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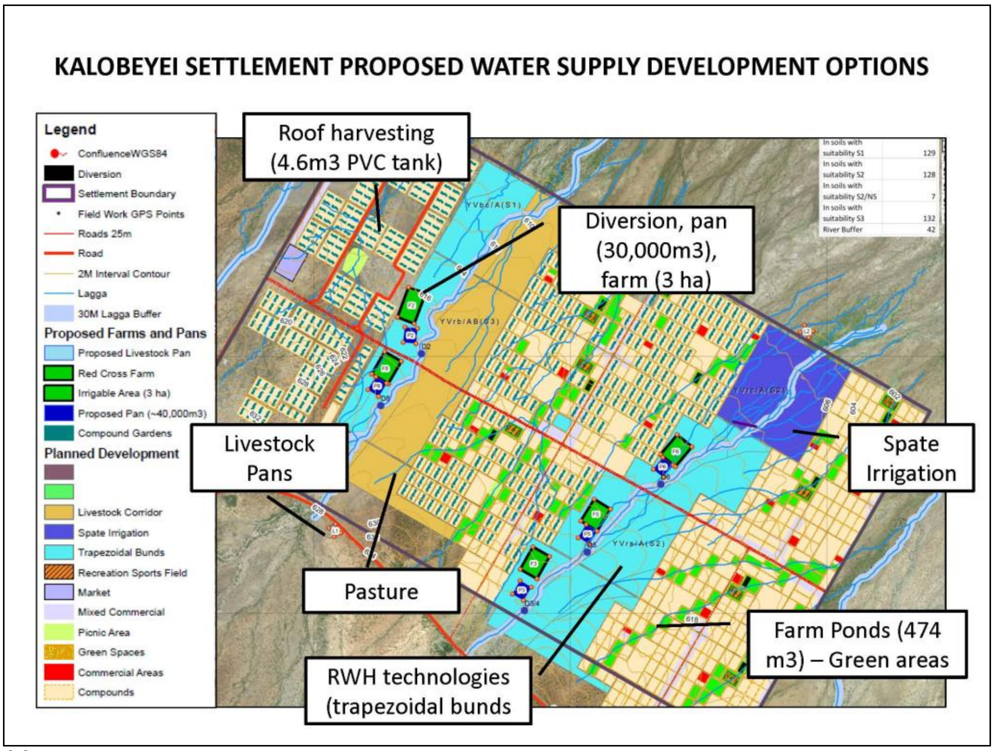
FEASIBILITY STUDY ON AGRICULTURAL VIABILITY AND WATER ACCESS FOR DRYLAND AGRICULTURE IN KALOBEYEI AND KAKUMA

TURKANA WEST SUB-COUNTY

EXECUTIVE SUMMARY



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DISCLAIMER

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EXECUTIVE SUMMARY

The Terms of Reference (TOR) clearly and expressly define the objective of this assignment as "Feasibility Study on Agricultural Viability and Water Access for Dryland Agriculture in Kakuma, Kalobeyei and its Environs in Turkana West Sub-County". As such the consulting Engineers consisting of Mike Thomas and Gikone Consulting Engineers Limited laid down the focal strategies for achieving the set objectives including but not limited to conducting desk and field work studies and investigations, data review and analysis, stakeholders presentations and consultations all of which culminated into the production of this Feasibility Study Report.

CLIMATE AND WATER RESOURCES

Climate

The study indicates that Kakuma has an average annual rainfall of about 321mm, an average temperature of about 27.6°C and annual evapotranspiration (ET_o) of 2714mm. The rainfall pattern is bimodal with the 'long rains' in March to May and the 'short rains' in October and November. The data indicates that approximately 40% of mean annual rainfall falls within the long rains. Just as in other semi- arid zones, the rain is highly variable temporally and spatially making seasonal or daily forecasts very difficult. The high evaporation rate implies that most of the surface water is lost through evaporation as reflected in the UNEP aridity index (P/PET) of 14.6%. Information on climate change indicates the trend is towards increasing aridity.

Surface Water Potential

The study examined the surface and groundwater resource availability within the study area. The surface drainage network is defined by a number of large seasonal *laggas* or wadis with the Tarach and Napas rivers being the most prominent within the study area. These laggas are 50 – 100 m wide with deep sandy/gravelly beds and tree lined banks. The specific yield is approximately 0.12 – 0.16 l/s/km^2. Two smaller *laggas* (Esikiriet and Elelia) rise in the Moru Itai hills to the south west of the Kalobeyei Settlement area and traverse between the villages in the settlement area providing limited flood flows that can be harvested and used within the settlement area. Additionally there are small drainage channels within the residential areas of the settlement area that can also provide a source of flood water.
The local river system of interest to the study is dominated by:

Groundwater Potential

Kakuma is located on a flat alluvial plain with rhyolitic outcrops indicating a complex geological structure near the surface covered with sand and gravel deposits. RTI (2013) describe the most prominent structural features related to the structuration of the Tarach River bed to be a major North-South fracture that is recut by N45° and N160° (*en echelon)* fractures and the presence of two rhyolitic volcanoes in the area: the Pelekech and Muruasigar Hills. The basement in the Kakuma area is relatively shallow, ranging from 100 m to 150 m bgl.

Essentially the Kakuma aquifer system along the Tarach River corridor consists of two layers, one shallow porous aquifer made up of sedimentary material and one underlying fractured aquifer made of volcanic rocks. The shallow alluvial aquifer is generally associated with high yields (> 10 m^3/hr) and greater storage, lower EC (< 600 uS) and fluoride concentrations but greater vulnerability to bacterial contamination. The deeper fractured volcanic rock aquifer is associated with lower yields (< 10 m^3/hr), higher EC (> 600 uS) and fluoride concentrations but lower vulnerability to bacteriological and anthropogenic pollution. The groundwater provides a strategic resource for domestic, livestock and limited irrigation with more than 52 boreholes and shallow wells within a 10 km radius of Kakuma having been developed. This clearly illustrates the level of effort to exploit the groundwater resources and the importance of groundwater as a reliable water source. Existing studies indicate that the existing abstraction is equivalent to a portion of the aquifer recharge within the Kakuma area and further utilization of the aquifer is possible with its proper management and monitoring.

Drilling wells and boreholes in the Kakuma area carries high risk due to the pervasive intrusive volcanic plugs, which are often not visible on the surface. In order to minimize risk, it is highly recommended to drill within the fracture corridor of the Tarach River which is a belt of 35 km long and 2 km wide along the course of the Tarach River, where conductive fractures converge with high potential areas. Drilling outside of the corridor carries a risk of either difficult geology or low yields.

The numerous studies of the geology and hydrogeology within the Kakuma and Kalobeyei areas indicate that the geology is complex and while good productive boreholes have been established, the overall experience is one in which yield and quality have been highly variable. A better understanding of the geology and hydrogeology is required to improve the targeting and development of additional boreholes. This will require geophysical investigations using different methods (e.g. vertical electrical sounding, seismic refraction, Electromagnetic Resistivity Tomography) to be conducted by a registered hydrogeologist.

However, the indication is that, particularly along the Tarach corridor, additional groundwater resources can be exploited without detrimentally affecting existing productive boreholes. In essence additional boreholes (and possibly shallow wells) can be developed for irrigation purposes but the identification and development of these sites needs to be undertaken very thoroughly.

The existing studies indicate that groundwater potential within the Kalobeyei Settlement area is very low with all the drilling sites returning very low (<1 m^3/hr) yields and high salinity.

WATER SUPPLY OPTIONS

Roof harvesting: The roofs of the refugee houses can be used to harvest in the order of 4.9 m^3 of rainwater per rainy season into PVC tanks although with a lot of uncertainty. This water can be used to irrigate small kitchen gardens or fruit trees. The application of the technology requires attention to the gutters, the risk of stagnant water and basic operation and maintenance to manage the water demand. A system of this nature may cost in the order of USD 620 per house and serve a 4 m x 3m kitchen garden.

In-situ rainwater harvesting technologies: In-situ rainwater harvesting technologies create conditions suitable for rainwater retention in the soil and concentrate the runoff towards the cropping area. There are a number of the rainwater harvesting technologies (e.g. trapezoidal bunds, contour bunds, zai pits, micro-catchments, sunken/fertility beds etc.) that have been applied already within the wider Kakuma – Kalobeyei area with what appears to be good success. Most prevalent are trapezoidal bunds which have been widely adopted.

Small farm ponds: There are a number of small runoff channels that intersect the villages in the Kalobeyei Settlement area. This water can be channelled into small lined farm ponds (474m^3) from which the water could be used to support high value crops on a small fenced area (20m x 20m). The application of this technology introduces risks associated with stagnant water that must be mitigated and managed. The technology requires the use of a pump to extract the water. Various pump options are possible but a small portable solar pump (SF1) may provide a cheap and durable solution. A lined farm pond (475 m3) plus fenced farmed area all covered with shade netting would cost approximately USD 12,520.

Spate irrigation: Spate irrigation refers to a form of irrigation which relies on the diversion of flood water from an ephemeral water course to a farming area where the water is stored in-situ in the soil sufficient to produce a quick maturing crop. There is potential for spate irrigation within the northern parts of the Kalobeyei settlement area where the *lagga* channels bifurcate and the land gradient is flatter. The *lagga* banks are lower (0.5 m) and a low gabion weir can be used to elevate the water level to direct the flow into the flood plain. A low embankment (0.5 m height) constructed on a 0.5% slope would help to spread the flood water evenly across the flood plan. Inlets through the embankment would allow water into the farming area which should have a system of trapezoidal bunds to disperse the flood water throughout the farming area.

Water pans: Water pans are used to store water where the land gradient is flat or shallow, as is the case in the Kalobeyei Settlement Area. The storage capacity is created by excavation. Given the highly unreliable nature of the rainfall in the Kakuma-Kalobeyei area, storage of runoff is important to improve reliability of water for crop production. The *laggas*, transecting the Kalobeyei Settlement area provide an opportunity if the flood water can be stored. The development of a water pan for storage must therefore be accompanied with diversion works on the *laggas* and a channel to direct the water to the pan. The diversion works present design challenges due to the lack of suitable foundation material and the friable nature of the soils. The application of this model introduces various risks associated with ponded water which must be minimised and managed. This option requires a detailed design but a preliminary design indicates the possibility of developing five 30,000m^3 lined pans with gabion weirs for the diversion works. A unit of this nature is expected to cost approximately USD 204,000 and could support a farmed area of 2.5 - 3 ha. Livestock production is an important part of the host community livelihood and culture. The presence of uncontrolled livestock with the Kalobeyei Settlement Scheme is likely to induce conflict between the farmers and livestock herders. In order to provide adequate water sources outside of the Settlement Scheme area, two potential pan sites, have been identified. The livestock pans of approximately 15,000 m^3 would provide water for 2 – 3 months after the end of the rainy season which would extend the grazing period in the rangelands near the Settlement area.

Large Dam (KRCS Tarach dam): The proposed Tarach dam (Tulabalany Dam) site is located approximately 40km south of Kakuma on the Tarach River and is being investigated with support from KRCS. Initial information indicates a dam of 2 – 6 MCM capacity which would be able to yield 1507m^3/day sufficient to meet domestic demand and approximately 50 ha of irrigated land, although various different scenarios are being considered. The project will cost in excess of US$10 Million and should be considered a national "mega" project. This project is outside the scope of this feasibility study. However it is sufficient to conclude that the project is unlikely to be able to meet all the water demand requirements for the Kalobeyei Settlement area, and the project is likely to take some time to come into existence, if at all. Alternative and more immediate forms of water supply should be pursued.

Small dams in the Moru Itai Hills: The Moru Itai hills to the south of the Kalobeyei Settlement Scheme were explored for possible dam sites. The hills consist of steep bush covered slopes with sandy water courses. Two sites of potential interest were identified but it is clear that the catchment areas are too small and the hydrological analysis indicates insufficient runoff to justify further investigation of these sites.

Groundwater: The hydrogeology indicates that there is potential for further groundwater exploitation within the Tarach river corridor. At present the indications are that groundwater is unlikely to be found within or near to the Kalobeyei Settlement Scheme.

Given the potential for further groundwater exploitation within the River Tarach corridor, this study has considered a groundwater based model irrigated farm consisting of:

- Two boreholes capable of delivering approximately 20 m^3/hr or 400 m^3/day (solar pumps) of low EC water;
- Irrigated farm, fenced, of approximately 3 ha.

A model of this nature could be developed for the Kalobeyei Settlement Scheme, although it would require a 12km piped conveyance system between the wellfield on the Tarach river corridor and the irrigated area, storage tanks and surface pumping system. It is estimated that a system of this description would cost about USD 784,640.

This model, with modifications, can be applied within the host community area with a model farm located in close proximity to the boreholes, thereby reducing the conveyance cost, with a unit price of approximately USD 309,400.

A system of this nature can provide a reliable water supply but the institutional aspects related to running the system would be crucial to achieve the reliability of the supply.

One aspect that must be factored in is the management and monitoring of the aquifers along the Tarach River given the critical importance of these aquifers for the domestic water supply to Kakuma town, Kakuma refugee camp and the Kalobeyei Settlement Scheme. A wellfield developed for irrigation purposes should be identified north of Kakuma to avoid competition of groundwater with existing domestic sources.

LAND, AGRICULTURAL PRODUCTION AND MARKETING

Land tenure: Much of the land within the host community is communally owned. This was initially as a result of the traditional communal tenure system but since the enactment of the Community Land Act, 2016 all unregistered community land is held in trust for the community and administered by the County Government. To accommodate the increasing number of refugees in Kakuma, the Turkana County Government allocated 1,500 hectares of land in Kalobeyei for a new settlement on 19th June 2015. The Government of Kenya, the Turkana County government and all key stakeholders agreed to use the land to develop a settlement that will promote the self-reliance of refugees and host communities by providing them with better livelihoods opportunities and integrated services. The expectation is therefore that both a section of host and refugee communities would be allocated land and participate in the farming activities on 400 ha of land set aside for farming. The allocation process is delicate as the host community has previously used the land for agriculture and pasture. Intensive engagement between key stakeholders and the host and refugee communities is required and indeed is underway to allocate land in a manner consistent with the relevant legal frameworks and rules of natural justice. Therefore the host and the refugee communities have agreed on a set of criteria to select beneficiaries who are being allocated the land.

Soil suitability: A 2015 UNHCR Report provides a soil suitability map for Kalobeyei Settlement Scheme. Of the 438 ha set aside for commercial agriculture approximately 30% or 257ha is either highly or moderately suitable for agricultural production. This area is suitable for the application of in-situ rainwater harvesting technologies (trapezoidal bunds, zai pits, etc.), spate irrigation or high value crop production under conventional irrigation farming method. 30% of the land is unsuitable for crop production and it is suggested that this land be used for pasture and fruit trees. 10% of the land is the river buffer which should be preserved without agricultural activities.

Areas within the host community, particularly along the river corridors, have soil suitable for agricultural production. Indeed it is these areas that have recently been farmed by the host community.

Crop production and agronomic practices: Crop production within the host community areas has been heavily promoted through the Food for Asset (FFA) model with the application of rainwater harvesting technologies. Sorghum, maize and pulses such as green grams and cowpeas are the common crops grown. There are a small number of group model farms in which horticultural crops (kales, tomatoes, okra, spinach and traditional vegetables) are grown under irrigation. These model farms aim to build the capacity of the host community to undertake irrigated crop farming.

Crop production within the Kalobeyei Settlement Scheme is currently restricted to very small kitchen gardens (4m x 3m) irrigated with limited water supplies from the domestic supply. Crop production in other areas set aside and suitable for crop production is yet to take off due to land allocation, development of infrastructure and finalisation of an agreed plan. It is anticipated that the refugee community may be more familiar with rain-fed and irrigated crop production than the host community due to practices and experiences from their home countries. Training in crop production will therefore be required to enable both host and refugee communities to participate in crop production opportunities.

Agricultural marketing and post-harvest handling: The area is basically a food deficit zone so most crop harvests are retained for home consumption. The low agricultural production means that the host and refugee community have not had the need to engage in marketing activities. The market for food items, especially horticultural products is high due to the density of settlement within the Kakuma area. Although markets for horticultural products exist in other areas (e.g. Lodwar and Kitale) the distances and transportation costs would be significant.

Farmers' organisations: The host community have established group farms in which households are allocated farming areas within a specific trapezoidal bund. However, there are no well-developed farmer organisations or co-operatives with detailed skills in irrigated farming. The establishment of farmer organisations is an area that will require significant investments in capacity building of both host and refugee communities as part of developing sustainable farms.

IRRIGATION SYSTEM

The Kakuma-Kalobeyei area is semi-arid and rain-fed farming can be enhanced through the application of rainwater harvesting technologies and spate irrigation. These "unconventional" irrigation systems aim to concentrate runoff to specific areas to increase the soil moisture sufficient to produce a crop. The irrigation system is therefore opportunistic aiming to take advantage of the short term runoff.

Conventional irrigation systems aim to meet the crop water requirements through provision of a regular water supply. In order to achieve this within the Kakuma-Kalobeyei area, water sources must be established with sufficient capacity and reliability to meet the crop water demand for the entire cropping cycle. The options include flood water storage in farm ponds, pans or from groundwater.

Different forms of irrigation (furrow, basin or drip systems) can be applied within the Kakuma-Kalobeyei area although the choice is dependent on the water quality, complexity of the technology, capacity of the farmers, and infrastructure. It is advisable to utilise systems that are robust and reasonably straightforward for farmers to use. The high evapotranspiration rates means that attention is needed to avoid salinisation of the soils.

CONCLUSIONS

Water supply development within the Kalobeyei Settlement area

It is clear that there is no single obvious water supply solution to support agricultural production within the Kalobeyei Settlement area. The surface water resources consist of runoff water in small ephemeral water courses within the villages ("Green Areas") and the *laggas* transecting the settlement area. These surface water resources are unpredictable and sediment laden. Groundwater sources, which may provide reliable good quality water exist along the River Tarach corridor but these require significant conveyance systems (about 12.5km) and the groundwater may be contested by domestic abstractors.

The net result is that while various technologies may be utilised to create the opportunity for high value crop farming supported with irrigation water, it is unlikely that all of the land set aside for commercial farming can be developed for high value crops (especially in the short term). Therefore other rainwater harvesting technologies (e.g. trapezoidal bunds, zai pits, micro-catchments) should be employed to improve the likelihood for realising a crop harvest from the arable land. Of the 257ha of the commercial farming area with suitable soils, the analysis indicates that about 55 ha could be used under spate irrigation and about 15 ha under high value crops supported by lined water pans or partially by groundwater from potential boreholes along the Tarach river corridor. This leaves about 187ha that can be farmed using in-situ rainwater harvesting technologies. The land with poor soils can be used for pasture and fruit trees.

Water supply development within the Kakuma-Kalobeyei host community
Water supply developments for the host community are not restricted in terms of location in the same way as for the Kalobeyei Settlement area. The water supply technologies can therefore be applied wherever the opportunity exists. However, providing reliability of a low EC water supply should be given priority as the area still lacks sufficient model farms for training farmers on all aspects related to high value crop production and marketing.

RECOMMENDATIONS

The following recommendations are offered to guide the development of agricultural production within the Kalobeyei Settlement Area and the wider Kakuma-Kalobeyei environs.

1. Roof harvesting should adopted and applied on a piloting basis to improve water supply for kitchen gardens;
2. In-situ rainwater harvesting systems (e.g. trapezoidal bunds, zai pits and conservation agriculture) should be implemented within the commercial farming area specifically where the soils are suitable. Reference should be made to the soil suitability map;
3. Lined farm ponds (approx. 475 m^3) with small group farm (20m x 20m) should be piloted along the drainage courses within the Green Areas. A lined farm pond (475 m^3) plus fenced farmed area all covered with shade netting would cost approximately USD 12,520. Attention should be given to the risks associated with this technology;
4. A lined pan (30,000m^3) with associated diversion works and channel sufficient to support 2.5 – 3 ha under furrow irrigation should be fully investigated to the design stage;
5. In order to provide adequate livestock water sources in the vicinity of the Settlement Scheme area, two potential water pans of approximately 15,000 m^3 each are proposed;
6. Geophysical investigations should be undertaken to identify potential borehole drill sites for production boreholes along the Tarach and Napas river corridors to supply irrigation water to 2.5 – 3ha model farms in the Kalobeyei Settlement and also within the host community. This work should be coupled with stakeholder consultations related to which measures are required to manage the aquifer systems and ensure that the existing groundwater based domestic supplies are not threatened by abstraction for irrigation purposes;
7. Preference should be given to groundwater based water supply options that can deliver a reliable supply of good quality water over surface water solutions that have attendant environmental risks and supply uncertainties;
8. Careful consideration should be given to the environmental risks associated with any water supply options adopted. This implies strict adherence to the environmental and water regulations to minimise and mitigate the risks;
9. Operation and maintenance of the adopted water supply options requires careful analysis, planning, capacity building and mentoring in order to ensure that the reliability of supply is not degraded by the institutional, organisational, technical and financial aspects of operating and maintaining a water supply system for irrigation;
10. Detailed stakeholder consultations and engagement are required in relation to the equitable distribution of opportunities for improved agricultural production within

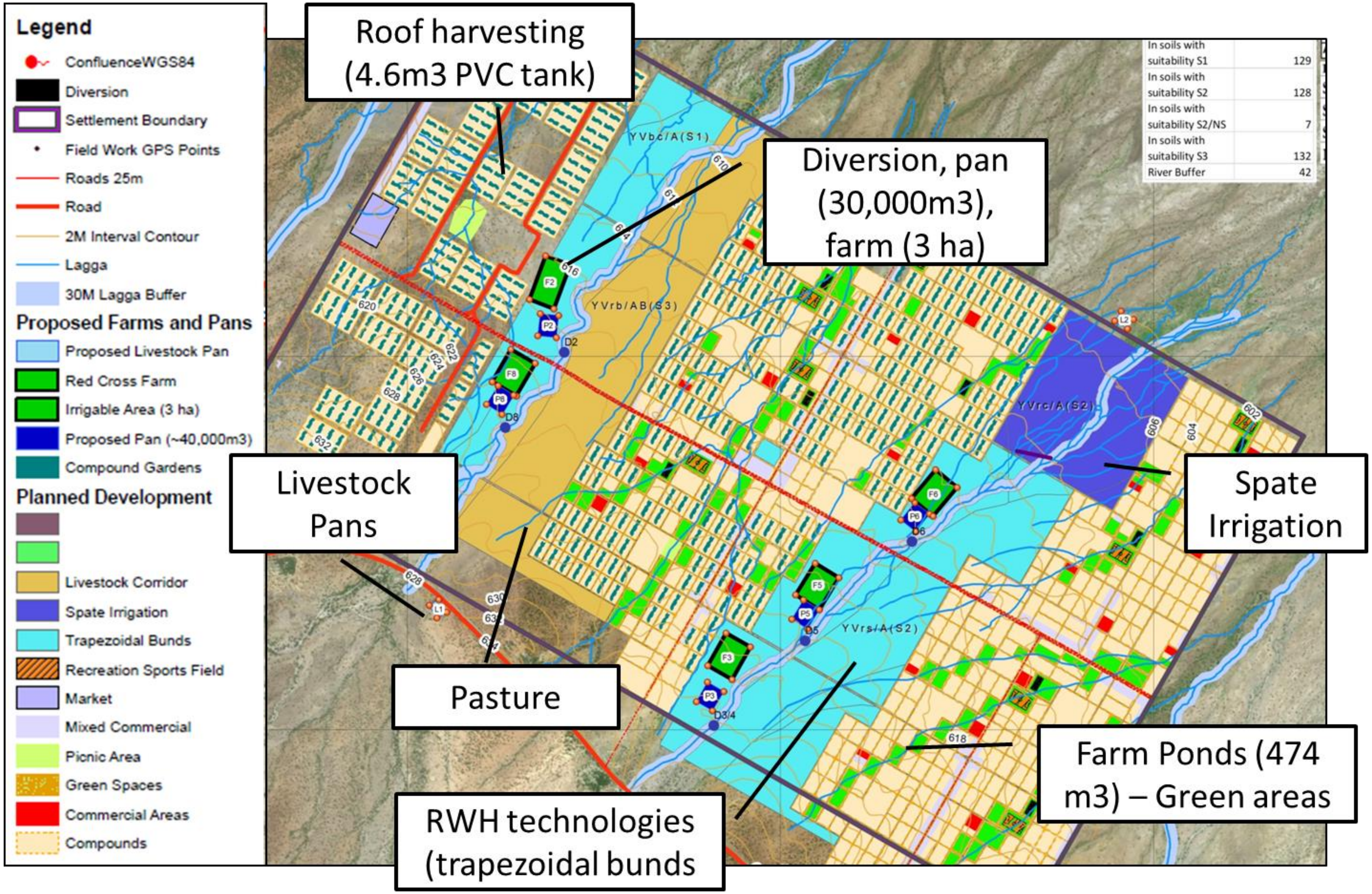
refugee community within the Kalobeyei Settlement Area and the host community; and

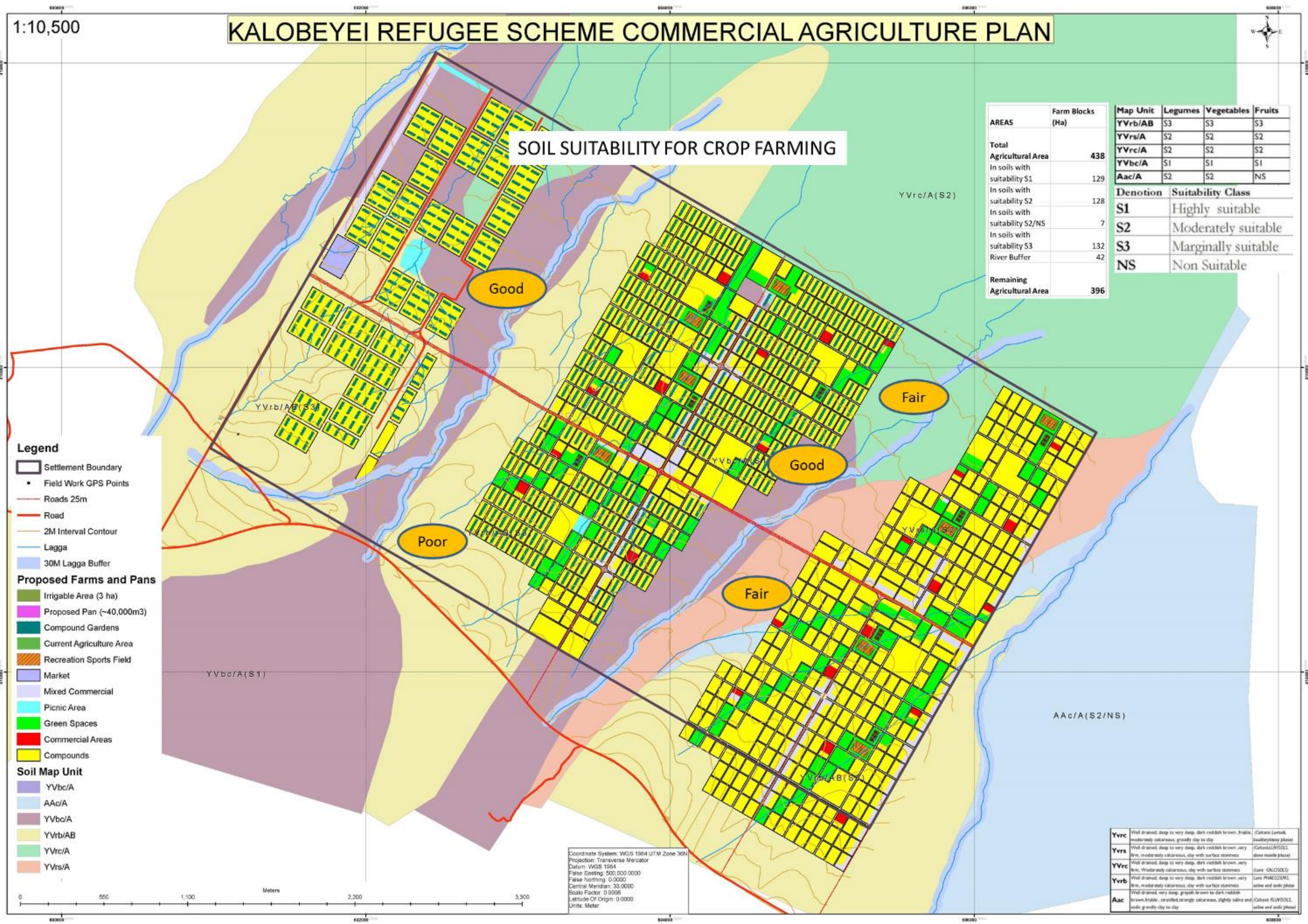
11. Development agencies and the Turkana County Government should endeavour to establish model irrigation farms for both the host and refugee communities to enhance food production and to build capacity on crop production. This will require careful attention to technical, social, organisational, environmental, agronomic, and crop handling aspects to develop robust, productive and sustainable farms.

Water Development Options

Item	Detail	Unit Price (USD)	Farming Area (ha)	Irrigation Set up Costs (USD)	Total Cost (USD)	Cost per Farmed Area (USD/ha)	Reliability of resource	Comments
KALOBEYEI SETTLEMENT AREA								
Roof harvesting	4.6m^3 PVC tank, gutters, downspout	620	0.0012	0	620	516,667	Low	Bucket
Farm Pond	474 m^3, PE liner, SF1 pump	12,520	0.04	0	12,520	313,000	Low	SF1 pump shared between 2 farms
Diversion works, Pan	Gabion structure, 30,000 m^3 lined pan	204,273	3	63,460	267,733	89,244	Low	2 for livestock, 5 for crops
Spate Irrigation	Gabion structure, lateral embankments	21,130	32	-	21,130	660	Low	
2No. Tarach BHs & delivery pipe	2 No. Bhs, 2No 500 m^3 GS tanks, pumping systems, 12.5km piping	784,640	3	63,460	848,100	282,700	Good	Solar pumping, needs further groundwater assessment
HOST COMMUNITY								
Roof harvesting	4.6m^3 PVC tank, gutters, downspout	620	0.0012	0	620	516,667	Low	Bucket
Farm Pond	474 m^3, PE liner, SF1 pump	12,520	0.04	0	12,520	313,000	Low	SF1 pump shared between 2 farms
Water pan for livestock	15,000 m^3 clay lined pan, well + cattle trough						Low	
2No. Tarach BHs & delivery pipe	2No. Bhs, 1No. 500m^3 GS tanks, pumping systems, 2km piping	309,400	3	63,460	372,860	124,287	Good	Solar pumping, Reliable Supply

KALOBEYEI SETTLEMENT PROPOSED WATER SUPPLY DEVELOPMENT OPTIONS





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KALOBEYEI REFUGEE SCHEME COMMERCIAL AGRICULTURE PLAN
SOIL SUITABILITY FOR CROP FARMING
AREAS | Farm Blocks (Ha)
Total Agricultural Area | 438
In soils with suitability S1 | 129
In soils with suitability S2 | 128
In soils with suitability S2/NS | 7
In soils with suitability S3 | 132
River Buffer | 42
Remaining Agricultural Area | 396
Map Unit | Legumes | Vegetables | Fruits
YVrb/AB | S3 | S3 | S3
YVrs/A | S2 | S2 | S2
YVrc/A | S2 | S2 | S2
YVbc/A | SI | SI | SI
Aac/A | S2 | S2 | NS
Denotion | Suitability Class
S1 | Highly suitable
S2 | Moderately suitable
S3 | Marginally suitable
NS | Non Suitable
Good
Fair
Good
Poor
Fair
YVrc/A(S2)
YVrb/AB(S3)
YVbc/A(S1)
AAc/A(S2/NS)
Legend
Settlement Boundary
Field Work GPS Points
Roads 25m
Road
2M Interval Contour
Lagga
30M Lagga Buffer
Proposed Farms and Pans
Irrigable Area (3 ha)
Proposed Pan (~40,000m3)
Compound Gardens
Current Agriculture Area
Recreation Sports Field
Market
Mixed Commercial
Picnic Area
Green Spaces
Commercial Areas
Compounds
Soil Map Unit
YVbc/A
AAc/A
YVbc/A
YVrb/AB
YVrc/A
YVrs/A
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False Northing: 0.0000
Central Meridian: 33.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter
Yvrc
Yvrs
YVrc
Yvrb
Aac