Socio-economic factors influencing the spread of drinking water diseases in rural Africa: case study of Bondo sub-county, Kenya

Anthony Joachim Rodrigues, Wandiga Shem Oyoo, Francis O. Odundo and Enos W. Wambu

ABSTRACT

Socio-economic and medical information on Bondo sub-county community was studied to help establish the relationship between the water quality challenges, community health and water rights conditions. Health challenges have been linked to water quality and household income. A total of 1,510 households/respondents were studied by means of a questionnaire. About 69% of the households have no access to treated water. Although 92% of the respondents appear to be aware that treatment of water prevents waterborne diseases, the lowest income group and children share a high burden of waterborne diseases requiring hospitalization and causing mortality. Open defecation (12.3%) in these study areas contributes to a high incidence of waterborne diseases. The community's constitutional rights to quality water in adequate quantities are greatly infringed. The source of low-quality water is not a significant determinant of waterborne disease. The differences in poverty level in the sub-county are statistically insignificant and contribute less than other factors. Increased investment in water provision across regions, improved sanitation and availability of affordable point-of-use water purification systems will have major positive impacts on the health and economic well-being of the community.

Key words | point of use, treatment of water, socio-economic indicators, water quality, waterborne diseases

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INTRODUCTION

The Constitution of Kenya gives every citizen the right to clean and safe water in adequate quantities (Constitution of Kenya 2010, Article 33 d). However, the majority of the local communities around the Lake Victoria basin and elsewhere do not have access to safe drinking water and so are forced to consume contaminated water (Meigh *et al.* 1999). This contributes to a high incidence of waterborne diseases, which negatively affects their socio-economic development and human rights (Onyuka *et al.* 2011). In order to create an integrated health knowledge base that includes clinical and epidemiological science, biostatistics, health risk and vulnerability analysis, and medical anthropology, socio-economic data about the community were collected to support establishing the relationship between the water quality challenges, community health conditions and water rights.

The research was developed in order to define health indicators and analytical methods. Data were collected, integrated to requisite data and prototype health surveillance and an analytical tool to capture, store, analyse and interpret raw geo-referenced data was developed and tested. The results were then presented to the community leaders and policymakers who helped compare the results across stratified areas.

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Community mindset change: linking water quality to health and well-being

Despite several well-documented studies and initiatives (Ntiba *et al.* 2001; Muyodi *et al.* 2010) water quality still presents serious problems and challenges to Lake Victoria riparian communities. Since these initiatives are not having an impact and saving lives, there is a need to rethink the approaches so far used in water quality at the point of use. A new approach should cover community sensitization, capacity building and community involvement in water quality at the point of use, in a bid not only to control the prevalence of waterborne diseases, but also to improve quality of life and opportunities for the community.

The overall objective of this project was to mobilize and train the local communities on water quality at the point of use and sensitize individuals as to their water rights as provided for in the Kenya Constitution 2010. The awareness created would improve well-being, create income generation opportunities and reduce poverty of the people (Hunter *et al.* 2010).

Study area

The study was conducted in Bondo sub-county, which lies between latitude 0 °26′ and 0 °90′N and between longitude 33 °58′E and 34 °35′E. It has a population of 157,522 comprising 76,468 males and 81,054 females giving a mean population density of 266 persons per km^2 (Kenya National Bureau of Statistics 2010). The average poverty index level is given as 70.6% (Bondo District Environment Plan 2006–2011). The River Yala forms the sub-county boundary largely in the north/north-west, while Lake Victoria forms the southern border (see Figure 1). The area under study was stratified as follows: Lake region (up to 10 km inwards from the lake shore), River Yala region (up to 10 km south of the river), and Middle region (area between Lake and River regions above).

The study area is approximately 1,972 km^2 of which 972 km^2 is landmass and the rest is water surface. The area is characterized by a moderately wet climate and receives mean annual rainfall of between 1,000 and 1,400 mm. The rainfall is bimodal with dry spells

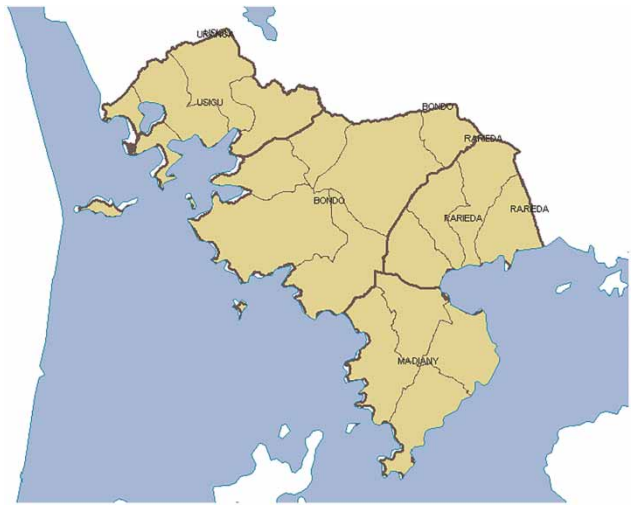

Figure 1 | Bondo sub-county (*Source:* World Agroforestry Centre).

experienced between December to March and July to September (Olago *et al.* 2007). The distribution of rainfall is strongly influenced by the topography and south-westerly winds from the lake. There is gradual decrease in the amount of rain from above 1,400 mm per annum in the northerly areas to less than 700 mm in the vicinity of the shore of Lake Victoria (Anyah & Semazzi 2004). The rainfall pattern formed the basis for study area stratification.

METHODOLOGY

Assessment of water purification/disinfection practices

To acquire suitable and diverse information and data, the pilot study was carried out in three socio-economic and biophysical settings: the vicinity of Lake Victoria, the vicinity of River Yala and the area in between. Socio-economic data about the community were collected to establish the relationship between the water quality challenges and community health conditions (Hunter *et al.* 2010).

Design of the questionnaire

The questionnaire was designed to capture the following information: demography of the respondent's dwelling,

including coordinates and geospatial-topology; bio-data of respondents, including marital status and level of education; household incomes and expenditure patterns, and data on crops grown and foods consumed; indicators of wealth, such as land owned, types of house occupied, bicycles, radios and televisions owned; access to and availability of sources, storage, treatment and transport of water; accessibility and affordability of health facilities; knowledge, impacts and attitude towards waterborne diseases; culture, practices and impacts; availability and access to sanitation facilities; knowledge of and attitude to cholera and impact of cholera.

Administration of questionnaire

The questionnaire was approved at a start-up workshop held on 11–12 September 2012 with participants involving community members, district government officers and stakeholders. The approved questionnaires were administered from 26 October 2012 to 20 November 2012 and to a total of 1,510 households/respondents selected in proportion to the respective stratified populations. The distribution by gender was 658 males and 852 females. The questionnaire was administered by: (a) traditional paper and pencil self-administration 'interview' methods by handing paper questionnaires to people in person and asking them to complete them by hand and return them to the researcher; and (b) verbal interviews, using traditional paper and pencil interview questionnaires (Klepac *et al.* 1981).

Due to illiteracy among adults and in situations where respondents were not found in the households, the questionnaires were administered to students from the respective households attending nearby educational establishments in order to improve the response. The level of education of respondents was primary education 14.3, secondary education 61.4 and tertiary education 3.2%.

The distribution of respondents by gender was 56.4% female and 43.6% male and the distribution by regions was Lake 45.6%, River 17% and Middle 37.4% which was proportional to their respective populations.

RESULTS AND DISCUSSION

A total of 1,158 questionnaires, distributed proportionately across the sub-county, were received and analysed. The response was as follows: 52.2% of respondents indicated the presence of stagnant water in their location; 66.7 lacked adequate food; 63.6% had no access to agricultural land; 95.1% bought foods from the market; and 87.4% kept livestock. Wealth indicated by ownership of land was 59.0%, radio 87.9%, television 35.7%, bicycles 80.2%, motor cycle 23.2% and access to newspapers 49.6%.

Regarding health, 65.4% had easy access from home to a health centre facility, 67.1% could access medical services, 81.1% of treated patients got well after treatment and 86.6% could pay for their medical services. Although 51.2% could afford health facility services, 33.9% considered the cost to be very high while only 14.9% considered the cost to be low. Those who could not afford the cost got help from relatives. A large majority (89.2%) thought the government should pay the hospital bills for treatment of waterborne diseases and 88.2% thought the government should be responsible for preventing diarrhoeal diseases. Patients predominantly (67.8%) attended government hospitals, 20.3% visited health centres and the rest (9.8%) visited local dispensaries. Sustainable sanitation was fairly good as 77.4% of the respondents had pit latrines and 10.1% flush septic tanks toilets but 12.3% still practised open defecation.

Awareness of diarrhoea was very strong, with 95.7% of respondents indicating attendance at a health facility when family members had waterborne disease, while prevalence of cholera was considered to be high (66.5%). With regard to the treatment of waterborne diseases, whereas 35% felt traditional healers could cure such diseases, only 11% sought such treatment; 33.2% of the respondents indicated a member of their family above 5 years having diarrhoea, while 39.4% of cases were life-threatening. In the case of cholera, 42.1% reported that they had visited a health facility for treatment, while 34.1% had a member of their family hospitalized for cholera and 11.8% indicated that they had lost a member of their family to the disease. However, data obtained from medical clinics regarding incidence of cholera show that there had been not a single case

of cholera in the district in 2012. Apparently, the community tends to mistake diarrhoea/dysentery for cholera. Information on other diseases causing diarrhoea was not gathered and cannot be quantified.

The common source of water for the community varies and is shown in Table 1.

Major sources of water stratified by region from Table 1 are: Lake–lake water (55.3%), River–tap water (47.4%) and Middle–tap water (29.2%). Since only tap water is treated, we can conclude that about 69% of the households overall have no access to treated water. Water drawn from other sources may, in general, require treatment to eliminate disease-causing microorganisms (Mwamburi 2009; Onyuka *et al*. 2011).

Table 1 | Common sources of water in the study areas

Water source (%)	Lake	River	Middle	Overall
Tap	10.1	47.4	29.2	30.6
Borehole	3.6	6.8	23.9	14.8
Roof water, pond	7.2	6.8	8.9	7.9
Lake water	55.3	5.1	2.0	13.8
Protected well	1.7	7.1	8.7	6.8
River/stream	5.5	11.3	1.4	5.1
Unprotected well	6.7	3.4	3.9	4.3
Pond	4.6	7.3	18.4	12.4
Man-made depression	2.9	2.5	1.2	1.9
Pans	0.0	0.0	1.5	0.7
Others	2.4	2.4	1.0	1.7
Total	100.0	100.0	100.0	100.0

Culture and practice

The communities' perceptions of how often water sources are treated and how often they treated their own water showed no statistical difference using an analysis of variance (ANOVA) test. This indicates that the distinction between the two questions was not clear or that the respondents interpreted them to be the same issue. It is apparent that the community needs improved public awareness on water treatment.

Ninety-two per cent of the respondents appeared to be aware that water treatment prevents waterborne diseases, and 96.4% washed their hands before eating a meal.

On the influence of culture on water sources use, 35% of the respondents indicated that recent widows are prevented by tradition from sourcing water from where the community normally gets it.

Poverty/income and disease impact

The low-income groups share a high burden of waterborne disease deaths, as revealed by the number of hospitalizations and deaths shown in Figures 2 and 3, respectively. Of the

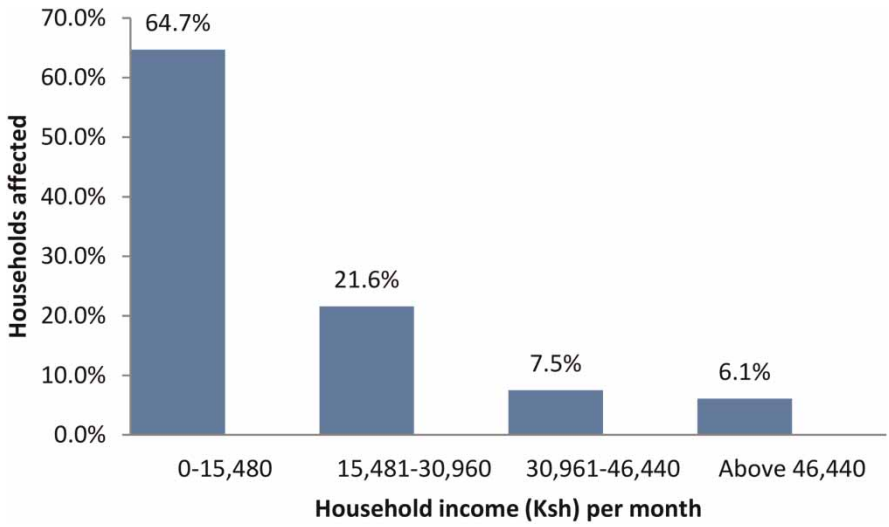

Figure 2 | Impact of waterborne diseases on hospitalization by income levels.

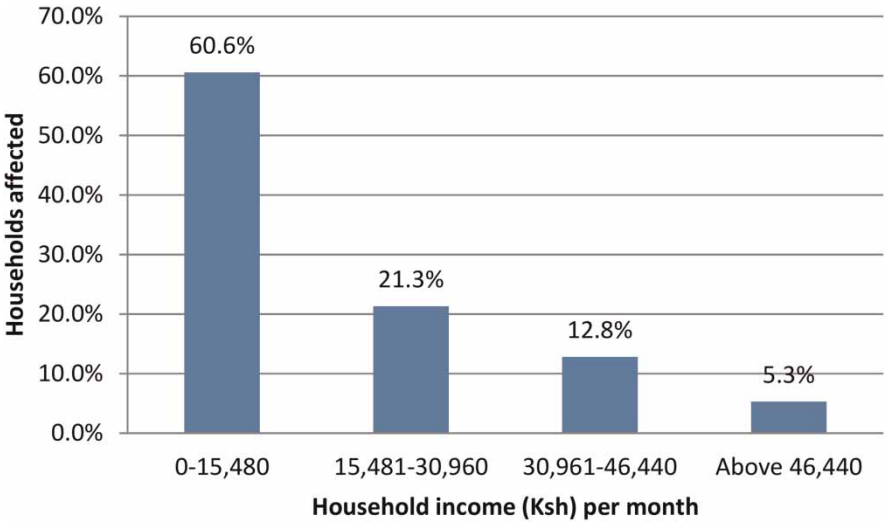

Figure 3 | Impact of waterborne diseases on mortality by income levels.

households affected by hospitalizations and mortality due to waterborne diseases, 64.7% and 60.6%, respectively, were from the lowest income group (KSh. 0–15,480).

As the Constitution of Kenya 2010 gives every citizen the right to quality water in adequate quantities, the low-income group's right to quality water is the most infringed. Improvement of water quality will have a major positive impact on the health and economic well-being of the poor.

Demographics and seasonality

Children share a great burden of waterborne diseases: 82.9% as shown in Figures 4 and 5. This is in agreement with the World Health Organization (WHO) reports (Prüss-Üstün *et al*. 2008; WHO 2010) that indicate deaths in Kenya in 2004 from all causes to be 443,900, of which all deaths related to water, sanitation and health were 42,400 or 9.6%, including 29,100 deaths related to

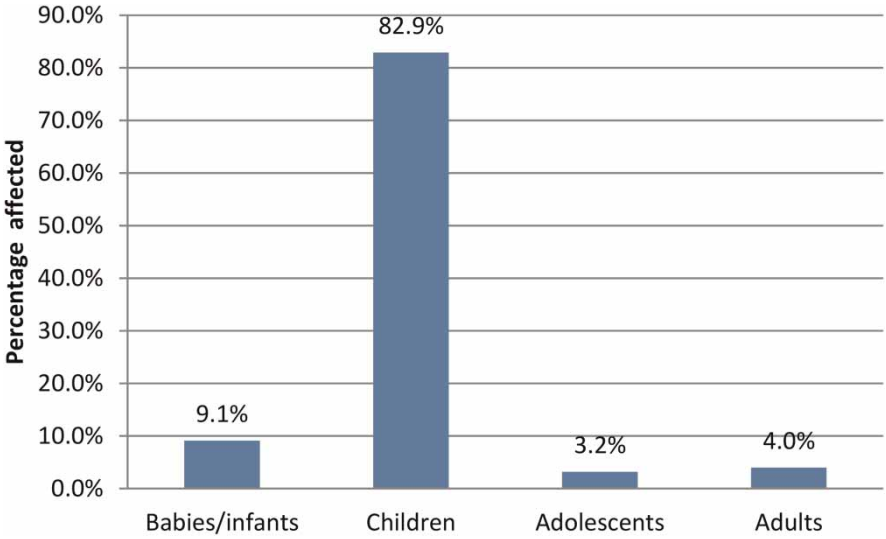

Figure 4 | Waterborne diseases by age.

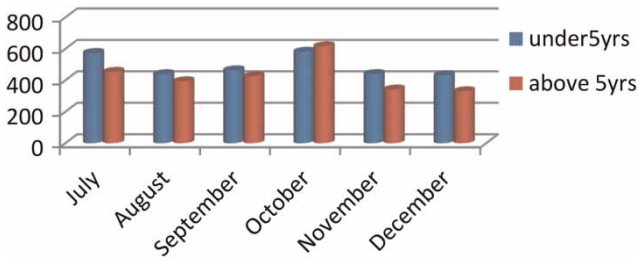

Figure 5 | Diarrhoeal diseases incidences during the study period by age, dry and rainy seasons (*Source:* Medical Clinic Data (Bondo)).

water supply, sanitation and hygiene and 10,700 from malaria.

The increase in the prevalence and incidence of waterborne diseases during the wet season is due to the continuing practice of open defecation in these areas, which stands at 12.3% in this study compares to 15% globally (UNICEF & WHO 2012).

Table 2 | Methods of storage of water

	Responses	
Storage	***n***	**%**
Jerrycan	597	32.5
Drum	333	18.1
Large tank	217	11.8
Pail	285	15.5
Pot	311	16.9
Others	95	5.2
Total	1,838	100.0

Storage

Table 2 shows that jerrycans are the predominant water storage method at 32.5% across all regions, followed by drums 18.1%, pots 16.5%, pails 15.5% and large tanks 11.8%.

Storage of water might appear from Figure 6 to be significant in controlling the spread of waterborne diseases.

However, Table 3 shows that water storage is associated with income groups.

From Table 3, we note that $\chi(33) = 57.645$, $p = 0.005 < < 0.5$ which indicates a significant association between income and water storage. Thus, water storage is a dependent variable of income. Low-income earners mostly use jerrycans for storage of water (64.3%) while high-income earners use large tanks (74%).

Treatment

An ANOVA test with respect to mortalities and frequency of treatments of water was carried out using the responses to questions 'Have you lost a member of your household to water diseases in the last 5 years?' and 'How often do you treat your water: often, never, rarely?' The results are summarized in Table 4.

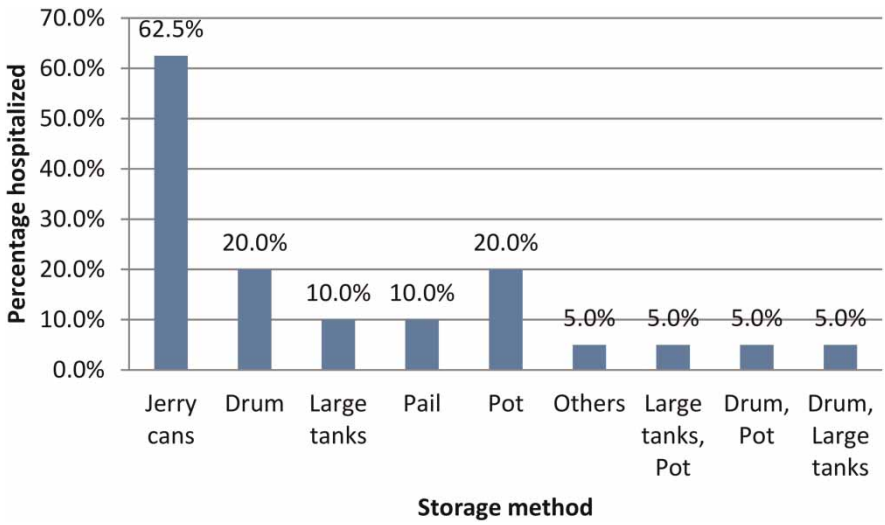

Figure 6 | Waterborne diseases and storage.

Table 3 | Income and storage test of association by Chi-squared test

	Value	df	Asymp. sig. (two-sided)
Pearson Chi-squared	57.645[a]	33	0.005
Likelihood ratio	55.985	33	0.008
Linear-by-linear association	0.175	1	0.676
No. of valid cases	1,046		

[a]Sixteen cells (33.3%) have expected count less than 5. The minimum expected count is 0.64.

Table 4 | Identification of significant groups using *post hoc* Tukey's test

Dependent variable: Have you lost a member of your household to waterborne diseases in the last 5 years?

(I) How often do you treat your own water?	(J) How often do you treat your own water?	Mean difference (I–J)	Std. error	Sig.	95% confidence interval
Often	Rarely	0.033	0.025	0.397	−0.03 to 0.09
	Never	0.224[a]	0.048	0.000	0.11 to 0.34
Rarely	Often	−0.033	0.025	0.397	−0.09 to 0.03
	Never	0.191[a]	0.049	0.000	0.08 to 0.31
Never	Often	−0.224[a]	0.048	0.000	−0.34 to − 0.11
	Rarely	−0.191[a]	0.049	0.000	−0.31 to − 0.08

[a]The mean difference is significant at the 0.05 level.

Table 4 shows that there are significant differences in number of deaths between the group that often treats water and the group that never treats water ($p = 0.224$) and number of deaths between the group that rarely treats water and that which never treats water ($p = 0.191$). However, there were no differences between the groups that often treat water and that which rarely treats water ($p = 0.033$). The latter result is counter-intuitive and is probably due to the respondents not being clear about the difference between often and rarely in the vernacular. As a result of the test, we reject the null hypothesis and accept the alternative hypothesis that there are at least two group-means that are significantly different from each other.

Stratification

From Table 1 one might expect that the sources of water are related to the stratified regions. However, the impact of waterborne diseases on stratified regions (Figure 7) shows that prevalence does not vary significantly when data are normalized.

In other words, the source of water is not a significant determinant of waterborne disease. This implies that all sources have low water quality.

Major household water issues

Table 5 indicates that the household water problems vary across the stratified regions.

Post hoc multiple comparisons tests shows that water problems along the lake region are different from problems along Yala River and also those of Yala River are different from those of the middle region (Table 6). This therefore suggests that intervention strategies could be different across regions.

Comparison of the water problems seems to be significant between either pair of regions that involves the Yala River, i.e. $p < 0.05$. In the case involving Lake and Middle region $p = 0.285$ which is not significant.

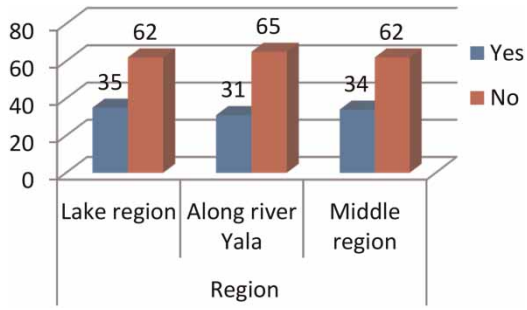

Figure 7 | Normalized prevalence by region.

Table 5 | Variation between water problems across the stratified regions

ANOVA

What are the major water problems in your house?

	Sum of squares	df	Mean square	F	Sig.
Between groups	41.309	2	20.655	8.374	<0.001
Within groups	2,757.613	1,118	2.467		
Total	2,798.922	1,120			

Table 6 | *Post hoc* Bonferroni test: household water problems across stratified regions

Multiple comparisons

Dependent variable: What are the major water problems in your house?

(I) Region	(J) Region	Mean difference (I–J)	Std. Error	Sig.	95% confidence interval
Lake region	Along river Yala	−0.544[a]	0.133	0.000	−0.86 to −0.22
	Middle region	−0.173	0.103	0.285	−0.42 to 0.08
Yala River region	Lake region	0.544[a]	0.133	0.000	0.22 to 0.86
	Middle region	0.371[a]	0.136	0.019	0.05 to 0.70
Middle region	Lake region	0.173	0.103	0.285	−0.08 to 0.42
	Along river Yala	−0.371[a]	0.136	0.019	−0.70 to −0.05

[a]The mean difference is significant at the 0.05 level.

Figure 8 gives the major issues ranked across the stratified regions as: availability (2,1,1), quality (1,2,4), affordability (4,3,2), accessibility (3,4,3), reliability (5,6,5) and quantity (6,5,6). The numbers in parentheses are the rankings of said issues in the lake, river and middle regions, respectively.

Income vs. stratified region

When income and water problems were tested against stratified regions using ANOVA, no significant differences were noted. This implies that the poverty level in the sub-county is statistically insignificant (Bondo District Environment Plan 2006–2011). Prevalence of poverty makes the effects of other factors diffuse.

CONCLUSIONS

The major sources of water are lake water in the lake region and tap water in both the river and middle region. However, since availability of water is the first-ranked issue in the river region, which is predominantly supplied by piped water from the Siaya and Bondo Water and Sanitation Co. Ltd, it is clear that the piped water supply is inadequate since quality and affordability are also issues in this

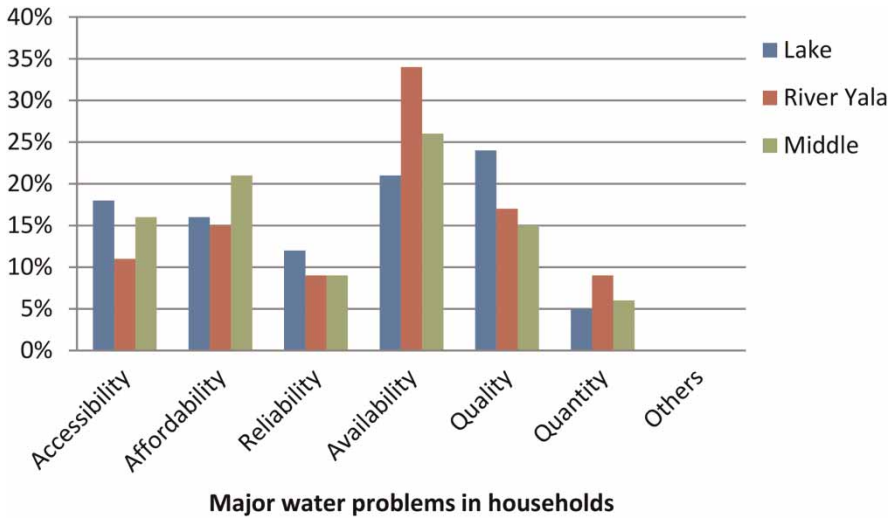

Figure 8 | Major water problems across regions.

region. In the lake region, water quality is the major issue followed by availability, access and affordability; the latter three presumably exacerbated by household distance from the lake. Analysis of data shows that about 69% of the households have no access to treated water. In general, water may require some form of treatment to eliminate the disease-causing microorganisms. Certainly, the right to quality water in adequate quantities has not been met in the sub-county. While the constitution provides this right, no legislative framework has been outlined in the same document or passed by Parliament. Stringent measures need to be put in place to improve sanitation in the district and eliminate open defecation.

The lowest income group and children share a high burden of waterborne diseases requiring hospitalization and causing mortality. Improvement of water quality will have a major positive impact on the poor. Waterborne diseases also cause nutrition imbalances and mental retardation. Prüss-Üstün *et al.* (2008) and WHO (2000) clearly demonstrate that water, sanitation and hygiene cause more deaths in Kenya than malaria and other Millennium Development Goal diseases. Increased investment in water will serve the interest of all as well as meeting the constitutional requirement for rights to water and sanitation.

Recommendations

Based on the findings of this study and the conclusions made, we recommend the following:

(1) Piped tap water supply along the river region by the Siaya and Bondo Water and Sanitation Co. Ltd be enhanced and extended to the middle region to improve availability, affordability access and quality.
(2) Given the fact that the Lake Victoria region will require extra unavailable financial resources to develop new, and maintain existing, piped supplies for household water, it is critical that in the meantime a new policy be instigated to encourage and establish point-of-use water purification systems.
(3) The County government provide improved sanitation systems in the sub-county to cover all users.
(4) Improvement of water quality will have a major positive socio-economic and health impact on the poor.

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