Conventional 2m3 brick basins cost about 120 EURO each. Hence, including the pipes and spray cans this type of irrigation system will cost about 450 EURO for a 1000 m2 garden.

The total cost for the water supply of a school garden would cost around 7500 EURO per system, provided that sufficient boreholes are planned to mobilise the drilling company. That would be the cost excluding fencing, agricultural inputs and labour for the agronomic activities (field preparation, planting, weeding, harvesting) and irrigation. The garden could then be used to add vegetables to the daily meal of maximum 40 pupils, which is far below the total number of pupils in a school. To increase this capacity, another borehole would need to be drilled in order to set up a second or third system.

More realistic than food production could be the educational potential of school gardens. Farming as a business is a relevant topic in which pupils can apply the theory of a variety

[2] Santos, W., Lopes, N., Barbosa, J.J., Chaves, D. and Valente, J.C. (1978). Nutrition and food science – Present knowledge and utilization. Volume 1: Food and Nutrition Policies and Programs. Springer Science and Business Media LLC.

of disciplines. In this perspective, vegetable gardening could allow pupils to learn about plants, soil, water and food, as well as accounting, business and marketing. The business dimension of agricultural production is becoming of increased importance for farmers in the region. School gardens are a good opportunity to teach pupils at the youngest age to students what farming is about, what is the potential and what skills to develop. To this end, ZOA could work with schools to develop a Farming as Business course and corresponding training materials.

However, the challenges to make school gardens sustainable are many. The issue is not so much on the construction of the garden, but on its operation and maintenance. Farming is a full-time job and profession that is not likely to be realised in between classes. The purchase of inputs and deployment of labour require a highly capable and motivated coordinator with a mandate to invest time and resources in the school gardens. In the absence of this, it is unlikely for the gardens to flourish as a learning playground.

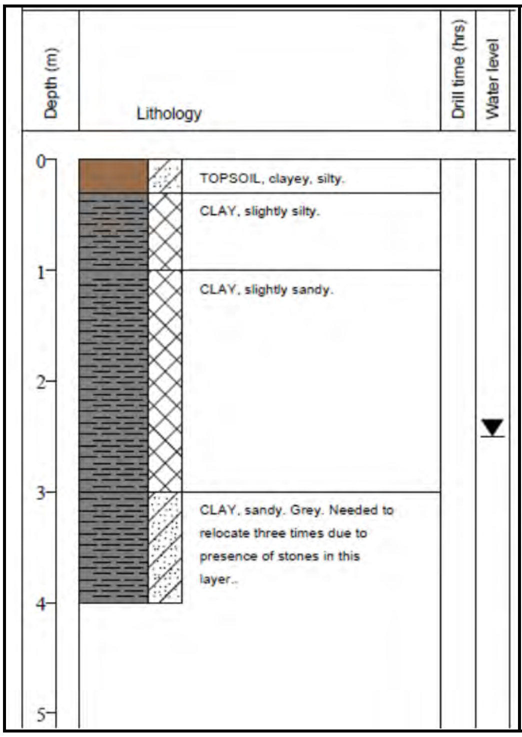
As an alternative, ZOA could support the organisation of excursions to the farmer group irrigation gardens. In this way a much larger number of children can be reached to get in touch with irrigated vegetable production. Representatives from the farmer groups could facilitate the sessions in exchange for the support received by ZOA.

APPENDIX A: TEST DRILL LOGS

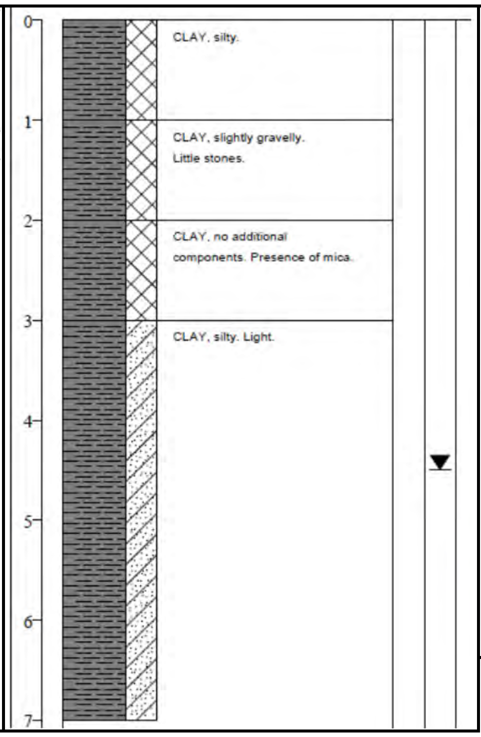
Kakres T3

T1 + T2 similar profile,

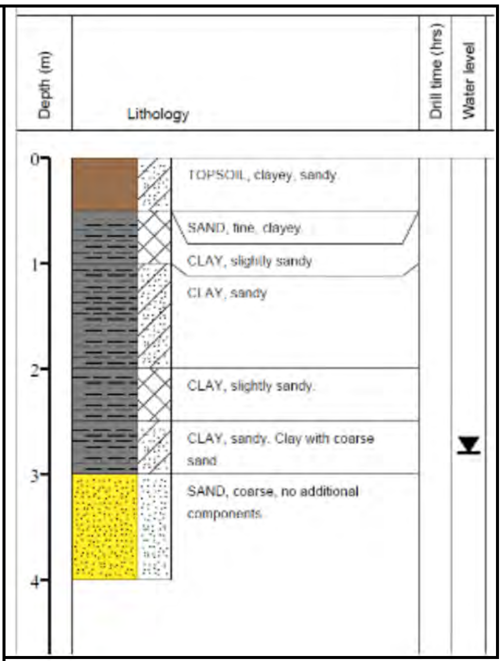
but stones hit at 3m.



Lokales T1



Alakas



Nabokotom T1, T2, T3