

Perceptions of Safe Water and Accessibility by Rural Farming Communities Residing Along the Fringes of the Okavango Delta, Botswana

Galase Tshepiso Ramolefhe*, Barbara Ntombi Ngwenya§, Njoku Ola Ama*, Maria S. Nnyepi*, Moses John Chimbari*

Abstract

Globally, access to safe water for domestic use is a key social development indicator promoting health and enhancing national development. About 1 in 10 people are without access to safe water with Sub Saharan Africa facing greater challenges. Botswana, a semi-arid country, is not an exception to these challenges. Existing research has focused on water supply issues, physico-chemical properties and the effects of human activities on water quality but with little attention given to the community residents' perceptions on accessibility of safe water. The study objective is to assess the community perceptions of safe water and accessibility amongst rural farmers of Ngamiland district. This is a descriptive cross-sectional study that uses data from socio-economic survey (SES) conducted between July and August of 2010, Participatory Rural Appraisal (PRA) workshop reports from 2010-2012 and unobtrusive field observations by authors to assess the flood recession "*molapo*" farming communities' perceptions of safe water and accessibility. A total of 161 farmers from Tubu, Xobe, and Shorobe that participated in the SES Survey are the ones being assessed in the current study. In order to investigate factors influencing safe water access, binary logistic regression model was fitted to some socio-economic and environmental variables. Results were reported using descriptive frequencies. Almost 80% of rural farming participants' perceived water from all sources, improved and unimproved to be safe and adequate. Perceptions of water accessibility, availability and safety changed with 2010 showing satisfaction and 2012 dissatisfaction with these aspects. There is a significantly strong relationship between source of domestic water and communities (The contingency coefficient, $r=0.707$, $p<0.05$). Number of people in a household is a significant predictor of access to safe water ($p<0.05$). People who hold the view that *molapo* farming has potential to cause water borne disease and that *molapo* farming can be potential health hazard are, respectively, 1.25 and 1.71 times more likely to access safe water than those holding contrary views. Results further reveal that those who think that drinking water directly from a stream /river can cause diarrheal diseases are less likely to access safe water (OR= 0.542). Rural farmers largely perceive the water they use for domestic purposes to be safe regardless of whether source is improved or unimproved, adequate and accessible. Farmers do not seem to link drinking water directly from unimproved sources as a potential cause of diarrheal diseases. Additionally, they do not think improved sources such as taps and communal standpipes help with accessibility to safe water probably because of their frequent malfunction and dryness. Public education is encouraged to promote community awareness of contamination of all water sources whether improved and/or non-improved.

Keywords: Flood recession farmers, water quantity, water quality, Okavango Delta, Botswana

* Galase T. Ramolefhe, Department of Family and Consumer Sciences, University of Botswana, Email: gamolph@ gmail.com

§ Barbara N. Ngwenya, Okavango Research Institute, University of Botswana. Email: bntombi @ub.ac.bw

* Njoku O. Ama, Department of Statistics, University of Botswana. Email: amano@mopipi.ub.bw

* Maria S. Nnyepi, Department of Family and Consumer Sciences, University of Botswana. Email: nnyepims@ub.ac.bw

* Moses J. Chimbari, College of Health Sciences, University of KwaZulu-Natal. Email: Chimbari@ukzn.ac.za

Introduction

Despite the importance of water to sustenance of life, health and social and economic needs it has become a scarce resource globally (Bigas 2012). Currently approximately 768 million people are estimated to still be without access to an improved drinking water source (United Nations Children's Fund 2014). Developed and developing countries alike are experiencing water problems. Even Europe, which is considered to have adequate water resources, is experiencing water scarcity with at least 11% of its population affected (European Union 2016). The African region is also hard hit with the water crisis. This crisis has been reported in the literature since as early as the 1970's. Most of the African nations today are importers of food since they do not have sufficient water to support irrigated agriculture (Allan, 2002). Some African countries, like Ghana, are experiencing water demand far exceeding the available supplies leading to rationing schedules where over 75% of the city residents have supply only for few hours and about 10% have no access (WaterAid 2005; Peloso & Morinville 2014). Shortage of water is a global problem hence the explosive concern and seeking of resolutions by many organizations and/or global communities such as the United Nations Human Rights Council, United Nations Children's Fund (UNICEF) and World Health Organization (WHO) (United Nations Children's Fund 2014). In all instances of water scarcity, common factors such as climate change, rapid population increase, agriculture, energy production, urbanization and increasing demands due to growing economic activities are responsible for the problem (Food and Agriculture Organization 2012).

Perception of safe water is an important determinant of community acceptance of public water. It is influenced by many factors including organoleptic properties of the water and perceived level of risk associated with water sources (de França *et al.* 2009; de França 2010). It is not uncommon for the public to have positive perceptions of public water even during periods marked by increases in water-borne diseases, which suggest the potential contamination of the water (Wright *et al.* 2012).

Water quality and/or safety issues are a major and growing challenge facing governments in both developed and developing countries (Schwarzenbach *et al.* 2010). Safe water implies that drinking water (water used for drinking, cooking, food preparation and personal hygiene) is free from pathogens and any levels of toxicants at all times and poses no significant threat to health (WHO 2016). Water quality problems are likely to be aggravated by poor sanitation and hygiene and extreme climate change events such as floods and droughts. These all have a direct adverse impacts on human health due to infectious disease outbreaks, waterborne diseases due to viruses (Hepatitis A and E viruses, rotaviruses), bacteria and parasitic protozoa spread via the faecal oral route is often associated with inadequate water supply and poor hygiene (Hunter *et al.* 2010). Water-wash disease infections (trachoma, scabies and Shigella) are likely to spread in communities that have insufficient water for personal hygiene. Trachoma and other eye infections are prevented by facial hygiene. Hand washing with soap reduces the risk of endemic diarrhoea, respiratory and skin infections. Cost-effective interventions to provide safe drinking water and improved sanitation are key to reducing the disease burden of largely preventable diseases in developing countries (Bartram & Cairncross 2010). Improved access to safe water and sanitation contributes towards achievement of several millennium development goals (MDG) (Rosemarin *et al.* 2008; WHO/UNICEF 2008) and supports household productive activities.

Access to portable water denotes that there be a clean, sufficient and reliable source of water to meet domestic needs (WHO, 2016). Accessibility also suggests that the water can be collected not more than 1 km from the dwelling, corresponding to a maximum water hauling round trip of 30 minutes (WHO/UNICEF/Joint Monitoring Programme 2008). A safe, reliable, affordable, and easily accessible water supply is essential for good health (Hunter *et al.* 2010).

Wetland ecosystem services (provisioning, regulating, supporting and cultural) such as the Okavango Delta, determine both environmental and human health. Such an ecosystem can serve as a source of safe water, food, nutrition, psycho-social well-being, livelihoods diversification and medicinal products (fungi and bacteria) (Horwitz *et al.* 2012). Ideally, the ecosystem provides a free service by purifying water for populations living in the area. In practice, wetland ecosystems can also become sites of exposure to pollution, toxicants, infectious diseases and physical hazards. Drivers of ecosystem change, either direct (climate change, land use change, air/water pollution) or indirect (demographic, socio-political/cultural), can negatively impact water quality to the detriment of human wellbeing (Kgathi *et al.* 2013) and consequently on the accessibility of quality water for domestic use.

Botswana, is not an exception to water scarcity challenges and provision of potable water is an essential social development service that is important for the quality of life for urban and rural population alike (Kujinga *et al.* 2014a; Kujinga *et al.* 2014b; Kujinga *et al.* 2014c). The demand for water is growing on account of not only population growth, particularly in peri-urban centres and rural villages (Vandepost 2009), but also in relation to increasing per capita water use that is related to improved access of households to piped water (Ngwenya & Kgathi 2006). About 96% of households in Botswana have access to potable drinking water resources (Central Statistics Office and UNICEF 2007). Ngamiland District has abundant natural water, it hosts one of the largest inland wetlands the Okavango Delta, yet it faces water insecurity challenges that compel residents to resort to the use of untreated water (Kujinga *et al.* 2014a). It has been shown that about 74% of households in the Ngamiland district encounter water insecurity exacerbated by unreliable water supply even from improved water sources (Kujinga *et al.* 2014b).

The Okavango river system communities, especially those on its fringes are those practicing flood recession '*molapo*' farming. Tubu, Xobe and Shorobe are such villages and were our study sites. These communities take advantage of the moisture levels from the annual flooding to support their crops. Water in this river system is not only used for farming but for a wide variety of activities including for domestic use. However, the Okavango river system is potentially vulnerable to pollutants and other physical hazards because it is a shared water course between Angola and Namibia (upstream countries) and Botswana (downstream). Regulatory services are threatened by expanding populations and livelihood activities in upstream and downstream communities. For instance, increases the possibility of chemical and microbiological contamination of water supply. In particular the introduction of exogenous chemicals, insecticides, the impacts from outboard engines boats/houseboats and vehicles in the tourism industry, soil degradation, wind erosion, decadal drought cycles, periodic fires and storms, are likely to play important roles as factors affecting water quality and consequently accessibility for domestic use (Garstang *et al.* 1998; Mbaiwa 2005; Murray-Hudson *et al.* 2006; Masamba 2009; Mmualefe & Torto 2011).

Ngamiland district's current growth rate per year is 2%. There is, therefore, an increasing demand for potable water consumption amidst persistent challenges regarding unreliability and coverage of supply in Ngamiland district (Ngwenya & Kgathi 2006; Talenyana & Maunge 1994; Kgomotso & Swatuk 2006; WHO 2011). Shortage of potable water in District forces households to use untreated water from open sources such as rivers and open wells for cooking, bathing, drinking and cleaning. This predisposes them to water-borne and/or water-wash related diseases.

Existing research has focused on water supply issues (Talenyana & Maunge 1994; Kgomotso & Swatuk 2006), physico-chemical properties (Mmualefe & Torto 2011) and the effects of human activities on water quality (Masamba & Mazvimavi 2008) with little emphasis given to the community residents' perceptions on access of safe water. There has been research on opinions and perceptions

of household water security in Ngamiland district (Kujinga et al. 2014c) but there has not been any research conducted on water safety and accessibility amongst rural farming communities in this area and/or any area of Botswana. This study bridges this gap by describing perceptions of water safety and accessibility in a rural farming community living along the fringes of the Okavango Delta.

Conceptual framework

The paper is guided by the concept of water being a human right. In recognition of the right to life and dignity, the international community recognized that humans have a right to safe drinking water (amongst other resources) (United Nations 2014). In 2011, in recognition that this right was not enjoyed by the global population, the international consultations reached an agreement that to better address this human right “safe drinking water” ought to include accessibility, availability and quality (WHO/UNICEF/Joint Monitoring Programme, 2013). According to World Health Organization, drinking water means water used for drinking, cooking, food preparation and personal hygiene whereas accessibility implies that water is sufficient and meets domestic needs and is reliably available to homes (WHO, 2016). With accessibility, it is also suggested that water is collected within a distance of not more than 1 km of the dwelling, corresponding to a maximum water hauling round trip of 30 minutes (WHO/UNICEF/JMP, 2008). Additionally, availability not only implies the presence of a water source but one that is also functioning enabling water collection of at least 20L of drinking water per person per day. Finally, ‘quality’ implies pathogen-free water posing no significant threat to health (WHO/UNICEF/JMP, 2008). In this paper, indicators of safe water and accessibility of drinking water are captured in a qualitative manner through the perceptions of the rural farming community members. The specific objectives are to i) assess community perceptions on water accessibility, availability and safety ii) assess community perception of water adequacy to meet household daily needs and iii) to determine factors affecting access to safe “clean” water.

Materials and Methods

Study area and background

The study was conducted in Tubu, Shorobe and Xobe, which are villages/ settlement located on the Okavango Delta (OD) fringes (Figure 1) in Ngamiland District in north-western Botswana. Every year, water enters the OD at Mohembo with flows peaking in April and declining to their lowest level in November. Usually, the floodwater inundates low-lying flood-plains until it reaches the villages in this study. There are, therefore, a wide range of water sources in the areas that these farming communities access. These study sites experience distinct types of flooding, namely frequent flooding (Tubu), periodic flooding (Shorobe) and occasional flooding (Xobe) characteristic of their location on the flood-plain fringes of the upper, middle and lower Okavango Delta respectively. The study sites details are as follows:

The first study site is Tubu and is located about 300 km from the urban village of Maun, i.e. a settlement with a population $\geq 5,000$ with at least 75% of the labour force in non-agricultural occupation. It has a population of 626 (Central Statistics Office 2011). It is situated on the banks of the Thaoge River (Figure). Tubu village has an administrative chief, tribal administration offices and a village development committee (VDC) that guides development planning and implementation in the village. Tubu has also a health post staffed with a nurse and a health education assistant. While there is a primary school, there is no secondary school in the village, so graduating primary school pupils have to seek secondary school placement in Gumare (about 15 kilometres away). The major source of livelihood in Tubu is agriculture (both crops and livestock). Some flooding occurs every year but the extent of the flood varies.

The second study site is Xobe which is a settlement located approximately 35 km from Maun. This small village sits on the south bank of the Boteti River. The 2011 national census survey placed the population size of Xobe (Fig. 1) at 277 (Central Statistics Office, 2011). Livelihoods in Xobe primarily revolve around rain fed farming (known as ‘*molapo* farming’), irrigated vegetable production and livestock rearing. Other activities include harvesting of wild plants for sale and consumption. These include harvesting of ‘*tswii*’: water lily tubers, ‘*letlhaka*’: reeds and ‘*mepako*’: construction poles. Fishing is also practised although to a limited extent. Xobe is on the south bank of the Boteti River, about 13 km east of the urban village of Maun. In good years, when water level in the OD is high, flood water reach Xobe around July; while in low flood years, the water dries up before reaching Xobe. Due to its small population size, the settlement is not provided with essential services such as schools, piped water supply, or public transportation. If a community has less than 250 people, it is ungazetted and does not qualify for these services/developments (Kujinga *et al.*, 2014c). Although Xobe population was recorded at 277 in 2011, no developments were seen at the time of data collection; hence the community still used river water for all use. Children from this village attend both primary school and secondary school in the nearest urban village (Maun). However Xobe has an administrative headman and is serviced by a mobile clinic (manned by a nurse and health education assistant) once a month.

Lastly, Shorobe which is the third study site, has 1,031 residents (Central Statistics Office 2011) and is located about 40 km from Maun. It has an extensive network of flood recession fields fed by the Santantadibe and Gomoti Rivers and by backflow from the Thamalakane River (see Fig. 1). The villagers practise both arable and pastoral farming. Shorobe has an administrative chief and tribal administration facilities, a village development committee and a range of facilities including a primary school, a clinic with maternity ward (staffed with two nurses and a health education assistant) and several extension staff (social welfare officer, agricultural demonstrator and a veterinary assistant). In addition to services from their clinic, Shorobe residents also have good access to specialized health care services including preventive, curative and rehabilitative care services from Letsholathebe district hospital in Maun approximately 50 km away because of the availability of public transport system and the tarred road. However, as is the case for Tubu, graduating primary school children also need to seek placement in Maun as there was no village secondary school during the period of this study.

Study design

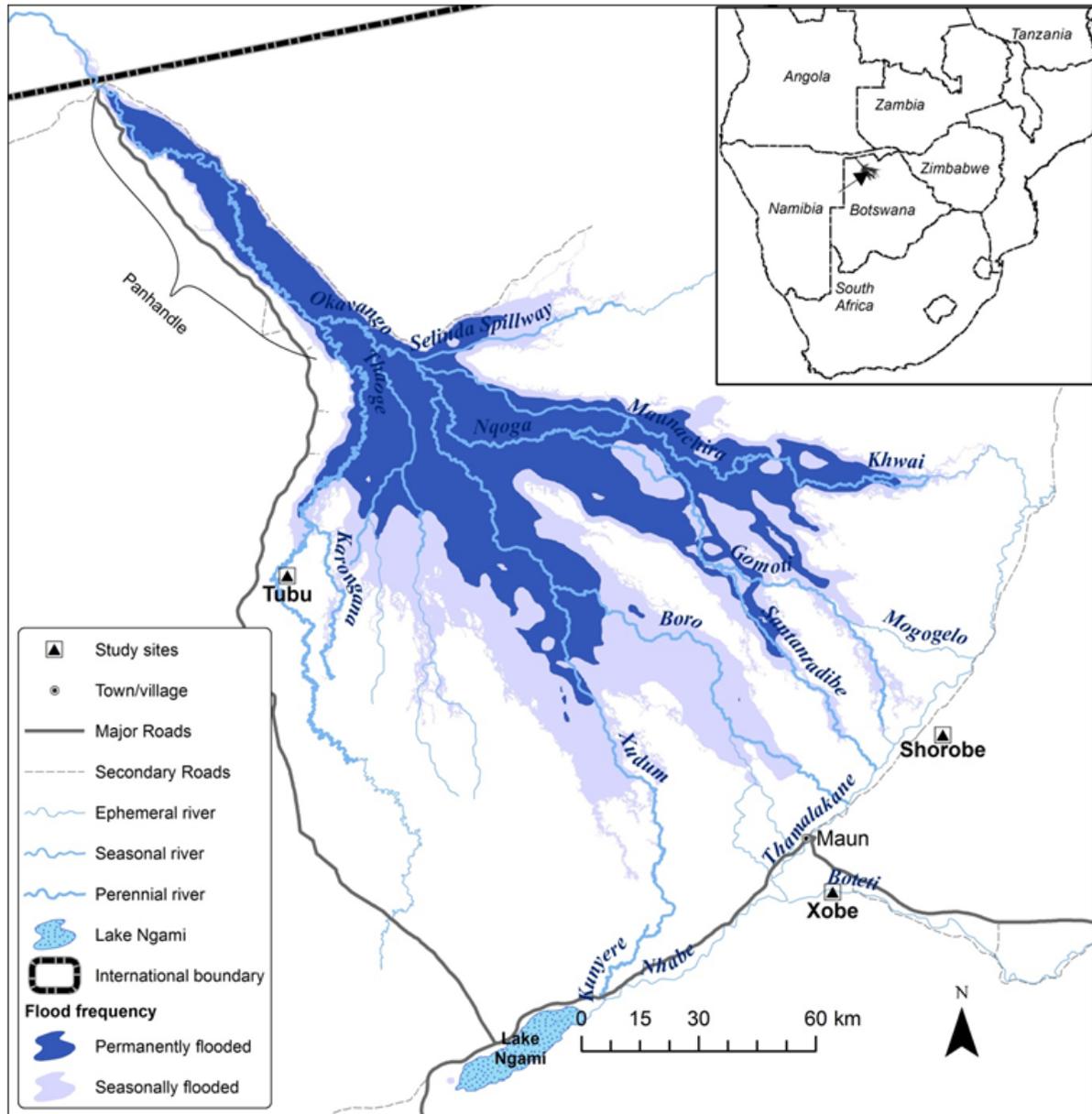
This is a cross-sectional descriptive study that uses data from a socio-economic survey (SES) of the Botswana Ecohealth Project (BEP) to assess the flood recession *molapo* farming communities’ perceptions of safe water and accessibility.

Sampling

This study was conducted between the period of July and August, 2010. Although the focus of the BEP was on *molapo* farming, and farmers this study also includes dry land and/or rain-fed farmers who formed 20 and 19 households from Xobe and Shorobe respectively.

Prior to sampling, a household list was compiled for each study village and was categorized by type of farming; i.e. either as: *molapo* (flood recession) or ‘dry-land’ farming. ‘Dry-land’ farming is solely dependent on rainfall. Since Tubu is an entirely flood recession farming community, all households in this village were included in the study. In Shorobe and Xobe all households with *molapo* farms were included in the study, plus an additional, simple, random sampling of households with dry-land farms. Thus, a total of 122 *molapo* and 39 and dry-land farming households were sampled making a total of 161 households sampled (Table 1).

Figure 1: Map of the Okavango Delta showing study sites. Source: Okavango Research Institute GIS laboratory



Socio-economic survey

Information used in the study was gathered through a survey instrument developed and pretested on 10th June 2010 at Matsaudi Village in the lower Delta and revised accordingly. This village is similar to the study villages, particularly with regard to livelihood activities and gazette status. A questionnaire was administered face-to-face to 161 sampled farmers residing in Tubu (n=60), Shorobe (n=58) and Xobe (n=43). The questionnaire captured the socio-demographic profile of the respondents, household infrastructure, access to water and sanitation, major sources of livelihoods, land resource access, nutrition and health. Of specific interest to this study were aspects capturing the community’s perceptions on water accessibility, availability and safety. Questions used to address water accessibility inquired about primary water sources and distance to water source(s). The question on water availability prompted on the adequacy of water in meeting the household needs. Finally questions on water safety revealed

community perceptions about its cleanliness and common water-related diseases. This tool also captured the socio demographics of the community such as gender, age and household composition such as number of people living in a household. Interviews in households were conducted with household heads over the age of 18 years.

Table 1: Proportions of respondents per village for the SES

Village	No. of farms	Type of farm	
		Molapo	Dry land
Tubu	60	60	0
Xobe	43	23	20
Shorobe	58	39	19
Total	161	122	39

Participatory rural appraisal workshops and field observation

Community perceptions of water quality were also captured through data cumulatively collected in nine participatory rural appraisal (PRA) workshops conducted in the three villages over three consecutive years: three between April and June 2010; three between June and August 2011; three between April and August 2012). These workshops were conducted as part of Botswana Ecohealth Project and at least 50 individuals attended the workshops in each village.

Field observations

Authors had the privilege of staying at the three sites during the project (BEP) period from 2010 until the completion in 2014. This therefore allowed us to have first-hand experience of the way of living of the study community.

Data analysis

Data denoting perceptions were analysed using the IBM SPSS programme version 23 and was presented using descriptive frequencies or percentages. In order to investigate factors influencing safe water and accessibility, binary logistic regression model was fitted to some socio-economic and environmental variables.

The model defines as its dependent variable the log of the odds of having access to safe water. Eight independent variables were identified: i) number of people in the household, ii) distance of cattle post from the village (ploughing occurs in cattle posts) and if it is far from the village, chances are that water from untreated sources will likely be used. Even if water is packed in containers, once it has been transported it will be defined as usage of water from unimproved sources. iii) water security, it is not guaranteed that there will always be water in the village standpipes so people use any available water which is usually from untreated sources. iv) Opinions on whether *molapo* farming can cause potential water borne disease, diarrheal diseases, potential health hazards and v) primary source of drinking water, vi) own tap connection in house, vii) own tap connection in yard and viii) communal standpipe. The responses to these variables were coded, as shown in Table 2.

Results

Socio-demographic profile

A total of 161 rural farming households were surveyed from the three communities of Shorobe, Tubu and Xobe villages at counts of 58, 43 and 60 respectively. All respondents were farmers. The respon-

dents were predominantly female (79.5 %, n = 128) and mostly household heads (64.6%, n = 104), with an average number of six people living in each household. Forty-five percent (45%) of the respondents indicated that a total number of between 7 and 17 people were living in one household. The average age of the respondents was 51.9 years (SD = 17.9), ranging from 18 to 96 years old. Household composition suggests that there were more females than males (52% and 48% respectively) and the age structure was skewed towards those between 0 and 15 years (36%).

Table 2: Variable coding for safe water accessibility

Categorical variables	Coding
Distance of cattle posts from village	1=Within village 2=Just outside the village 3=Several hours' travel 4=A day's travel
Number of people in household	1=1-5; 2=6-10; 3=11 and above
Molapo farming has potential to cause water borne disease	1=Yes; 2=No
Drinking water directly from stream /river can cause diarrheal diseases	1=Yes; 2=No
Have own tap connection in house	1=Yes; 2=No
Have own tap connection in yard	1=Yes; 2=No
Have communal standpipe	1=Yes; 2=No
Molapo farming can be potential health hazard	1=Yes; 2=No

Source of data: *Botswana Ecohealth Project Questionnaire for Tubu, Xobe and Shorobe, 2010*

Perceptions of accessibility, availability and safe water

Qualitative data synthesis from the PRA workshops (Table 3) suggests that the farming communities had concerns about the accessibility, availability and safety of water they used. For instance, comments 1 and 5 show that water fit for domestic use was inaccessible, meaning that it was insufficient whereas comments 1, 2, 5, 6, and 7 have insinuations that water might be contaminated and as a result may contribute to some adverse health issues prevalent in the villages such as malnutrition (Ramolefhe *et al.* 2011). From these comments, it can be gleaned that the community feels water treatment may be a solution to the purging of pathogens or disease causing agents in the water. There is an outstanding element of dissatisfaction with quality of water regardless of water source being improved or unimproved. For example, comments 2 and 3 implies usage of untreated river water which has a bad taste (comment 3) and contributes to malnutrition (comment 2) because of contamination. Comment 6 and 7 implies that water from improved sources should be treated suggesting a perception that water is directly pumped to their taps from the boreholes without purification whereas comment 5 shows a general concern over water of quality in Shorobe and surrounding villages. Finally it can be interpreted from the community comments that this is a group of people accustomed to drinking untreated water and even that some prefer it over water from improved sources (Comment 4). Field observations by the authors during their one week stay in each community whilst conducting PRA workshops record that the water situation in 2010 was characterized by minimal flooding and interrupted water supply. In 2012 field observations were that there was water scarcity and that the communities had resorted to other means of procuring water such as using unimproved sources for example river water.

Table 3: General group comments on water accessibility, availability and safety by farming communities

1. “Mangwe a mathata a re a bonang mo motseng wa rona ke lethoko la metsi a a phepha” (Translated “one of the problems we are facing is lack of clean water”) (Chimbari and Magole, 2012a).
2. “Mopalo o bakwa ke tiriso ya metsi a molapo a leswe, mme go a bidisa go a a sulafatsa” (Translated “child malnutrition is caused by dirty river water, however boiling it makes it taste worse”) (Chimbari and Magole, 2012a).
3. Metsi a molapo a a bedisitsweng a busula mo le bana ba ganang go a nwa. (Translated “Boiling river water makes it taste bad more so that even children refuse to drink it”) (Chimbari and Magole, 2012a).
4. “Metsi a noka a monate mo le ba ba berekang ko sekgweng batla ba a ipaketse ga ba tla mo motseng”. (Translated “River water is tasty even residents working in Safari companies in the Delta often bring back some river water for drink”) (Chimbari and Magole, 2012b).
5. “Re na le lethoko la metsi a a siametseng go nowa mo Shorobe le metsana ya teng” (Translated “There is scarcity of water fit for drinking in Shorobe and its remote areas”) (Chimbari and Magole, 2012b).
6. “Metsi a a tlhatswiwe pele a neelwa batho”. (Translated “borehole water should be treated prior to being distributed to taps”) (Chimbari and Magole, 2012b).
7. “Metsi a a tlhatlhabiwe gore a tle a siamele go nowa”. (Translated “water should be tested to ensure meeting of drinking water quality standards”) (Chimbari and Magole, 2012b).

Source: Botswana Ecohealth Project PRA Reports for Tubu, Xobe and Shorobe, 2012

Table 4: Primary source of drinking water

Source	Number of households	Percent (%)
Own tap connection in yard	36	22.4
Communal standpipe/ neighbour	74	45.9
Own tap connection in house	8	5.0
River/stream/well/harvested roof water	43	26.7
Total	161	100

Source of data: Botswana Ecohealth Project questionnaire for Tubu, Xobe and Shorobe, 2010

Perceptions of water accessibility

The analysis (Table 4) shows that the primary water sources of drinking water were from communal standpipes or using neighbour tap (45.9%), river/stream/well/harvested roof water (26.7%) and own tap connection in the yard (22.4%).

When the sources of domestic water (Table 5) by the communities are further tabulated the results of the analysis show that majority of households from Tubu (70%) and those from Shorobe (50%) received their water from communal standpipe while majority of households from Xobe (95%) got their domestic water from river/stream/well. Other sources included own tap connection in yard recorded as 25% in Tubu and 36% in Shorobe. There is a significantly strong relationship between source of domestic water and communities (The contingency coefficient, $r = 0.707$, $p < 0.05$).

With regards to distance travelled to reach water sources for domestic purposes (Table 6), majority of the households (55.9%) travelled less than half a kilometre to fetch water. One out of every three households covered more than a kilometre to fetch water for domestic use.

Table 5: Cross-tabulation of primary source of domestic water according to location

Primary source of domestic water		Name of village			Total
		Tubu	Xobe	Shorobe	
Have own tap connection in yard	Number	15.0	0.0	21.0	36.0
	%	25.0	0.0	36.0	22.4
Have communal standpipe	Number	42.0	0.0	29.0	71.0
	%	70.0	0.0	50.0	44.1
Have own tap connection in house	Number	1.0	0.0	6.0	7.0
	%	1.7	0.0	10	4.3
River/stream/well/harvested roof water	Number	2.0	42.0	0.0	44.0
	%	3.3	97.7	0.0	27.4
Rain tank	Number	0.0	1.0	0.0	1.0
	%	0.0	2.3	0.0	0.6
Other/neighbour	Number	0.0	0.0	2.0	2.0
	%	0.0	0.0	3.4	1.2
Total	Number	60.0	43.0	58.0	161.0

Source of data: *Botswana Ecohealth Project SES questionnaire, 2010*

Perceptions on water adequacy

Over half of the households reported that water was adequate to meet their household needs (Table 7). Only 23% showed dissatisfaction with water adequacy.

Perceptions of water safety

Water safety or cleanliness

Table 8 shows the participants' perceptions about safety of water to drink. About 43.5% of the households believed they always had water that was clean and safe to drink and 34.2% indicated usually, whereas for 22.4% of the households, the water was either seldom safe to drink.

Table 6: Distance travelled to reach the source of domestic water

Distance covered to fetch water	Number of households	Percent (%)
Less than 500 m	90	55.9
500 m-1 km	19	11.8
More than 1 km	52	32.3
Total	161	100

Source of data: *Botswana Ecohealth Project Questionnaire for Tubu, Xobe and Shorobe, 2010*

Table 7: Adequacy of water to meet household needs according to participants' perceptions

Water adequacy	Number of households	Percent (%)
Always or almost always	33	20.5
Usually	91	56.5
seldom	37	23.0
Total	161	100

Source of data: Botswana Ecohealth Project Questionnaire for Tubu, Xobe and Shorobe, 2010

Perceptions on prevalence of water-borne diseases

Figure 2 shows perception of common water related diseases in the communities of Xobe, Tubu and Shorobe. It is evident that most residents of Xobe struggled more with diarrhoeal diseases whereas Tubu and Shorobe residents were complaining of both skin and vector-borne than diarrhoeal ones.

Factors influencing safe water accessibility

The results of the analysis (Table 9) show that number of people in a household is a significant predictor of access to safe water ($p < 0.05$). Households that have 1-5 individuals are less likely to have access to safe water than households with 11 or more persons (OR = 0.075). Similar results apply to households with 6-10 individuals (OR = 0.022).

People who hold the view that ‘*molapo* farming has potential to cause water borne disease’ and that ‘*molapo* farming can be a potential health hazard’ are, respectively, 1.25 and 1.71 times more likely to access safe water than those holding contrary views.

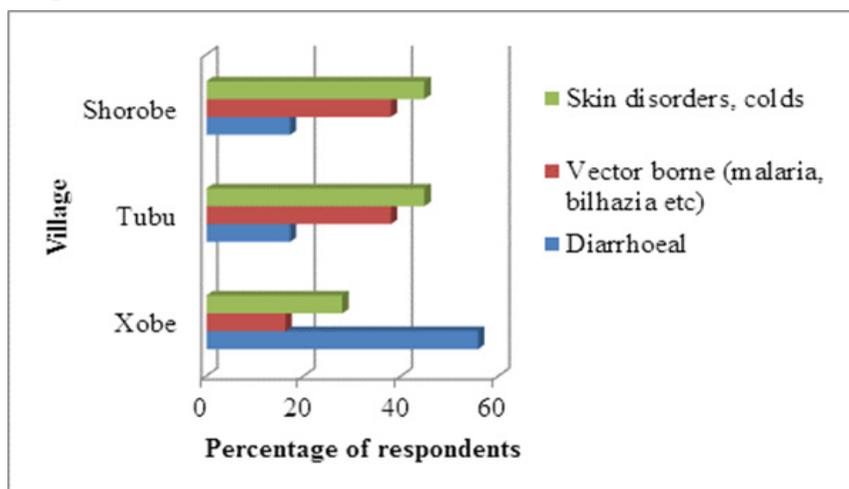
Results further reveal that those who think that drinking water directly from stream /river can cause diarrheal diseases are less likely to access safe water (OR= 0.542). Although distance of cattle post from the village is not a significant predictor of access to safe water ($p > 0.05$), households whose cattle post are within the village, just outside the village or several hours travel from the village are, respectively, 1.031, 1.701 and 1.225 more likely to access safe water than those who have to travel a day to their cattle posts. Households that have own tap connection in yard or have communal standpipe are less likely to access safe water than where these do not exist.

Table 8: Perceptions on water quality (cleanliness) from sources

Is water safe to drink?	Number of households	Percent (%)
Always or almost always	70	43.5
Usually	55	34.2
Seldom	19	11.8
Almost never	17	10.6
Total	161	100

Source of data: Botswana Ecohealth Project Questionnaire for Tubu, Xobe and Shorobe, 2010

Figure 2: Perceptions of respondents on water-related diseases in Shorobe (n=58), Tubu (n=60) and Xobe (n=43).



Discussion

The overall objective of the study was to assess the community perceptions of safe water and accessibility. The specific objectives are to understand i) community opinions on water accessibility, availability and safety ii) assess community perceptions of water adequacy to meet household needs and iii) to predict factors affecting access to safe “clean” water. Major findings of the study are as follows:

General perceptions on water accessibility, adequacy and safe water

Opinions of the farming communities differed on the accessibility, availability and safety of water used for domestic use according to current water situation and time of data collection. For instance the Socio Economic Survey (SES) results show that water for domestic use was accessible, adequate and safe. In contrast, PRA results of the year 2012 show a general concern over these aspects. It should be noted that despite the seemingly differing opinions by the same community, there is no contradiction when taking the timing factor into consideration. The year 2010 was marked with flooding which readily availed water that was used for domestic purposes in addition to that from improved sources such as taps, hence perceptions that water was accessible and available for domestic use. With regards to safety, the communities perceive their water to be safe despite their awareness of the different water-borne diseases plaguing their community. This is in line with the findings of Wright and colleagues (2012) who state that it is not uncommon for the public to still perceive their water positively despite periods marked with increases in waterborne diseases. The situation of water in the year 2012 was characterized by minimal flooding and interrupted water supply. Therefore, communities resorted to using unimproved sources (e.g. River water) hence the discontent shown in their comments on water accessibility, availability and safety.

Another aspect gained from the study is that majority of people in the study areas thought that the water was safe/ “clean” regardless of whether it was from an improved (piped) or an unimproved (river/streams/wells/harvested rain water) source. This is because they equate the safety of water with not getting sick or having few episodes of sicknesses not that a tap may be more hygienic. It is also likely that since study participants have used the same water sources for years, their immune systems may have adapted to the water and hence rarely getting sick from it and therefore perceive it as safe (Chimbari & Magole 2010a). For example, participants of Xobe settlement use river water and they consider their river water to be safe, it is their sole source of domestic water unless they go to Maun, about 20 km away.

Perceptions on accessibility and water availability

The majority of participants perceived the water they used for domestic purposes to be adequate. Furthermore, many indicated that they travelled shorter distances to water sources. Thus since water sources are nearer to their homesteads, this allowed them to fetch water as needed. The participants’ perceptions seem to be aligned with the UNDP definitions of having accessible water (WHO/UNICEF/ JMP 2008).

Community perceptions on water safety

Despite communities attesting to water being adequate, there is however concerns over the quality of the available water. This agrees with the literature that although Botswana has vast networks of water supply, but most of these have quality that is not up to par with world standards. Community perceptions reflect the level of development in their areas, the type of water sources and prevailing diseases. For instance, in a settlement area such as Xobe with no developments, river water was predominantly

used and common water related diseases were mostly diarrhoeal and water borne. Diarrhoeal diseases are associated with poor water supply and sanitation and lack of hygiene (Hutton & Haller 2004). Sanitation plays a role in the contamination of water and increases the risk of water related diseases. This is supported by the a study that showed contamination with microbiological organisms in an urban setting with limited sanitary facilities where drinking water was supplied through communal standpipe system (Jagals *et al.* 1997). Furthermore most of the communities have no safe means of disposing excreta and are using the bush or a pit latrine toilet which has been associated with higher contamination with the microorganisms responsible for diarrhoeal diseases (Buszin *et al.* 2008). For instance, Ngamiland district has the largest population (76%) in the west without proper sanitary services (Masamba 2009). It can be expected that open surface water bodies, such as rivers may be contaminated from faecal runoff of both humans and animal excreta (Nogueira *et al.* 2003; Kgomotso & Swatuk 2005). This will be pronounced during flooding or rainy seasons. Water insecurity could also be making the practice of washing hands after toilet use to be a challenge thus allowing transference of diarrhoeal causing germs. Lack of proper excreta disposal in the rural areas (where most of the people use the bush) also increases the risk of disease transmission to humans using the water from open surfaces. Nonetheless, despite the communities using river water and being aware of some level of contamination in river waters and possible negative consequences to health, some still preferred it over tap water. It seems that taste is then prioritized above all else. The reason for this could be adaptation to river water since it had been predominant source of water. Of concern is that some of the participants felt that boiling the water worsened the taste, suggesting that they may not practice this basic household water purification process. Water treatment is important in curbing pathogens that can cause water related health problems.

Table 9: Logistic regression model with dependent variable ‘access to safe water’

Reference category		B	S.E.	Wald	df	Sig.	Exp(B) (OR)
11 and above	Number of people in a household			7.089	2	0.029	
	1-5	-2.588	1.33	3.784	1	0.052	0.075
	6-10	-3.802	1.443	6.936	1	0.008	0.022
No	Molapo farming has potential to cause water borne disease	0.223	0.932	0.057	1	0.811	1.25
No	Drinking water directly from stream /river can cause diarrheal diseases	-0.612	1.165	0.276	1	0.599	0.542
No	Molapo farming can be potential health hazard	0.537	0.925	0.337	1	0.562	1.711
A day's travel	Distance of cattle post from village			0.213	3	0.975	
	Within village	0.03	2.017	0	1	0.988	1.031
	Just outside the village	0.531	2.072	0.066	1	0.798	1.701
	Several hours travel	0.203	2.095	0.009	1	0.923	1.225
No	Have own tap connection in yard	-4.579	1.431	10.237	1	0.001	0.01
No	Have communal standpipe	-5.858	1.629	12.938	1	0	0.003
	Constant	3.889	2.166	3.224	1	0.073	48.877

Source of data: *Botswana Ecohealth Project questionnaire for Tubu, Xobe and Shorobe, 2010*

Due to scarcity of water, certain practices such as washing hands maybe overlooked or less practiced and thus lead to pathogen transference from hands to taps and even to water. It has been hypothesized that as more people use the same tap they were more likely to transfer different pathogens onto it, thereby facilitating the sharing of pathogens responsible for diarrheal diseases (Genthe *et al.* 1997). This means that even if the water was clean at distribution point, post contamination is possible during collection and point of use. This deterioration may influence the occurrence of water related diseases. Further deterioration of the quality of water can occur during the process of storage (Jagals *et al.* 1997; Machdar *et al.* 2013). Most residents in the rural areas store water in plastic bottles that are not

frequently cleaned and which by time accumulate biofilms and support microbial growth adding to the deterioration of water (Machdar *et al.* 2013). It has also been shown that even if water could have been cleaned and disinfected, storage for long periods may facilitate stagnation, dissipation of disinfectant residuals and deterioration of water quality (Nogueira *et al.* 2003).

In Tubu and Shorobe villages where more household used improved water sources such as private taps and standpipes, the quality of water was perceived as better compared to Xobe residents. In Tubu both river and improved water sources were reported to be used, water was perceived to be unclean by the majority of them and there was almost an equal distribution of diarrhoeal, vector borne and other diseases. River and tap water are used interchangeably especially during times of water shortage and /or when taps are non-functional. Furthermore, since Tubu is predominantly a *molapo* farming community and many farmers spend most of their time in the fields and/ or at the cattle posts where there is no piped water, they use river water for drinking as well as cooking. Authors observed that farmers camped with their families by the *molapo* fields from morning till late afternoon when working in their fields. They cooked with and drank river water. Even with their limited education the farmers perceived that that water would be dirty because they shared it with their livestock and used the same open source for many activities (washing of clothes, fishing in the midst of the river and often serve as river a crossing point which is usually done using animals such as donkeys).

Shorobe, as a peri-urban village, predominantly using water from improved water sources has experienced a shift in the type of diseases prevalent. Thus other diseases (skin problems) were more prevalent compared to diarrhoeal and vector-borne ones. Many people in Shorobe rated the water as clean although it was thought to taste bad. This change in disease pattern could indicate greater dependence on treated tap water and less on raw water. Moreover, since they are closer to the urban village of Maun, they have an option of transporting treated tap water from there to store and use in cases of water shortages. The shift in the type of diseases experienced in Shorobe could also point to the level of education about a variety of health issues since there is a clinic and health staff. The health staff could be educating the community on a range of health issues from disadvantages of using raw water, to water treatment methods and self-protection from acquiring vector-borne diseases.

From a health perspective, regardless of the water source in each study area and the level of perceived water related diseases, all three communities need to be given robust education on water treatment methods, water handling and storage from point of source to that of use. Furthermore, the issue of hygiene and sanitation cannot be ignored. All these are critical aspects in improved water quality and consequently individual health.

Factors influencing safe water accessibility

Household size is a determining factor to safe water accessibility. Smaller households with less than 10 members are less likely to access safe water as compared to those with 11 and more people. This phenomenon can be explained in relation to labour division. In large households for instance the division of labour among members of the family for doing different chores is likely to influence water collection from safer sources. Existing studies tend to focus on linking household size and water consumption (Arouna & Dabbert 2009; Asiedu 2012; Mazvimavi & Mmopelwa 2006) and less on household size and safe water accessibility.

Participants who perceived *molapo* farming to be a potential cause for waterborne diseases and a potential health hazard were more likely to access safe water as compared to those holding an opposite view. This is simply explained: if one understands a certain process to be hazardous to health and/ or disease causing, one is likely to either avoid such a process or look for an alternative to the problem.

For example, participants practicing molapo farming who hold the view that the way they live may be hazardous to their health tend to build their houses in high ground, away from fields and other areas likely to be flooded (Chimbari & Magole 2010b). Likewise, participants who think that *molapo* farming is jeopardous to health through the exposure to waterborne disease, they too are likely to take appropriate measures towards their prevention. These measures may include having multiple residences, allowing them to temporarily relocate to until problem subsides, or they may wear protective clothing when working in wet fields whilst farming their *molapo* (Magole and Ngwenya 2014). This type of farming involves farming in a flood receded area and the proximity of water is very close allowing a chance to contract waterborne diseases. Also participants holding view that the *molapo* farming process may be health hazardous may have an increased interest in treating the water they drink. The interest may be perpetuated by observation that water used for domestic purposes especially drawn from open sources is shared by both humans with animals. One study in *molapo* farming village of Shorobe showed that they used water saving strategies by saving preserved water from improved sources, especially tap water, for drinking. Whereas water from non-improved sources they used sparingly for other domestic purposes such as bathing and laundry (Ngwenya & Kgathi 2006). Research has shown that study participants appeared to have good knowledge of health issues, especially with regards to waterborne diseases (Chirebvu *et al.*, 2013), and hence it is likely that they would have greater likelihood of seeking access to safe water.

The likelihood of accessing safe water for participants holding a view that drinking water directly from river/stream/well/harvested rainwater causes diarrheal diseases were less than those holding contrary view. There was a perception that water used by participants from all sources whether improved or unimproved was safe. However it contradicts expectation from elsewhere that water from unprotected sources is likely to cause diarrheal diseases (Mazvimavi & Mmopelwa 2006). As has been found in other studies, it is not uncommon for the public to have positive perceptions of public water, even during periods marked by increases in waterborne diseases which would suggest that the water is potentially unsafe (Wright *et al.* 2012).

Less distance to the water source increased the likelihood of accessing safe water as compared to traveling longer distances. When improved water sources are near to the homesteads, water may be sought as needed. For instance when the cattle post is near the village, it means that distance to improved sources is minimized which allows liberal fetching of water. The advantage of traveling less distance to water source is that from water source to point of use, contamination is reduced raising the likelihood of accessing safe water. The closer the water source the easier it is to obtain enough water for use, this raises per capita volume of water used to satisfy basic personal and household hygiene (Mazvimavi & Mmopelwa, 2006) but also diminishes the chances of contamination from prolonged storing.

Contrarily, the conveniences of having own tap connection and/or using communal standpipe did not help with safe water accessibility. This point is unexpected. However there is a possible explanation. For instance since improved water sources such as taps communal standpipes and taps are maintained by government Water Utilities, there could be problems with maintaining water pipes (Water Quality and Health Council 2016). Thus even if the water is from a 'safe' supply, if the pipes are old, broken, leaking and rusty the chances of that water being contaminated are high thus undermining the efforts of people trying to access 'safe' water. Due to scarcity of water, practices such as washing hands maybe overlooked and thus lead to cross contamination of people as they transfer pathogens from hands to taps and even to water (Genthe *et al.* 1997). It has been hypothesized that as more people use the same tap they are also more likely to transfer pathogens onto it, which facilitates sharing of

various pathogens (Genthe et al. 1997). This means that even if the water is clean at distribution point, post- distribution contamination is possible during collection and point of use. This deterioration may influence the occurrence of water-related diseases (Jagals *et al.* 1997; Machdar *et al.* 2013). It has also been shown that even if water was cleaned and disinfected, storage for long periods may facilitate stagnation, dissipation of disinfectant residues and deterioration of water quality (Nogueira *et al.* 2003).

Conclusions

Rural farmers largely perceive the water they use for domestic purposes to be safe, adequate and accessible regardless of whether source is improved or unimproved. Safe water accessibility is influenced by multiple factors which include perceiving *molapo* farming to be a potential cause of waterborne diseases, a potential health hazard and having a cattle post closer to the village. Unexpectedly, the farmers do not seem to link drinking water directly from unimproved sources as a potential cause of diarrheal diseases. Additionally, they do not think improved sources such as taps and communal standpipes help with accessibility to safe water.

Public education is encouraged to promote community awareness of potential contamination of all water sources, whether improved and/or non-improved. Education on water handling should also be included. Furthermore, health professionals also need to be encouraged to educate the community on water contamination at all sources including taps. Education dispelling incorrect perceptions held by the community is critical in curbing waterborne diseases, diarrheal diseases and ensuring safe water accessibility necessary for individual health.

Acknowledgement

We acknowledge Botswana Ecohealth Project which allowed us to use its socio-economic data to write this paper.

References

- Allan, JA 2002. *The Middle East water question: Hydropolitics and the global economy*, I.B. Tauris Publishers, London and New York
- Arouna, A and Dabbert, S 2010. 'Determinants of domestic water use by rural households without access to private improved water sources in Benin: A seemingly unrelated Tobit approach', *Water Resources Management*, vol.24, 7, pp. 1381-1398.
- Asiedu, AB 2012. 'Household access to water and sanitation facilities: A case study of the Offinso South Municipality', MSc. Thesis, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
- Bartram, J and Cairncross, S 2010. 'Hygiene, sanitation, and water: Forgotten foundations of health', *PLoS Med*, vol.7, 11, pp.e1000367. doi:10.1371/journal.pmed.1000367
- Bigas, H (Ed.) 2012. *The global water crisis: Addressing an urgent security issue*, The InterAction Council, 2011-2012, Hamilton, Canada: UNU-INWEH
- Buszin J, Reed H, Smith DC, Rahman Z, Andrzejewski C, Awusabo-Asare K White M 2008. 'Community and household determinants of water quality in coastal Ghana', *Journal of Water and Health*, vol.6, 3, pp. 339-349.
- Central Statistics Office 2011. '2011 Population and housing census', Available at http://www.cso.gov.bw/index.php=com_content1&id=2&site=census Accessed on 02/03/2016
- Central Statistics Office and UNICEF 2009. '2007 Botswana family health survey IV report', Central Statistics Office, Gaborone.

- Chimbari, MJ and Magole, L 2010a. 'Participatory rural appraisal workshop for Xobe village', Okavango Research Institute Library, Maun.
- Chimbari, MJ and Magole, L 2010b. 'Participatory rural appraisal workshop for Tubu village', Okavango Research Institute Library, Maun.
- Chimbari, MJ and Magole, L 2012a. 'Participatory rural appraisal workshop for Xobe village', Okavango Research Institute Library, Maun
- Chimbari, MJ and Magole, L 2012b. 'Participatory rural appraisal workshop for Shorobe village', Okavango Research Institute Library, Maun
- Chirebvu, E, Chimbari, MJ, and Ngwenya, BN 2013. 'Knowledge and practices on malaria in tubu village, in a malaria-endemic area in northern Botswana: Implications for interventions', *Malaria World Journal*, vol.4, 15, pp. 1-9.
- de França, DM 2010. 'Factors influencing public perception of drinking water quality', *Water Policy*, vol.12, 1, pp. 1-19.
- de França, DM, Pidgeon, N, and Hunter, PR 2009. 'Perceptions of drinking water quality and risk and its effect on behaviour: A cross-national study', *Science of the Total Environment*, vol.407,21, pp. 5455-5464.
- European Union 2016. 'Water scarcity and droughts in the European Union', Available at: http://ec.europa.eu/environment/water/quantity/scarcity_en.htm Accessed on 04/10/2016
- Food and Agriculture Organization 2012. 'Coping with water scarcity: An action framework for agriculture and food security', *FAO Water Reports No. 38*, FAO, Rome.
- Garstang, M, Ellery, WN, McCarthy, TS, Scholes, MC, Scholes, RJ, Swap, RJ, Tyson, PD 1998. 'The contribution of aerosol- and water-borne nutrients to the functioning of the Okavango Delta', *South African Journal of Science*, vol.94, 5, pp. 223-229
- Genthe, B, Strauss, N, Seager, J, Vundule, C, Maforah, F, and Kfir, R 1997. 'The effect of type of water supply on water quality in a developing community in South Africa', *Water Science and Technology*, vol.35, 11-12, pp. 35-40.
- Hunter, PR, Zmirou-Navier, D, Hartemann, P 2009. 'Estimating the impact on health of poor reliability of drinking water interventions in developing countries', *Science of the Total Environment*, vol.407, pp. 2621-2624.
- Horwitz, P, Finlayson, M and Weinstein, P 2012. 'Healthy wetlands, healthy people: A review of wetlands and human health interactions', *Secretariat of the Ramsar Convention on Wetlands, Gland, Switzerland and The World Health Organization, Geneva, Switzerland*.
- Hutton, G and Haller, L 2004. 'Evaluation of the costs and benefits of water and sanitation improvements at the global level', *WHO, Geneva*.
- Jagals, P, Grabow, W, and Williams, E 1997. 'The effects of supplied water quality on human health in an urban development with limited basic subsistence facilities', *Water SA*, vol.23, pp. 373-378.
- Kgomotso, PK, and Swatuk, LA 2006. 'The challenges of supplying water to small, scattered communities in the lower Okavango Basin, Ngamiland, Botswana: An evaluation of government policy and performance', in *Proceedings of the 7th WaterNET/Warfsa/GWP/SADC Symposium, Lilongwe, Malawi, 1-3 November 2006*.
- Magole, L and Ngwenya, BN 2014. 'Shakawe/Ngarage participatory rural appraisal workshop report', *Okavango Research Institute, University of Botswana, Shakawe Village Main Kgotla, Ngamiland District*.
- Mbaiwa, JE 2005. 'Enclave tourism and its socio-economic impacts in the Okavango Delta,

- Botswana', *Tourism Management*, vol.26, 2, pp. 157-172
- Murray-Hudson, M, Wolski, P and Ringrose, S 2006. 'Scenarios of the impact of local and upstream changes of climate and water use on hydro-ecology in the Okavango Delta', *Journal of Hydrology*, vol.331, pp. 73-84.
- Kgathi, DL, Mmopelwa, G, Vanderpost, C, Wolski, P and Motsholapheko, MR 2013. 'Impacts of desiccation on ecosystem services and household adaptation in the Okavango Delta, Botswana', *Biodiversity and Ecology*, vol.5, pp.263-277.
- Kujinga, K, Mmopelwa, G, Vanderpost, C, and Masamba, RL 2014a. 'Short and long term strategies for Household Water Insecurity in Ngamiland, Botswana', *Journal of Sustainable Development*, vol.7, 3, pp. 96-117.
- Kujinga, K, Vanderpost, C, Mmopelwa, G, and Masamba, RL 2014b. 'Analysis of gender and other social dimensions of household water insecurity in Ngamiland, Botswana', *Journal of Management and Sustainability*, vol.4, 4, pp. 86-103.
- Kujinga, K, Vanderpost, C, Mmopelwa, G and Wolski, P 2014c. 'An analysis of factors contributing to household water security problems and threats in different settlement categories of Ngamiland, Botswana', *Physics and Chemistry of the Earth A/B/C*, vol.67, pp. 187-201.
- Machdar, E, Van Der Steen, N, Raschid-Sally, L, and Lens, P 2013. 'Application of quantitative microbial risk assessment to analyze the public health risk from poor drinking water quality in a low income area in accra, Ghana', *Science of the Total Environment*, vol.449, pp. 134-142.
- Masamba, WRL 2009. 'Transboundary diagnostic analysis of the Botswana portion of the Okavango River basin: Output 4: Water supply and sanitation', Available at <http://iwlearn.net/resources/documents/3305>
- Masamba, WRL, and Mazvimavi, D 2008. 'Impact on water quality of land uses along thamalakané-boteti river: An outlet of the Okavango Delta', *Physics and Chemistry of the Earth, Parts A/B/C*, vol.33, 8, pp. 687-694.
- Mazvimavi, D, and Mmopelwa, G 2006. 'Access to water in gazetted and ungazetted rural settlements in Ngamiland, Botswana', *Physics and Chemistry of the Earth, Parts A/B/C*, vol.31, 15, pp. 713-722.
- Mmualefe, LC, and Torto, N 2011. 'Water quality in the Okavango Delta', *Water SA*, vol.37, 3, pp. 411-418.
- Ngwenya, BN, and Kgathi, DL 2006. 'HIV/AIDS and access to water: A case study of home-based care in ngamiland, Botswana', *Physics and Chemistry of the Earth, Parts A/B/C*, vol.31, 15, pp.669-680.
- Nogueira, G, Nakamura, CV, Tognim, MC, Filho, BA, and Filho, BP 2003. 'Microbiological quality of drinking water of urban and rural communities, Brazil', *Revista de Saúde Pública*, vol.37, 2, pp. 232-236.
- Peloso, M and Morinville, C 2014. "Chasing for water": Everyday practices of water access in peri urban Ashaiman, Ghana', *Water Alternatives* vol.7, 1, pp. 121-139
- Ramolefhe, G, Nnyepi, M, Chimbari, MJ, and Njoku, OA 2011. 'Feeding practices, environment and growth status of children (2-5 years) in Tubu, Shorobe and Xobe molapo farming villages in Botswana', *Thari ya Bana*.
- Rosemarin, A, Ekane, N, Caldwell, I, Kvarnstrom, E, Mcconville, J, Ruben, C, and Fogde, MI 2008. *Pathways for sustainable sanitation: achieving the millenium dvelopment goals*, IWA Publishing, Stockholm.
- Schwarzenbach, RP, Egli, T, Hofstetter, TB, Gunten von, U and Wehrli B 2010. 'Global water pollution and human health', *Annual Review of Environment and Resources*,

vol.35, pp. 109–136

- Talenyana, N, and Maunge, F 1994. 'Management of water supplies: Urban and rural aspects', in *Proceedings of Integrated Water Resources Management Workshop, Gaborone*.
- United Nations 2015. 'The millennium development goals report 2015', UN, New York
- United Nations 2014. 'International decade for action 'Water for Life' 2005-2015', Available at: http://www.un.org/waterforlifedecade/human_right_to_water.shtml. Accessed on 02/04/2016
- The United Nations International Children's Fund 2014. 'The right to safe water and to sanitation', *Current Issues, No.3, UNICEF*.
- Vanderpost, C 2009. 'Transboundary diagnostic analysis of the Botswana portion of the Okavango River Basin. Output 5: Assess existing social services and projected growth through national and regional development plans', OKACOM.
- WaterAid 2005. 'Ghana national water sector assessment', Prince Consort House, Albert Embankment, London.
- Water Quality Health Council 2016. 'Safety water delivered safely', Retrieved from www.waterandhealth.org/drinkingwater/safewater.html. Accessed on 02/03/2016
- Water.org. 2016. 'Global water crisis: Water and sanitation facts', Retrieved from <http://water.org/water-crisis/water-sanitation-facts/> Accessed on 02/03/2016
- WHO 2016. 'WASH Post-2015: Proposed indicators for drinking water, sanitation and hygiene', WHO/ UNICEF Joint Monitoring Programme for Water Supply and Sanitation, Geneva, Switzerland.
- WHO/UNICEF Joint Monitoring Programme 2006. 'Meeting the MDG drinking water and sanitation target: The urban and rural challenge of the decade', WHO, Geneva, Switzerland.
- WHO/UNICEF Joint Monitoring Programme 2008. 'Progress on drinking water and sanitation: Special focus on sanitation', World Health Organization.
- WHO/UNICEF Joint Monitoring Programme JMP 2013. 'Progress on sanitation and drinking water 2013 update', World Health Organization.
- Wright, JA, Yang, H, Rivett, U, and Gundry, SW 2012. 'Public perception of drinking water safety in South Africa Africa 2002–2009: A repeated cross-sectional study', *BMC Public Health*, vol.12,1, pp. 556-565.