Preliminary results from an evaluation of the Blue Pump in Turkana, Kenya

Type: Short Paper (up to 2,000 words)

Authors: Tim Foster[a], Brian McSorley, Juliet Willetts
[a]Chancellor's Postdoctoral Research Fellow
Institute for Sustainable Futures, University of Technology Sydney, Australia
Email: tim.foster@uts.edu.au, Tel: +61413231799

Abstract/Summary

This paper presents the preliminary results of an evaluation of the Blue Pump in Turkana County, Kenya. Field work was carried out at 142 waterpoints to comparatively assess the operational performance and water user experiences for the Blue Pump. In order to appraise the broader factors affecting the suitability and sustainability of the Blue Pump, a group of key stakeholders was also convened to apply the Technology Applicability Framework. While 1 in 3 Blue Pumps in Turkana was found to be non-functional, breakdowns were less frequent than for the India Mark II and Afridev. Users of the Blue Pump were more satisfied with the reliability of their water service than those using other handpump types, but the difficulty of operation was a prominent complaint. In the Turkana context, the Blue Pump appears to be a more reliable handpump than the India Mark II and Afridev, bearing in mind its higher upfront cost. However, its full value will only be realised if coupled with effective and sustainable maintenance arrangements for which users are willing and able to pay.

Introduction

The Blue Pump is a lever-action reciprocating handpump which is promoted as a more durable alternative to mainstream handpump models. Developed by Fairwater Foundation, the pump has been deployed in numerous countries throughout sub-Saharan Africa.[1] According to the developer, the pump is a low maintenance technology with a number of comparative advantages, including lower recurrent costs, ease of installation, and greater depth range (Van Beers, 2013a, 2013b). The pump has an open top cylinder design which allows for the rods and the cylinder to be removed without the need to pull up the riser pipes, while a bottom support system enables cylinder depths up to 80 meters.[2] Other design features include the lack of a rubber seal in the piston, PVC pipes, heavy duty bearings, and compatibility with the pedestal of an old India Mark II or Afridev.

In order to appraise the suitability of the Blue Pump as a rural water supply technology, in February 2016 Oxfam Kenya commissioned an evaluation of Blue Pump installations in Turkana County. Although previous studies have investigated the early stages of the Blue Pump roll-out in Turkana (McSorley, 2011) and 14 installations in Mozambique (Cornet, 2012), there have been calls for further empirical evidence that sheds light on the performance of the Blue Pump relative to other handpump technologies. This paucity of information is not unique to the Blue Pump – despite the enduring dominance of handpump water supplies in rural areas, there have been surprisingly few field evaluations of different technologies in the last two decades. Since the large-scale testing carried out under the auspices of the World Bank in the 1980s (see e.g. Reynolds, 1992), only a handful of investigations have attempted to conduct field-based comparisons of performance (Harvey & Drouin, 2006; Coloru et al., 2012, Nampusuor & Mathisen, 2000). Analyses of waterpoint mapping datasets have begun to illuminate functionality rates for different handpump types (Foster, 2013; Fisher et al., 2015), although the limitations of this binary metric are well

[1] See http://www.fairwater.org/sponsor-a-bluepump/
[2] In some circumstances in Turkana, pump cylinders have been installed at depths of up to 90m.

documented (Carter & Ross, 2016).

Since 2007, Oxfam Kenya and its partners have overseen the installation of more than 100 Blue Pumps in Turkana County in the north of Kenya. Turkana provides a particularly challenging environment for handpumps. The region is characterised by low levels of rainfall (typically <400mm per year) and there is a heavy dependence on handpumps both for domestic purposes and for watering livestock. Handpump usage levels can be extreme, with many used non-stop throughout daylight hours and often late into the evening. Moreover, pump cylinders often need to be positioned at great depths (e.g. up to 90m) owing to the deep groundwater levels in certain areas. There are two further distinguishing features of the rural water landscape in Turkana. First, in addition to the Blue Pump, the county plays host to Afridev, India Mark II and Duba Tropic 2 handpumps in roughly equal numbers (RVWSB, 2013). Second, maintenance service provision for handpumps of all kinds is by way of a centralised scheme operated by the Diocese of Lodwar. As such, very few repairs (if any) are carried out by communities or local area mechanics.

Figure 1 – Blue Pump installation in Northern Turkana

Table 1 – Technical and supply chain details of handpumps in Turkana County

	Blue Pump	Afridev	India Mark II	Duba Tropic 2
Technical details				
Operation	Lever	Lever	Lever	Rotary
Depth	<80m	<45m	<80m	<100m
Open-top cylinder	Yes	Yes	No	Yes
Rising main	PVC	PVC	GI	GI
Domain	Private	Public	Public	Private
Supply chain details				
Location of manufacturer	Netherlands	India	India	Belgium
Location of suppliers	Nairobi	Lodwar, Nairobi	Lodwar, Nairobi	Belgium
Buyers	Oxfam, Practical Action	County Government, Diocese of Lodwar	County Government, Diocese of Lodwar	Diocese of Lodwar[3]

[3] New Duba Tropic 2 pumps are no longer installed, although the Diocese of Lodwar continue to procure spare parts.

Description of the Case Study – Approach or technology

In order to evaluate the performance of the Blue Pump in Turkana, the evaluation consisted of two components:

1. Site visits at Blue Pump installations to understand operational performance, life-cycle costs, and water user experiences. Given the challenging conditions of Turkana it was decided to also include site visits at India Mark II, Afridev and Duba installations to allow for a comparative assessment. For these "comparator" pumps a convenience-quota sampling method was preferred over a randomized sampling approach due to incomplete information about handpump locations and the vast size of the county.
2. A Technology Applicability Framework (TAF) workshop was conducted to appraise the broader building blocks for sustainability of Blue Pump installations. This involved stakeholders from local government, maintenance service providers, and implementing organisations. The workshop followed the methodology outlined in Olschewski & Casey (2015).

In total, 100 Blue Pump installations were identified from records kept by Oxfam and Practical Action.[4] Of these, 25 could not be accessed as they were situated in insecure regions. Seventy-five sites were subsequently visited, with 71 Blue Pumps installations confirmed.[5] Data were also collected for 71 comparator handpumps, comprised of 34 India Mark IIs, 24 Afridevs and 13 Duba Tropics. Characteristics of waterpoints visited are summarised in Table 2.

Table 2 – Mean characteristics of waterpoints visited in Turkana County

Characteristics	Blue Pump (n=71)	India Mark II (n=34)	Afridev (n=24)	Duba Tropic 2 (n=13)
Cylinder depth (m)	42	36	12	56
Age (years)	3.6	4.6	8.6	13.2
Distance to Lodwar (km)	86	81	97	92
Electrical conductivity (µS/cm)[a]	1897	1629	922	1062
pH	7.61	7.50	7.52	7.39
Maintenance scheme subscription (%)	34	41	21	85

[a] Excludes two extreme outlier values.

Information at each waterpoint was collected on handpump performance and user satisfaction levels. Operational performance was measured across four indicators: (i) functionality rate, (ii) breakdowns in the previous 12 months, (iii) operational days in the previous 12 months, and (iv) flow rate when operated by an adult female. A handpump was deemed non-functional if it was not producing water for users on the day of inspection. Information relating to the number and duration of breakdowns was based on user recollections. Flow rate was measured by observing the number of seconds an adult female took to fill a 20 litre jerrican. In order to take into account other factors that can influence these performance metrics, data pertaining to cylinder depth, handpump age, usage levels[6] and maintenance arrangements were also sought. To ascertain water user views on the Blue Pump, a series of questions were asked about satisfaction levels with respect to reliability,[7] flow rate and ease of use. This paper presents the preliminary results across each of these operational and satisfaction measures for the Blue Pump vis-à-vis the India Mark II and Afridev.[8]

Main results and lessons learnt

[4] This excludes a number of installations which were known to have been upgraded to solar pumps.
[5] One site could not be found and three Blue Pumps had been replaced – one by a solar pump, one by an India Mark II and one by an Afridev.
[6] As settlements in Turkana are often highly dispersed and migratory, estimating the number of households using the handpump was difficult. Moreover, the livestock population is likely to be a more significant driver of usage in many instances. Thus usage level was classified as either 'non-stop during the day' or 'intermittent use'.
[7] In this context, reliability referred to how frequently (or infrequently) the system broke down.
[8] Full results and discussion (including results for the Duba Tropic 2) will be available in the final evaluation report.

Operational performance

Based on the sample of handpumps assessed, overall the Blue Pump outperformed both the India Mark II and Afridev across measures of functionality, breakdowns per year and operational days per year (Table 3). This is tempered by the observation that one in three Blue Pumps was still found to be non-functional. On average, the Blue Pump broke down less frequently than other pumps across different cylinder depths, ages and usage levels (Table 4). Disaggregated differences in functionality rate and operational days were more mixed.

Table 3 – Summary of operational performance of sampled handpumps in Turkana County

	Blue Pump	India Mark II	Afridev
All handpumps			
Sample size	71	34	24
Functionality rate (%)	67.6	61.8	41.7
Avg. breakdowns per year[a]	0.4	0.8	1.3
Avg. operational days per year	284	255	167
Avg. flow rate for female adult (l/min)	11.3	13.1	14.6
Handpumps 0-7 years			
Sample size	66	28	10
Functionality rate (%)	68.2	60.7	20.0
Avg. breakdowns per year[a]	0.3	0.9	2.5
Avg. operational days per year	285	247	132
Avg. flow rate for female adult (l/min)	11.2	12.9	ND

ND = No data. [a] Calculated as weighted average of the number of breakdowns per operational year.

Table 4 – Operational performance of sampled handpumps in Turkana County disaggregated by key characteristics

	Characteristics	Categories	Blue Pump	India Mark II	Afridev
Functionality rate (%)	Cylinder depth	<20m	57.9	25.0	33.3
		20-40m	75.0	85.7	NS
		40+m	67.7	71.4	ND
	Age	0-3 years	75.0	60.0	20.0
		4-7 years	60.0	61.5	20.0
		8+ years	NS	66.7[a]	63.6[a]
	Maintenance scheme subscriber	Yes	76.2	83.3	75.0
		No	65.0	52.9	40.0
	Functionality rate – All (%)[b]		**67.6**	**61.8**	**41.7**
Avg. breakdowns per year	Cylinder depth	<20m	0.2	NS	1.7
		20-40m	0.7	1.3	NS
		40+m	0.4	1.0	ND
	Age	0-3 years	0.4	0.8	3.4
		4-7 years	0.3	0.9	NS
		8+ years	NS	NS	0.7
	Usage level	Intermittent	0.3	0.5	1.1
		Non-stop	0.5	0.9	5.5
	Avg. breakdowns per year – All[b]		**0.4**	**0.8**	**1.3**
Avg. operational days per year	Cylinder depth	<20m	240	183	128
		20-40m	306	323	NS
		40+m	283	303	ND
	Age	0-3 years	318	232	192

		4-7 years	248	267	73
		8+ years	NS	NS	222
	Maintenance scheme subscriber	Yes	310	322	222
		No	274	210	174
	Avg. operational days per year – All[b]		**285**	**255**	**167**
Avg. flow rate for female adult (l/min)	Cylinder depth	<20m	18.6	18.8	14.7
		20-40m	12.0	12.8	NS
		40+m	7.9	10.4	ND
	Avg. flow rate for female adult – All[b]		**11.3**	**13.1**	**14.6**

NS = Not shown due to small sample size (n<3); ND = No data. Note: It was not always possible to ascertain cylinder depth and/or age for India Mark II and Afridev handpumps. [a] Further investigation is needed to determine why the older cohort of India Mark II and Afridev handpumps appear to have better functionality rates than the newer cohort. Possible explanations include a 'denominator problem' (see Carter & Ross, 2016) or confounding factors. [b] 'All' results include those handpumps with unknown cylinder depth and/or age.

It is instructive that the Blue Pump maintained an edge over the India Mark II for both operational days and functionality rate when handpumps were three years of age or less, but not for those pumps aged between 4 and 7 years. This may point to the limits of durability in the Turkana context – although first-time breakdowns may occur further down the track for the Blue Pump, sustainability in the long term will ultimately be defined by the presence or absence of effective maintenance systems.[9] Indeed, when subject to the same centralised maintenance service operated by the Diocese of Lodwar, the functionality rates for all three handpumps lay within a band of 75-85%. This compares to 40-65% for those waterpoints not registered for the maintenance scheme.[10] The functionality rate of the Afridev was particularly low for those communities not subscribing to the maintenance scheme. As well as more frequent mechanical breakdowns, this may in part be due to the susceptibility of shallow wells to dry up or silt up, and also their tendency to be located beside river beds, thereby offering alternative (unimproved) water sources.

Work is still underway to ascertain precise failure modes and root causes of Blue Pump breakdowns. Early estimates suggest 15-35% of failures may be attributable to factors other than mechanical faults (e.g. dry boreholes, wells silting up, flood damage). The most common mechanical failure modes appeared to relate to the cylinder (either leaking or clogged with silt), rod breakages and pipes. Work to determine the lifecycle costs of the Blue Pump is also ongoing. Data provided by the Diocese of Lodwar suggest an average Blue Pump repair costs $68 in parts, compared with $56 for an India Mark II and $71 for an Afridev.[11]

On average, the discharge produced by the Blue Pump was 14% lower than for the India Mark II, a disadvantage which held across different cylinder depths. On the surface, this may seem a less important measure than other operational indicators assessed. However, one of the most prominent procurers of handpumps in Turkana chooses to install the India Mark II over the Blue Pump primarily because of the perceived difference in volumetric output.

Water user satisfaction

Water user perceptions largely accord with the findings on operational performance (Table 5). Overall, Blue Pump users were more satisfied with their water supply than users of other handpumps. This likely stemmed from the high reliability rating users attributed to the Blue Pump. Conversely, users preferred the alternatives when it came to flow rate and ease of operation. A widespread complaint among water

[9] Another possible contributing factor is the evolution of the Blue Pump design, with component modifications potentially leading to a difference in operational performance between newer and older Blue Pump models.

[10] This maintenance model may obscure the potential benefits of reliability that might materialise in other contexts. Fewer breakdowns may not necessarily translate into higher functionality rates in Turkana because the Diocese of Lodwar provides communities with an unlimited number of repairs for a fixed annual tariff. In other words, the community pays the same fee irrespective of the number of breakdowns in a given year.

[11] Assumes an exchange rate of 100 KES = 1 USD.

users was that the Blue Pump is a 'heavy' pump that is significantly more difficult to operate, particularly once the cylinder depth exceeds 40 metres. In some instances, this precluded use by young children, and for deeper boreholes required 3 to 4 women to operate the pump simultaneously. When users directly compared the Blue Pump with other pump types that had previously been installed on the same borehole or well, the Blue Pump was marginally favoured over both the Afridev and India Mark II.

Table 5 - Percentage of interviewed water users satisfied with their handpump water supply

	Blue Pump	India Mark II	Afridev
All handpumps			
Users satisfied with handpump overall	95%	85%	88%
Users satisfied with reliability	97%	74%	69%
Users satisfied with discharge	69%	73%	81%
Users satisfied with ease of operation	42%	56%	73%
Handpumps 0-7 years			
Users satisfied with handpump overall	94%	83%	88%
Users satisfied with reliability	96%	74%	50%
Users satisfied with discharge	71%	68%	88%
Users satisfied with ease of operation	41%	52%	75%

There are a number of caveats to the findings on operational performance and water user satisfaction. First, the sample sizes involved are relatively small, particularly when disaggregating results by various characteristics such as depth and age. Second, investigations into failure modes and lifecycle costs are still ongoing, limiting some of the inferences that can be made at this juncture. Third, information on breakdown frequency and duration was reliant on user recall. Fourth, these results apply to the Turkana context, which has some unique environmental, social and institutional characteristics.

Applying the Technology Applicability Framework

To assess the broader factors that impinge upon the suitability and sustainability of the Blue Pump in Turkana, stakeholders from local government, NGOs and service providers were convened at a workshop to apply the Technology Applicability Framework (TAF). The perspectives of users, service providers and investors were considered across six key sustainability dimensions (Figure 2).

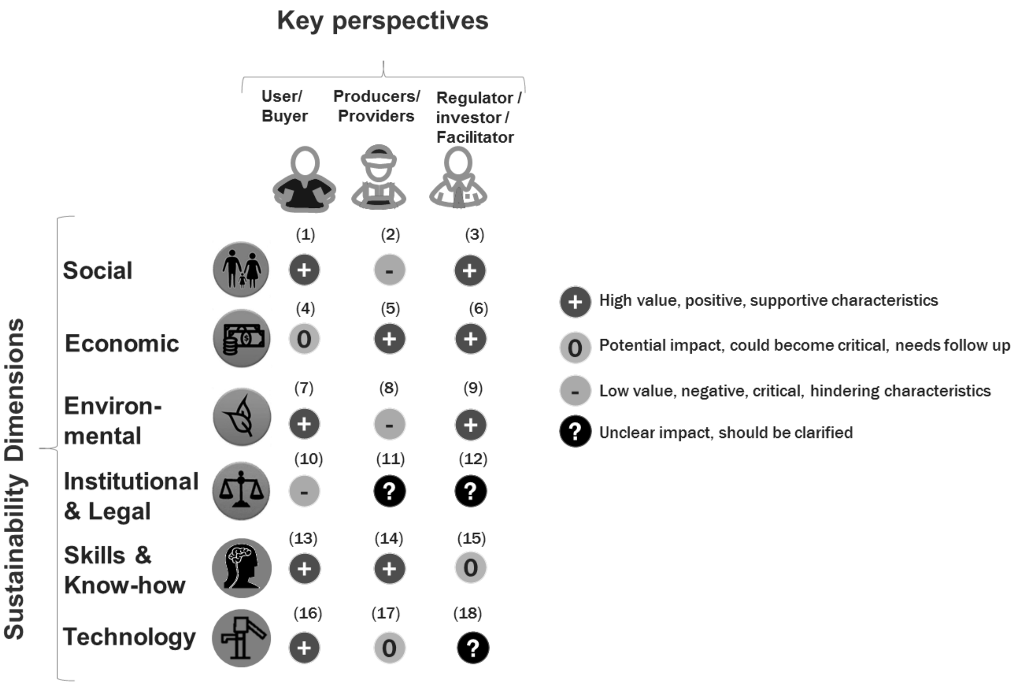

Figure 2 – TAF traffic light matrix for Blue Pumps in Turkana

Among the numerous issues debated, workshop participants identified several critical dimensions:

- **Social:** Overall, workshop participants believed there was demand from water users for the Blue Pump due to its durability. However, it should be noted that very few interviewed water users felt their community had a choice as to which technology was installed. From the buyers' perspective, many participants agreed that the manufacturer and/or supplier needed to invest more in marketing and promotion at the local level so stakeholders knew how they could procure new pumps and access technical support. Although there is a Nairobi-based supplier (Techno Relief) who is able to deliver pumps to Lodwar and provide technical support, discussions revealed that two of the major handpump installers (County Government & Diocese of Lodwar) were unaware of this possibility.
- **Economic:** It was widely assumed that ongoing Blue Pump maintenance costs would require some form of subsidy in addition to user contributions. This was not necessarily seen as a problem as compared to other handpumps, as the centralised maintenance scheme operated by the Diocese of Lodwar has long offered a subsidised tariff (currently $35 per waterpoint per year), irrespective of the handpump type. Water users generally view this as a fair and reasonable price, although in reality not all communities are willing and able to pay the annual subscription fee. Participants did, however, note capital costs as a disadvantage of the Blue Pump. Depending on the cylinder depth, a Blue Pump costs between $1,500 and $4,000, some two to three times more expensive than an India Mark II or Afridev for equivalent depths.
- **Skills and knowledge:** There was a consensus that the Blue Pump was not conducive to community-level maintenance arrangements in Turkana. Reliance instead is placed on the Diocese of Lodwar technicians, who have previously been trained on Blue Pump repairs and installation by Fairwater Foundation, and are now well versed on Blue Pump maintenance.
- **Technical:** Participants believed water users were satisfied with the Blue Pump, though were aware that many find the pump heavy and difficult to use. The question of whether a viable spare part supply chain exists generated substantial debate. Despite the existence of a Nairobi-based supplier who could deliver Blue Pump parts to Turkana, several attendees were of the view that in effect there was no viable supply chain because few were aware of this option. It is important to note that up until this point the supply chain issue has had little bearing on the sustainability of the Blue Pump. As the sole maintenance provider in Turkana, the Diocese of Lodwar continues to draw on a large consignment of parts originally provided to them by Oxfam (in contrast, the Diocese of Lodwar purchases India Mark II and Afridev parts from Nairobi-based suppliers).

Conclusions and Recommendations

In the Turkana context, the Blue Pump appears to be a more reliable water supply technology than the India Mark II and Afridev. However, the pump is by no means maintenance free. A focus on reliability does not supplant the need for effective maintenance arrangements and other building blocks for sustainability. Given the uniqueness of the Turkana setting, further investigations are needed to verify whether the results hold up in other contexts. Aside from the social and hydrogeological characteristics of Turkana, the centralised maintenance model limits the degree to which these findings can be extrapolated to other rural areas where local area mechanics are the norm.

References

Carter, R. & Ross, I. (2016) 'Beyond 'functionality' of handpump-supplied rural water services in developing countries', Waterlines, 35(1): 94-110.

Coloru, B., Mgaya, S. & Taubert, R. (2012) 'Appropriate technologies for rural water supply', SHIPO & ACRA-CCS.

Cornet, L. (2012) 'A Comparative Evaluation Of Ultra Deep-Well Handpumps', MSc Thesis, Cranfield University.

Fisher, M. et al. (2015) 'Understanding handpump sustainability: Determinants of rural water source functionality in the Greater Afram Plains region of Ghana', Water Resources Research, 51 (10): 8431-8449.

Foster, T. (2013) 'Predictors of sustainability for community-managed handpumps in Sub-Saharan Africa: Evidence from Liberia, Sierra Leone, and Uganda', Environmental Science & Technology, 47(21): 12037-12046.

Harvey, P. & Drouin, T. (2006) 'The case for the rope-pump in Africa: A comparative performance analysis', Journal of Water & Health, 4: 499-510.

Nampusuor, R. & Mathisen, S. (2000). 'Report on The Performance of Afridev and Nira Handpumps on the Upper Regions Community Water Project (COWAP) Ghana', COWAP Field Paper 27.

Olschewski, A. & Casey, V. (2015) 'The Technology Applicability Framework. A Participatory Tool to Validate Water, Sanitation, and Hygiene Technologies for Low-Income Urban Areas', In Hostettler et al. (eds) Technologies for Development Springer International.

Reynolds, J. (1992) 'Handpumps: Towards a Sustainable Technology', UNDP-World Bank Water and Sanitation Program, Washington DC.

RVWSB (2013) 'Water Point Mapping Report, Turkana County', Rift Valley Water Services Board, Nakuru.

Van Beers, P. (2013a) 'The FairWater Blue Pump', Fairwater, Amsterdam.

Van Beers, P. (2013b) 'Summary Graphic: Bluepump vs Public Domain Pump', Fairwater, Amsterdam.

Acknowledgements

The authors would like to thank and acknowledge the role of Oxfam in supporting the evaluation – in particular, Sepharinus Owino, Nicholas Sikenyi, Mark Nakalale and Robert Samal – as well as all stakeholders and water users who participated in the assessment. The authors also owe a debt of gratitude to members of the evaluation advisory group (Sean Furey, Peter Harvey, Richard Carter and Rob Hope) and to André Olschewski for his guidance on the Technology Applicability Framework.

Contact Details

Name of Lead Author: Tim Foster
Email: tim.foster@uts.edu.au

Name of Second Author: Brian McSorley
Email: BMcSorley@ght.oxfam.org