35th WEDC International Conference, Loughborough, UK, 2011

THE FUTURE OF WATER, SANITATION AND HYGIENE:
INNOVATION, ADAPTATION AND ENGAGEMENT IN A CHANGING WORLD

Self-supply: bridging the gap between household demand and community water supply?

K. Kumamaru, I. Smout & F. Odhiambo

REFEREED PAPER 1089

This paper discusses rural water supply at grassroots level, and challenges the assumption that a community water supply facility is the only solution for rural water supply, especially in sparsely populated areas. A comparison is made between two water service models from case studies in Zambia: those with conventional communal water supplies and Self Supply models. Findings revealed that a Self Supply service could significantly reduce faecal contamination risk in water quality and deliver higher per capita water use and better convenience of access than conventional supply, yet its reliability regarding water source dry up requires to be monitored. A conventional community-based water service may not fulfil the households' demand due to the nature of community ownership and the distance from household to a community water facility. Since the underlying service delivery models are different, an integrated approach is required for a rural water supply strategy and national policy.

Introduction

The priority for sustainable rural water supplies has changed from 'providing the physical systems' to 'delivering the water service' over the past few decades. The water sector generates a lot of analyses on costs, designs, post-construction supports, management models, efficiency and sustainability of supplies but these are mostly for conventional communal supply service models (Sutton 2010b). The term 'community' has no single definition but varies in the context of different view points from the place in which people live, to groups of population, culture, religion and history. One of the common features, however, is that more than one household (HH) makes up a community and all of them require water for their lives. Therefore, the households/families fulfill their water demands from conventional communal supply service provision by the governments or NGOs/external support agencies and/or from the grass roots level of accessing complementary water. For instance, Milenge District has one of the lowest water coverage areas in Zambia at 6% with only 19 boreholes and 3 subsidised protected wells for a population of about 33,600 persons and a low population density area of 1HH/km^2 (CSO 2006). This means that these protected water sources represent one conventional communal water source for more than each 1,500 persons (about 260HH). On the other hand, according to the 2007 baseline survey (Zulu Burrow 2008), there were about 620 private household wells and even this number is increasing in Milenge, meaning that every 9HH have their own well although these wells are not counted in water coverage statistics because of their unprotected condition. Despite such high demand and interest in water supply at the grassroots level, the idea of establishing a water service at household level has seldom attracted much attention.

The concept of Self Supply is that an individual household or community takes a decision to improve their traditional water source, putting in their own investment. This enables them to fulfill their demand incrementally and build a sustainable environment in order to access safe water. This approach is not a hardware subsidized model like the conventional communal supply, rather it supports the households' motivations and their investment which already exists and/or encourages their self-reliant development by providing software service components. To date there has been little monitoring or systematic analysis of what impact these changes have made. Monitoring of water quality, user satisfaction, water use and purposes of use, social status and economic benefits is required to develop national policy (Sutton 2010a).

This paper thereby discusses the efficacy of the Self Supply model associated with key indicators for a sustainable safe water supply in comparison with the conventional communal water service.

Background

A field study was conducted in Luapula Province of northern Zambia from March to September 2010, in collaboration with UNICEF, WaterAid and Development Aid from People to People (DAPP). Luapula Province has the lowest water supply coverage in Zambia at just 37% whilst also having the highest availability of surface and groundwater at a shallow depth (Zulu Burrow 2008). To accelerate water coverage in order to achieve the MDG water targets alongside conventional communal water service provision under the National Rural Water Supply and Sanitation Programme, a Self Supply project has been implemented as a pilot service model in three Districts namely Milenge, Nchelenge and Chiengi (Luapula Province) since 2008. In Zambia, Self Supply is defined as the '*step by step improvement of private and communally owned traditional water source using the beneficiaries' own investment*' (Mukonge et al. 2010). In particular, four components of Self Supply are established:

- creating awareness of the Self Supply concept by sensitization of multiple stakeholders,
- private sector capacity building,
- technology advice and
- financial mechanism.

In addition, donor activity has supported communal supply for Luapula, through borehole water supply facilities equipped with handpumps. Two hundred communal facilities with handpumps have been constructed by the Japan International Cooperation Agency (JICA) during 2008-2010 in Luapula Province including the same Districts targeted by the Self Supply project.

Methodology

Site selection

Two sites were selected from Zambia for conducting studies: Milenge and Nchelenge Districts. Both Districts were selected because they have not only conventional communal service but also the Self Supply was implemented by different NGOs in partnership with UNICEF: those in Milenge by WaterAid Zambia and those in Nchelenge by DAPP.

Research tools and sampling

The research framework includes a range of methodologies to critically examine the suitability and sustainability of water service in a sparsely populated rural area by assessing five indicators:

- water quality,
- per capita water use,
- accessibility,
- reliability and
- cost-effectiveness.

The standpoint of this study is pragmatic, and herein, mixing quantitative and qualitative methods was justified in order to design the research methodologies summarised in Table 1.

Table 1. Summary of information available in research database

Research Methods		Target key variables	Quantity
Technical inventory survey		Water supply types, Reliability	**274** (WP)
Environmental investigation	Water quality tests at source Sanitary surveys at source	Water quality, Sanitary condition	**269** (WP)
Household survey		Accessibility, Per capita water use, Cost-effectiveness	**447** (HH)
Management record		Cost-effectiveness	**2** (Set)

Note: WP=water point, HH=household

Main findings

Surveyed water supply types were separated into four categories:

1. Not protected hand dug well (HDW),
2. Partially protected HDW (include under improvement),
3. Protected (improved) HDW and
4. Borehole with handpump.

A **Protected** (improved) HDW would consist of a well with an apron, raised parapet walls and top slab and a drain. These also would have a cover, which might be lockable, and use windlass, rope pump or rope and bucket as a lifting device in study area. Conventional communal wells subsidised by the government were generally counted as 'Protected HDW' but some of them (5 in Milenge and 7 in Nchelenge) had slipped into 'Partially protected HDW' because of lack of apron/drainage. A **Partially protected** HDW would comprise of a raised ground/platform around the well mouth whether or not it was covered by a layer of cement and a cover, which might be lockable. This category was typically those that had only one or two components less than those in the Protected condition. A **Not protected** HDW had not reached the protection level of Partially protected features although this does not mean that they have no protection features or actions. The water service under Self Supply provide options for private/public well owners of trained artisans in the context of their affordability to reach further up the improvement ladder to either Partially protected or Protected statuses.

Water quality

It is notable that the greater the level of increased HDW protection under Self Supply in Milenge, the more the proportion achieving acceptable quality for drinking water (see Fig.1). This indicated that improvements to water sources under the Self Supply service could reduce the risk of faecal contamination which is greatly different from Partially protected and Not protected HDWs.

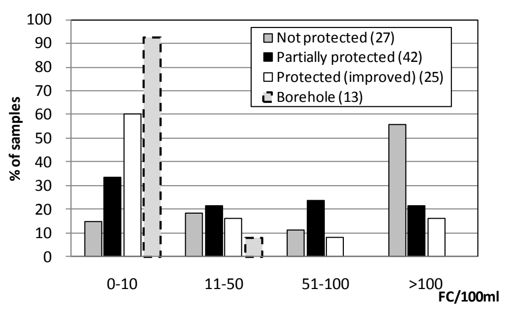

Figure 1. Faecal coli. test results in Milenge
(*source: Author's field studies*)

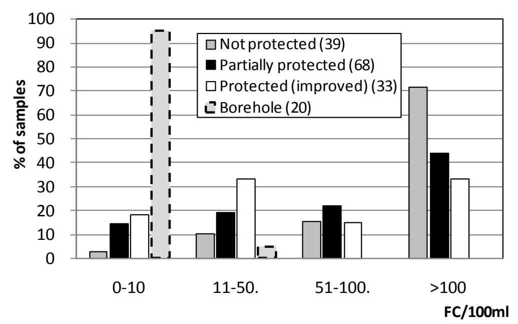

Figure 2. Faecal coli. results in Nchelenge
(source: Author's field studies)

On the other hand, less than 20% of Protected HDWs in Nchelenge were at an acceptable level for drinking (see Fig.2) even though the same protection level brought more of them into the less than 10FC/100ml range in Milenge (60%). This reflects the fact that all Protected HDWs in Milenge were improved by skilled artisans under Self Supply whilst 90% of Protected HDWs (n=30) in Nchelenge were constructed by conventional subsidized project or untrained community members. The Nchelenge improvements were not done by trained artisans under Self Supply at the time of visit.

Water quality change

Further, Fig. 3 is the summary of the microbiological water quality monitoring to assess what difference the improvements make to water quality and the seasonal change. Between April and August 2010, 29 water points were tested to investigate seasonal change; April was just after the wet season (Nov. – March) and August was a totally dry season. It is apparent from Fig. 3 that no significant differences are found between April and August in the Not protected and Partially protected HDWs which have been improved by the owner. On the other hand, Fig. 3 shows significantly more water quality improvement between the two months in the Protected and Partially protected HDWs which have been improved by skilled artisans (Self Supply). Out of 19 Protected HDWs water points sampled, 17 water points (90%) were found to be contamination-free in August. These results are similar to water quality from boreholes (see Fig.1).

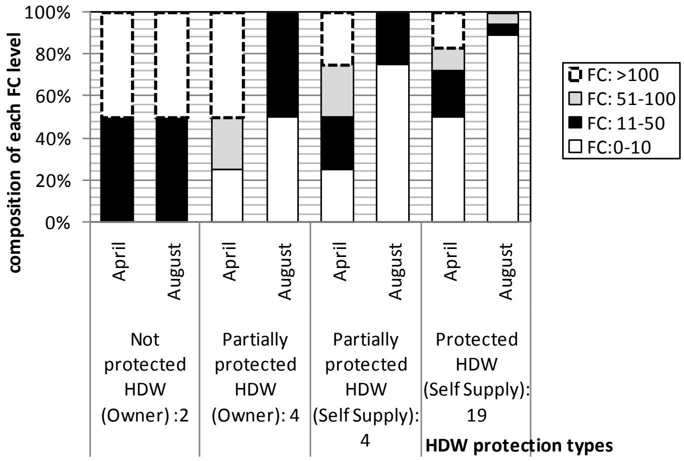

Figure 3. Monitoring results of faecal coli. test in Milenge

Source: Author's field studies

This evidence is supported by the study of Sutton (2004) where water quality was monitored in over sixty sources which had been improved. The study showed that in all of them water quality improved significantly. These findings also indicated that HDWs either protected or improved by trained artisans under the Self Supply service achieved the level of protection which met the required standard for 'Protected' water points despite the fact that they are not being equipped with a windlass and/or full lining which is standard design for 'Protected' sources when they implement conventional communal projects (NRWSSP 2007).

Sanitary condition

Sanitary Inspection (SI) was done alongside the microbiological water quality test to assess the sanitary risk of contamination occurring (see Table 2). For every hazard of HDW that has a 'Yes' answer one point is allocated and for every 'No' answer zero points are scored, and the bottom column showed the sum of the SI scores.

The figures in Table 2 give an average value for each protection type of HDW. There was a clear benefit to the general sanitary conditions for a water point from improvement works in Milenge. The total risk score confirmed that where the protection level is higher, fewer hazards were found in both Milenge and Nchelenge.

Table 2. Summaries of sanitary inspection of HDWs

SI	Hazard of TWS	Milenge			Nchelenge		
		Not protected	Partially protected	Protected	Not protected	Partially protected	Protected
1	Latrine within 10m of the well	0.00	0.00	0.04	0.20	0.19	0.090.19
2	Faeces within 10m of the well	0.19	0.14	0.29	0.32	0.26	0.18
3	Any other sort of pollution within 10m of the well	0.37	0.17	0.17	0.21	0.21	0.30
4	Fence missing or faulty	1.00	1.00	1.00	0.97	0.94	0.88
5	Cement less than 1m in redius around the top of the well	0.93	0.52	0.00	0.72	0.54	0.30
6	Animals roam around the well	0.26	0.19	0.25	0.77	0.57	0.33
7	Can water flow back into the well	0.85	0.48	0.04	0.64	0.32	0.09

8	Well mouth lower than surrounding ground	0.37	0.12	0.04	0.59	0.13	0.09
9	Rope and bucket leave on the ground	0.67	0.43	0.13	0.69	0.59	0.64
10	Well cover insanitary	0.89	0.64	0.08	0.74	0.50	0.36
Total		**5.53**	**3.69**	**2.04**	**5.85**	**4.25**	**3.26**

Source: Author’s field studies

Importance of sanitary condition on water quality

Not only the physical protection level of well, but also the sanitary condition may affect the risk of contamination. The research found that ‘animal faeces within 10m of the water supply facilities’ leads to higher rates of microbiologically contaminated water in Not protected HDWs at both Milenge and Nchelenge Districts, as well as Partially protected and Protected HDWs in Milenge ($p<.05$, statistically significant*). Further, the findings that faecal contamination levels of Not protected HDWs in Nchelenge correlated with ‘animal faeces within 10m of the well’ and ‘can water flow back into the well’, combined with findings that ‘well mouth lower than surrounding ground’ and ‘well cover insanitary’ are statistically correlated hazards with FC contamination levels at 95% levels of significance. These correlations suggest that each of these hazards increases the risk of faecal contamination at the sampled Not protected HDWs in Nchelenge. Therefore, the sensitization of households/communities to understand the importance of sanitary conditions is crucial with respect to mitigating contamination risk.

Per capita water use

Per capita water use refers to the amount of water in litres per capita per day by users. The figures are calculated from the volume of each container, number of containers and trips per day, and number of family members using the water, based on self-reporting by households. The usage is inclusive of water from the source for drinking, cooking, bathing and washing i.e. for both their consumption and hygiene purposes. Table 3 shows per capita water use reported by single source users; multiple water source users are excluded from the table.

Table 3. Per capita water use

District	**Milenge**		**Nchelenge**		**Average**
Water supply types	**(N)**	**(kd)**	**(N)**	**(kd)**	**(kd)**
Not Protected HDW	19	29.59	42	23.09	26.34
Partially Protected HDW	42	31.85	92	22.20	27.03
Protected HDW	43	38.44	46	25.80	32.12
Total HDW	**104**	**33.29**	**180**	**23.70**	**28.50**
Borehole	25	20.48	43	14.89	17.69

Source: Author’s field studies

For the aggregate sample, it is found from Table 3 that the mean value of per capita water use among HDW users is 28.5 lcd whilst the average value of borehole users is 17.7 lcd. In the definition of water supply coverage in NRWSSP (2007), access to safe water supply is a minimum of 25lcd of water from a protected source. Table 3 indicates that the sampled borehole users have not reached the Zambian standard level whilst HDW users can access over the minimum amount of per capita water use. In fact, out of 109 borehole users (HH), 41 HH use another water source to complement an inadequate supply of water collected from borehole every day.

Accessibility

The distance to the water source is one of the dimensions of accessibility for end users. Although access to a safe water supply is defined as people can access **within a distance of 500m from point of use** (NRWSSP 2007), about 30% of HHs collecting water from a borehole (28% in Milenge and 34% in Nchelenge, respectively) have to walk more than 500m to draw water. In contrast, no more than 15% of HHs using water from any type of HDWs have a distance to a water source of more than 500m (see Table 4). Further, accessibility to HDWs in Nchelenge is better than that in Milenge. For instance, over 90% of Not protected

HDW users in Nchelenge can access within 250m compared with 60% of Not Protected users in Milenge. This could be explained by the difference in population density where Milenge District has approximately 5.9 persons/km^2 (≒1HH/km^2) and Nchelenge District is about five times denser with 30.3 persons/km^2. The higher population density in Nchelenge than in Milenge indicates shorter distances to neighbouring houses and water points.

Table 4. Distance to primary water source

Water supply types	Valid Cases : N (Milenge, Nchelenge)	0-20m : % (Milenge, Nchelenge)	21-250m : % (Milenge, Nchelenge)	251-500m : % (Milenge, Nchelenge)	501-1000m : % (Milenge, Nchelenge)	>1000m : % (Milenge, Nchelenge)
Not Protected	82 (34,48)	(46,56)	(14,35)	(25,4)	(4,0)	(11,4)
Partially Protected	146 (52,94)	(38,53)	(38,36)	(10,6)	(4,4)	(10,0)
Protected	97 (49,48)	(33,46)	(49,48)	(12,4)	(2,2)	(4,0)
Borehole	109 (43,66)	(2,2)	(47,48)	(23,17)	(12,23)	(16,11)

Source: Author's field studies

On the other hand, more than 30% of borehole users in Nchelenge have a distance over 500m while it is about half for users (28%) in Milenge. This may be explained by the nature of borehole construction sites. The borehole construction sites are alongside the paved road since the construction equipment has a limitation on movement into the bush. However, not all the houses of village dwellers in Nchelenge were located roadside because of the higher population density than that of Milenge. These findings indicated that people who live in sparsely populated rural area are required to access water source at a considerable distance if the water point is a communal commodity rather than at household level. Overall, conventional community-based water supply approach has been facing fundamental contradiction between the Zambian government standard of serving 250 people (≒40HH) within a distance of 500m from point of use, and actual rural settlements with very low population density of 1HH/km^2 in Milenge and 5HH/km^2 in Nchelenge.

Reliability

Environmental sustainability is considered in this study as water source reliability. To access safe water **every day of the year** (one of the criteria for water supply coverage), adaptability with respect to the fluctuation of groundwater is an important factor as well as sustainable water supply technology with O&M. Therefore, reliability can be broken down into two components; one is depletion of water source, and the other is dysfunction of water lifting device.

First, it does not matter that Luapula Province has the highest availability of groundwater at a shallow depth (Zulu Burrow 2008), if water fluctuation may lead to the drying up of the water source due to an inadequate depth of well during the dry season and/or the well may collapse from the bottom parts with inadequate protection. It was found from household/caretaker surveys that only one borehole site (out of 37 sampled boreholes) had experienced inaccessibility to water during the dry season because of an inadequate depth of borehole and not because of a dysfunctional handpump. But on the other hand, the frequency of dry up is a challenging issue among HDWs. Table 5 shows the statistical test results whether frequency of water source dry up is different between bottom lining HDWs and non-bottom lining HDWs in Nchelenge. Since well head protection itself is not relevant to the reliability of water source, bottom lining is taken into account the relationship with frequency of dry up. In Nchelenge, there are 43 bottom lined HDWs (partially or fully) with 4 Not protected HDWs (10% of Not protected HDWs) followed by 20 Partially protected HDWs (29% of Partially protected HDWs) and 19 Protected HDWs (56% of Protected HDWs). Where they have no bottom lining, nearly half (46%) of the HDWs dried up during the dry season every year compared with less than a third of HDWs with bottom lining (28%). The study found that frequency of water source dry up has relationship with the bottom lining ($p<.05$, statistically significant) These findings suggest that bottom lined HDWs provide a sufficient water source every day of the year rather than those HDWs without linings. Where there is no lining at the bottom part of the wells, they may collapse from the bottom part of the well wall from soil erosion when the groundwater level is up. It was notable that the improvement work in bottom lining in Nchelenge was done not only for the subsidised communal well, but also for individual HDWs without any subsidy prior to the Self Supply project being launched. This is also linked to the lesson learned from the pilot Self Supply in Milenge in that they could not cast the rings for bottom lining in addition to re-deepening despite the fact that they initially planned to do it prior to having completed the well-head protection (They could have done a lining at least for the top metre of the shaft to improve water quality by reducing the seepage back of dirty water from the surface into the well, and for reducing the risk of the shaft collapse by using skilled artisans in Milenge).

Table 5. Frequency of water source dry up

Nchelenge		No dry up in last 5 years	Dry up once in last 5 years	Dry up twice in last 5 years	Dry up seasonary	Row total
Bottom lining HDW	Count	29	2	0	12	43
	% within bottom lining HDW	6%	5%	0%	28%	100%
No Bottom lining HDW	Count	34	6	5	38	83
	% within no bottom lining HDW	41%	7%	6%	46%	100%
X^2	**Value**	**Df**		**Significance**		
	9.140	3		0.0278*		

Source: Author's field studies

Second, although borehole sites experienced less water source dry up, downtime of the lifting device (handpump), is also a crucial issue for access to water. Reliability can be threatened where the lifting device is dysfunctional, which makes water inaccessible even when there is water in the borehole. According to the surveys with borehole caretakers, the handpump downtime at borehole sites is from a few days to over six months depending on the availability of pump mender, spare parts and amount of collected contribution. On the other hand, it was found from HDW owners' survey that they can replace the rope or bucket on the same day or next day when break down happened, especially where a local shop holds these in stock under the private sector involvement in the Self Supply approach.

Cost-effectiveness

To assess the cost-effectiveness of water service, lifecycle cost is useful for evaluating the impact of a product or process from 'cradle' to 'grave' (Fonseca et al. 2010). The lifecycle costs can be broken down into two dimensions: those with 'project costs' which were generally incurred by the government or NGO/external support agency and 'household/community costs'. This paper only looked into the capital costs of the latter costs to understand the viewpoint from the end users side. The 'household/community costs' was considered in the conventional communal water service including O&M and some portion of contribution towards the capital cost. For example, in Zambia, as a new initiative, the Sustainable Operation and Maintenance Project (SOMAP) for rural water supply has been piloted and adopted into the policy alongside the conventional communal service. One of the principles is that of cost sharing by communities: communities are expected to contribute 5% capital costs and 5% of rehabilitation and replacement costs and 100% costs for O&M (NRWSSP 2007). On the other hand, the pilot Self Supply in Zambia delivers a service to beneficiaries (households/communities), and beneficiaries use their own investment to improve their traditional water sources. In other words, households/communities take part in capital and O&M hardware costs by contrast with the conventional communal service. For an example of the sharing of capital costs by communities under the conventional subsidised model, per capita cost of the 5% capital cost of about ZMK1.5 million (≒US$350) becomes US$1.4 when shared by a standard served number of 250 persons. Meanwhile, the average cost for attaining an improved status (well with an apron, raised parapet walls and top slab, top lining, drain, lockable cover, rope and metal bucket) under the Self Supply model was about US$160, and furthermore they had already invested their money in order to construct a water source by using about US$50. So the Self Supply costs per capita "household costs" become US$1.4 when shared with 150 people which is standard served number of HDW in NRWSSP. Notably, these HDW capital and improvement costs were rarely shared by beneficiaries, but were invested in by individual owners or their families despite the fact that they shared their water source with neighbouring households. These findings pose the question as to whether a Self Supply service can be rejected by households/communities because of the need for a higher amount of investment towards access to water? It is necessary to monitor this alongside financial mechanisms. For example there is an on-going revolving loan fund in the pilot Self Supply project by WaterAid in Milenge in the period before harvest, when cash is very hard to come by. Over 40 traditional water sources were already improved or even newly constructed by trained artisans within Self Supply at the time of the visit and those were financed by the households/communities using loan (fully or partially).

Conclusions

The selection of water source that rural dwellers use is based on complex and complicated factors of social, environmental, financial and technical aspects. The study found that customarily there is high demand for a private water source, and communities have already started taking steps to access water. Self Supply is the approach for the delivery of water services to households/communities to complement their effort and accelerate sustainable access to safe water rather than to subsidize physical infrastructures. The study showed that a Self Supply water service could significantly reduce faecal contamination risk in water quality which is comparable with that of the conventional communal water service and deliver bigger per capita water use and better convenience of access than conventional water supply, but the factors of their reliability in terms of water source dry up and finances need to be monitored in the future. A Self Supply service may fit with people living in sparsely populated rural areas where a conventional communal service may have limitations for delivering water close enough to fulfill households' demand. Since the underlying service models are different within the Self Supply model and conventional communal model, an integrated approach is required for a rural water strategy at the macro level in order to bridge the gap.

Acknowledgements

The authors would like to extend thanks to UNICEF Zambia, WaterAid Zambia and DAPP for making this research possible. The first author also acknowledges the support of the Konosuke Matsushita Memorial Foundation.

References

Central Statistical Office Zambia (2006) *Summary report for the 2000 Census from Zambia*. Available: http://www.zamstats.gov.zm/ [2009, May] .

Fonseca, C., Franceys, R., Batchelor, C., Mclntyre, P., Klutse, A., Komives, K., Moriarty, P., Naafs, A., Nyarko, K., Pezon, C., Potter, A., Reddy, R. & Snehalasha, M. (2010) *WASH Cost Life-Cycle Costs Approach, Briefing Note1*, IRC International Water and Sanitation Centre, Netherland.

Government of Republic of Zambia (2007) *National rural water supply and sanitation programme 2006-2015*, Ministry of local government and housing, Lusaka.

Zulu Burrow (2008) *Baseline Survey for Self Supply in Luapula Province*.

Mukonge, M., Mumba, M., Likombeshi, C. & Kumamaru, K. and Mwale, M. (2010) "Self Supply approach in Zambia", *Providing Sustainable Water Services at Scale*, eds. S. Smits, H. Lockwood, K. Danert, C. Pezon, A. Kabirizi & Carter, R. and Rop, R., Thematic Group on Scaling Up Rural Water Services, Netherland, pp. 45-47.

Sutton, S. (2010a) *Accelerating Self Supply-A Case Study from Zambia*, Rural Water Supply Network, Switzerland.

Sutton, S. (2010b) "Self Supply- A blind spot?", *Proceedings of the International Symposium on Rural Water Services: Providing Sustainable Water Services at Scale*, eds. S. Smits, H. Lockwood, K. Danert, et al, Thematic Group on Scaling Up Rural Water Services, Uganda, pp. 72.

Sutton, S. (2004) *Low Cost Water Source Improvements*, First edn, TALC, UK.

Contact details

Koji Kumamaru
WEDC, Loughborough University
Loughborough, Leicestershire
LE11 3TU
Tel: +44 75486688338
Email: K.Kumamaru@lboro.ac.uk

Ian Smout
WEDC, Loughborough University
Loughborough, Leicestershire
LE11 3TU
Tel: +44 150922 2642
Email: I.K.Smout@lboro.ac.uk