Regional Learning & Advocacy Programme for Vulnerable Dryland Communities

The Turkana Aquifer discoveries and development proposals: A REGLAP discussion perspective[1]

Sean Avery, an independent consultant, November 2013[2]

Introduction

After years of marginalisation Turkana is very much in the news. There are exciting exploitable oil reserves in the County, plus mineral resources too, and to add to this, UNESCO recently announced the discovery of the Lotikipi aquifer, a vast underground lake the size of Lake Turkana, which "could provide water to Kenya for 70 years."[3] This aquifer find adds to four other smaller aquifers announced in the area earlier in the year. The discovery is based on new remote sensing technology not previously tested in Kenya.

Key findings of the RTI / UNESCO hydrogeological investigation in Turkana

UNESCO commissioned the hydrogeological resources investigation of a 36,000 km^2 zone of northern and central Turkana in Kenya - see Figure 1.[4] The zone is west of Lake Turkana, bounded to the north by the border of South Sudan (and includes the disputed Ilemi triangle), and bounded to the west by the western Rift Valley escarpment bordering the Karamoja region of Uganda.

The report includes the following statements and findings:

- Kenya is a nation "in the throes of a deepening water crisis".
- Aquifers in three "strategic locations" were investigated "directly in the field", namely Lodwar, Kakuma and Lokichoggio. [5]
- Shallow aquifers with overall recharge capacity 2.08 BCM/year [6] were assessed, although their storage capacity was undefined due to the high variability of soil and geological conditions at the local scale.

[1] REGLAP = Regional Learning and Advocacy Project for Vulnerable Dryland Communities.

[2] Contacts: sean@watres.com http://www.watres.com

[3] ITV News, *Huge water reserve discovered in Kenya*, 11th September 2013, www.itv.com

[4] Radar Technologies International (RTI): *Advanced Survey of Groundwater Resources of Northern and Central Turkana County, Kenya,* Final Technical Report, commissioned by UNESCO under the GRIDMAP Framework of the Government of Kenya, Ministry of Environment and Natural Resources, funded by the Government of Japan, August 2013.

[5] Lodwar town is Turkana's main governmental centre. Kakuma is the location of a large refugee camp, and Lokichoggio is located on the Kenya / South Sudan border, and was the launching point for relief operations into the once war-torn South Sudan.

[6] 1 BCM = 1 billion cubic metres = 1 km^3 (1 cubic kilometre).

- Aquifers deeper than 80 metres were also investigated, and "five large deep (water) reserves with significant scope" were identified. The total renewable groundwater resource was found to be 1.36 BCM/year.[4] Although there are significant volumes of water, there are warnings that "extraction of water should be done with extreme caution to avoid over-exploitation" (ibid.). Furthermore, in the case of the Lotikipi aquifer, drilling has explored to a depth 330 metres, encountering three aquifers of cumulative thickness 202 metres, the lowest being an ancient sedimentary aquifer (a palaeo lake) found at a depth of 300 metres, and perhaps extending 500 metres in thickness below this depth. Productivity in this palaeo lake may be less than the shallower aquifers, and "there is concern that water in this deep layer may be of lesser quality".

- "…Now that the resource has been properly mapped and assessed, Turkana County, as well as neighbouring counties and the nation at large, can begin to tap into the resource and build new economic opportunities…If developed safely and responsibly…(the water) offers new hope for 20 million Kenyans still living in poverty…"

- The total renewable groundwater resource of northern-central Turkana is estimated to be 3.447 BCM/year. Short-term, exploratory boreholes were recommended in Lotikipi and Lodwar to supply water to local communities, and the drilling of 200-500 shallow alluvial boreholes was recommended in high-potential areas identified by the survey.

- In terms of agricultural development potential, four target areas were proposed from a water potential perspective: (1) the riparian areas of the Turkwel river near Lodwar; (2) above the deep aquifer of Gatome; (3) above the deep aquifer of Nakalale; (4) the large area of the Lotikipi basin near the seasonal marsh.

- UNESCO has presented two aquifer development scenarios that demonstrate the magnitude of the water find. The first scenario is to exploit the resource renewably, in which case, for example, at the "normal rate of consumption" 39.4 million people can be sustained (at the all-in daily rate 240 litres/capita inclusive, in all economic sectors). The second scenario is where the water is mined beyond renewable rates to total depletion, perhaps in a time of crisis, to serve the entire nation assumed to number 41 million people. In this case scenario it would last 70 years.

Commentary on the Turkana water finds and prospects

The UNESCO report makes interesting reading in regard to the exciting developments in remote sensing technology and the opportunities these provide for groundwater exploration, but it raises a number of issues.

Traditional water sources in Turkana

Groundwater sources in the form of springs and wells have been the mainstay of the Turkana area since long before modern times. In 1969 geologists reported that: "The water supplies in the area though small (apart from Lake Rudolf) are generally ample for the needs of the small nomadic population and their stock, the latter being necessarily limited by the poor grazing available".[7] Later, in 1984, Turkana's Range Management Handbook stated: "…compared to other districts in arid and semi-arid Kenya, Turkana District is exceptionally well supplied with water".[8] Traditional local knowledge has long recognised that potable water is available not far underground along the main river drainage lines, for instance along the Turkwel and Kerio rivers, and other seasonal watercourses. Traditional water sources, mainly shallow wells, once made up over 90% of all the water sources in the district.

Borehole drilling in Turkana

Borehole drilling technology has been introduced in recent times, albeit with mixed success, for various reasons. By 1994, five hundred boreholes had been drilled in Turkana, although less than 50% were operational.[9] This led the Range Management Handbook to question at that time whether "there are too many boreholes in relation to the available forage". Permanent water sources lead to the concentration / settlement of human populations, and a consequent increase in surrounding habitat degradation. Many intervention agencies continue to drill boreholes however. For instance, Oxfam has drilled over 100 boreholes in the area since 2007, with a success rate of 70-80%.[10] RTI / UNESCO consider there is need for capacity building in the water well drilling sector.

Prospects for the people of Lake Turkana

In 1969 the Turkana area population was estimated at 165,000 people.[11] Today it numbers about 700,000 people. The Kenyan population is forecast to almost double by 2030, and to treble by 2050 (compared to 2010 population levels),[14] and hence the nation's food requirements will need to increase substantially. In Turkana, the population's food needs have long surpassed the area's traditional livelihood capacities due to many factors including lack of investment. Infrastructure in much of the area is non-existent, and the people are thus amongst Kenya's poorest. Today food relief interventions are a permanent feature. Without significant appropriate and immediate and sustained investment, the dependency situation can only deteriorate.

The oil and water discoveries suggest a wealth of new opportunities in prospect for the local people, but the reality may be very different. Whereas private property ownership is protected by the Constitution,

[7] Walsh, J., and R.G. Dodson: *Geology of Northern Turkana*, Geological Survey of Kenya, 1969.

[8] MALDM: *Range Management Handbook of Kenya, Vol II, 9, Turkana District*, Ministry of Livestock Development and Marketing, Republic of Kenya, Nairobi, 1994.

[9] Ibid.

[10] Oxfam: Personal Communication from Brian McSorley, November 2013.

[11] Avery, S.T.: *Lake Turkana and the Lower Omo: Hydrological Impacts of Major Dam & Irrigation Developments*, Volumes I & II, African Studies Centre, University of Oxford, October 2012.

mineral resources belong to the nation as a whole. Water resources are also vested in the nation. National resource exploitation calls for sensitive management, especially in considering the effects on local people and their expectations in terms of benefit sharing. The suggestion by UNESCO that the region's scarce water resources could be exported to sustain 20 million people elsewhere, whilst perhaps not a serious suggestion, will create local disquiet. It will reinforce already prevailing fears, that the area's new found resources are destined to be removed from the area, as has happened in the past. [12] To avoid potential conflict, the national benefits from resource development must prioritise the local people.

Underground lakes, aquifer sustainability and declining water tables

Whilst the underground lake finds are exciting news, they are not altogether surprising as the area was once very wet - with Lake Turkana once a freshwater lake 5-times its present size. This was the case as little as 6,500 years ago, at which time the recharge to underground water aquifers was huge. Today these lands have arid and semi-arid climates, with the potential to become hotter and more arid with ongoing climate change. As a consequence of the area's low rainfall the groundwater recharge is described by UNESCO as "considerably weak", which has an important bearing on sustainable water abstraction levels.[4] If these are exceeded, the aquifer level diminishes and its storage capacity can be permanently damaged. Aquifers beneath the city of Nairobi have in some areas been declining at the rate 10 metres per year due to over abstraction. There are also examples in other countries of major underground aquifers reduced by agricultural abstraction to the point where it is no longer economic to pump the water. The Al-Wajid aquifer in Saudi Arabia is an example where the water table in agricultural areas has declined 200 metres since the 1980s. [13]

Kenya's Water Resources Management Authority recently issued new Water Allocation Guidelines with which to determine sustainable water abstraction levels. The abstraction licences specify abstraction limits, and can be amended based on aquifer monitoring findings. It is essential that this aquifer monitoring be carried out, as recommended by UNESCO / RTI, and that borehole owners respect the abstraction limits specified in their licenses.

Kenya's National Water Master Plan – Groundwater resource assessment

Kenya's updated National Water Master Plan has predicted that groundwater potential exists throughout much of northern Kenya's arid and semi arid lands.[14] The Master Plan indicates the "groundwater resources potential for development" in the Lotikipi Basin as amounting to 20 – 100 mm/year, which can be compared with the figure of 96 mm/year derived from the UNESCO data. Other semi-arid lands in northern Kenya are predicted to have comparable potential.[14]

[12] The notable example is the Turkwel gorge dam, whose powerlines feed not locally, but to Kenya's far away cities.

[13] Al-Kahtani, Safar and Sobbhy M Ismaiel, Groundwater management in the Kingdom of Saudi Arabia: A case study of Al-Wajid Aquifer, December 2010.

[14] Nippon Koei / JICA Study Team: *The Project on the Development of the National Water Master Plan 2030* (the Master Plan), Interim Report, by Nippon Koei / JICA Study Team, for the Ministry of Water and Irrigation, Kenya, dated April 2012. See also "Workshop on Progress Report 4", dated August 2012.

The main historical challenge in the ASALs has not been lack of water, but the practicalities of its utilisation, namely the costs of effectively extracting and distributing the underground water resources, and of maintaining such infrastructure in remote areas. The naturally high evaporation losses have always posed a major challenge in regard to surface water sources.

Comparing the UNESCO and National Water Master Plan water resource assessments

UNESCO announced that the Turkana aquifer water resource find increases Kenya's water resources by 17% from 20.2 to 23.6 BCM/year".[4] By contrast the National Water Master Plan has determined Kenya's water resources to be 76.61 BCM/year, [14] i.e. more than 3-times the UNESCO figure. If the Master Plan is correct, the Turkana aquifer find would equate to 4% of the nation's water resource, and this from a land area roughly 6% of the entire country.

UNESCO has recommended that the remote sensing study technology be extended to the entire country. This is almost certainly a good idea, as it is otherwise premature to speculate that the Turkana water resource might become the country's reserve in a future national water crisis. The Turkana water resource needs to be contrasted with water resource availability throughout the country, taking into account costs of exploitation and conveyance. Only then can planners decide the national priority to attach to this particular water resource.

The UNESCO report recommends aquifer protection through "gazetting". This is also a good idea. Such protection would include attention to the surface catchment area so as to reduce runoff and enhance recharge to the aquifers. The aquifers will also need to be protected from contamination, either from surface pollution spillages, or through oil drilling operations that might encroach into these aquifers.

Rainfall in the Turkana rangelands contrasted with aquifer resource

The UNESCO study area was 36,000km^2, and the renewable water yield stated to be 3.442 BCM/year, which, as mentioned above, equates to 96 mm of water spread equally over the entire study area. When viewed in these hypothetical physical terms, the amount seems less impressive. It equates to 16.3 % of the annual rainfall, and rainfall is in any case low in these semi-arid rangelands. The average annual rainfall is less than 200 mm in some areas, but it is generally in the range 200 – 400 mm, although it can reach as high as 600 mm in the north of the Ilemi triangle.[4]

Lake Turkana – Kenya's largest lake, and the world's largest desert lake

It is useful to bear in mind a regional perennial surface water perspective. Lake Turkana forms the eastern boundary to the UNESCO study area, and is mentioned in their report. Lake Turkana is semi-saline and unsuitable for crop agriculture,[11] but rapid advances in desalination technology mean even a semi-saline lake like Lake Turkana might become an exploitable water resource in future. Small-scale reverse osmosis water treatment plants have been tried around the lake, mainly to remove the harmful excessive fluoride concentration in the lake water. These treatment plants are often energy intensive high-pressure systems restricted to drinking water provision. Some of the new desalination technology might remove this constraint, and offer potential for wider use.

The Omo Basin, a trans-boundary water resource

Whereas Lake Turkana is semi-saline, the inflowing Omo River's waters are fresh, and reach the lake close to the project area, providing about 90% of the lake's total inflow. This major perennial river rises in Ethiopia's high rainfall highlands, and has an average annual flow variously estimated to be between 17.3 to over 20 BCM/year.[11] It discharges 14% of Ethiopia's entire surface water runoff, and its average flow is 6-times the combined renewable yield of the new aquifers reported by UNESCO.

The Omo Basin is undergoing major hydropower and irrigation development, and Kenya will share some of the benefits through purchasing power from the Sodo sub-station in Ethiopia.[11] The Omo Basin's most valuable renewable resource is its water. The Lower Omo's planned development covers up to 445,500 hectares, including the Kuraz sugar plantation currently under construction and comprising up to 175,000 hectares. The UNESCO water find of 3.442 BCM/year would sustain less than 70% of the irrigation water requirement of the Kuraz sugar plantation. The Lower Omo is also semi-arid, and the water needs at Kuraz serve to emphasise that irrigation water requirements in arid and semi arid lands are enormous, almost beyond comprehension, and as such warrant careful study prior to investment.

Crop agricultural development targets in Kenya

Irrigation water requirements are seen as the most important factor in Kenya's water planning, today accounting for 65% of Kenya's current water usage, and forecast to increase to over 80% by the year 2030.[14] Kenya has ambitious plans to increase irrigation 600% nation-wide, with over 80% of the schemes being in arid and semi arid lands. This irrigation expansion policy is being emulated in other countries. Neighbouring Ethiopia's plans for commercial farmers producing food on 900,000 hectares of land within five years have encountered difficulties, with only 10,000 hectares achieved to date.[15] Extreme arid areas like the Sahel have "long suffered from drought, hunger and low economic growth", and in the Sahel, the World Bank is also calling for more large-scale irrigation".[16] In October 2013 the World Bank promoted two summits "on improving pastoralism and boosting irrigation in the Sahel". The findings will be of direct relevance to areas like Turkana. On 22nd November 2013, Kenya's Minister for Agriculture was reported in the press as having addressed a food security assessment briefing in Lodwar. [17] The Minister was shocked by the extent of drought, and said that in five years, the Ministry will have given the County the means to produce food to feed its own people. The Minister requested the allocation of 50,000 hectares of land to the Kenya Agriculture and Research Institute (KARI).

Crop agricultural development is clearly an important aspect of government policy, and sustainable water supply will be fundamental to its success. The newly announced Turkana aquifers have raised expectations for the Turkana area. However, the water needs in arid and semi-arid environments are exceedingly high as the potential evapotranspiration rates exceed rainfall by an order of magnitude. The National Water Master Plan has calculated that in the Turkana area, the average annual water requirement for irrigation is

[15] Bloomberg News, Ethiopia push to lure farm investment falters on flood plain, 25th November 2013.
[16] World Bank Press Release dated 27th October 2013, "the Sahel: New push to transform agriculture with more support for pastoralism and irrigation".
[17] Daily Nation, 22nd November 2013: "Relief food to be supplied as drought bites".

about 20,000 m^3 per hectare.[14] This is based on the water requirement of what the Master Plan calls a "typical cropping pattern." Specialist crops like cattle fodder might require three times this amount. Based on the "typical" cropping pattern, the UNESCO find of 3.442 BCM/year would sustain an irrigated area of 172,100 hectares, which is equivalent to Kenya's entire irrigated area in 2011. If crops with higher crop water needs were selected, the potential irrigated area would be much less. These are indicative figures for discussion purposes only, and do not take account of water for other purposes, for instance domestic and livestock consumption, and the industrial needs of oil exploitation, for which water needs have yet to be defined by the industry. These water needs will reduce the water available for crop production.

Whilst water is the main challenge facing crop development in Turkana, soil considerations are equally important, as stated by UNESCO / RTI. Arid land soils are vulnerable to salinization, which destroys agricultural potential.[18] To avoid this, adequate good quality flushing water and good drainage are needed.

All these considerations demonstrate that there are considerable challenges facing large-scale crop production in Turkana. The engagement of KARI in research in Turkana is an excellent idea, but it is very urgent, and the findings will contribute to rationalising the country's irrigation development goals, as was recommended in the National Water Master Plan.[14] The feasibility of crop production depends on the availability of water, and the Turkana aquifers are some years away from being proven and fully developed; and some of the water is very deep and will be costly to extract. Studies alone could take another ten years, during which time population pressure in the Turkana area will require urgent government investment. Whilst water resource availability will become critical, Kenya currently has an ongoing need to manage its existing resources effectively, which means adopting water conservation measures throughout the nation. There are many possibilities, but these are beyond the scope of this paper.

Conclusion

The poverty levels in Kenya's Turkana area are an ongoing national concern, and other northern areas are suffering similarly. Investment in infrastructure is essential, and is being planned. Kenya's virgin natural resources are finite and diminishing, and there is a shared duty to nurture these resources for future generations. Existing crop production systems should be optimised first before developing new resources: This includes renewed support to integrating the all-important livestock sector, shown to be more economically productive in arid lands than for instance irrigated sugar plantations.[19] It will also require ongoing support for the wildlife sector, a remarkable national asset that traditionally integrates with livestock, although it can lead to conflicts with crop producers. Land consolidation in highland areas is a

[18] FAO, Corporate Document Repository: Socio-economic considerations in reclamation and management of salt-affected soils. Also Land and environmental degradation and desertification in Africa: "The magnitude of the problem".

[19] Behnke, Roy and Carol Kerven, Counting the costs: replacing pastoralism with irrigated agriculture in the Awash Valley, north-eastern Ethiopia, Working Paper No.4, IIED, March 2013.

difficult but necessary consideration, and major investment impetus is needed throughout the country. FAO has warned that: "Africa's natural resource base is being degraded and destroyed at a rate which will soon make food and agricultural production unsustainable".[18] Some countries are mining their groundwater aquifers to near destruction, and having instead to source food from abroad. These are typical costly consequences of poor resource management.

The Turkana water aquifers will take many years to develop, as will the oil development. Some of the Turkana water is very deep and will be costly to extract. The large-scale crop development that is envisaged in the arid lands will also take time, and needs to be tested. The progress with the crop development ambitions in neighbouring Ethiopia suggest that optimistic goals will need to be tempered with realism, with contingency measures being sustained in the interim development / testing period. There is valuable African continental experience to guide the sustainable and integrated development of Kenya's drylands, a process in which REGLAP participates. These experiences indicate exciting prospects where crop development is integrated with livestock production, and they also indicate the importance of community level commercial crop agricultural development, rather than the centrist large-scale systems, which have failed in the past.

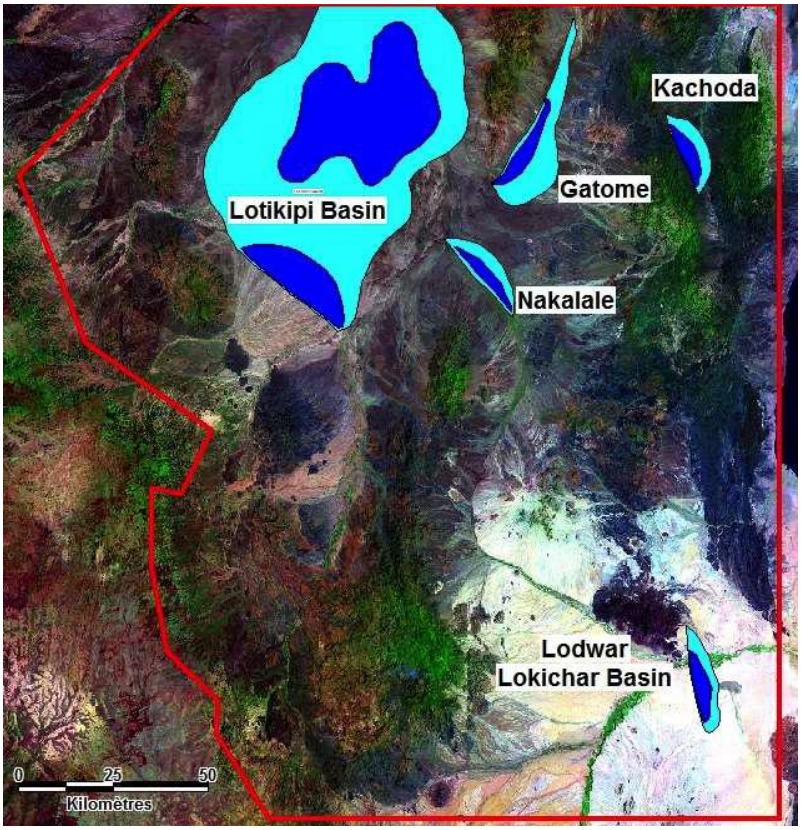

Figure 1: Turkana's regional deep aquifers (RTI, 2013) [4]

Humanitarian Aid
and Civil Protection

The project is funded by the European Commission Humanitarian Aid Department (ECHO)

Copies of this brief and the full report can be accessed at:
http://www.disasterriskreduction.net/east-central-africa/reglap