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Short and Long Term Strategies for Household Water Insecurity in Ngamiland, Botswana

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Abstract

The paper analyses coping (short-term) and adaptation (long-term) strategies by households to address water insecurity in Ngamiland, Botswana, a middle income and semi-arid country. Quantitative (i.e. structured household questionnaires) and qualitative (i.e. key informant and informal interviews, focus group discussions and participant observation) approaches were used. The concept of water security and the actor-oriented approach inform the paper. Households in Ngamiland are experiencing water insecurity and they mainly employ coping (i.e. accessing untreated water, traditional rainwater harvesting, bulk water hauling and buying, use prioritization, and buying bottled water) as opposed to adaptation (i.e. abstracting groundwater, connecting storage tanks to main water systems and modern rainwater harvesting) strategies to deal with water insecurity. More scientific research for informing water policies and implementation of sustainable water supply strategies is required in order to enhance water security in countries like Botswana.

Keywords: actors, adaptation, Botswana, coping, households, insecurity, security, strategies, water

1. Introduction

The world's freshwater resources are currently under considerable stress as demand is outstripping supply in many regions including sub-Saharan Africa (Chamberlain, 2008; Hanjraa & Qureshi, 2010; Rogers, 2008; Rosegrant, Cai, & Cline, 2002). In 1995, the world withdrew 3 906 km^3 of water and this is projected to increase by at least 50% by 2025 as more water will be required for agricultural, domestic and industrial purposes (Gleick & Palaniappan, 2010). Global freshwater withdrawals have tripled over the last 50 years and the demand for freshwater is increasing by 64 km^3 a year (Gleick & Palaniappan, 2010). Globally, the growing regional, national, and seasonal water scarcities pose severe challenges for national governments in the provision of water for domestic, productive and environmental purposes (Ringler, Bryan, Biswas, & Cline, 2010).

Developing countries are being affected most by freshwater scarcity because of climate change and variability, rapid population growth, urbanization and ineffective water governance systems (Banerjee et al., 2008). An estimated 1.1 billion people still lack access to safe water sources, despite considerable investments in water and sanitation in developing countries since the 1980s (Onda, LoBuglio, & Bartram, 2012; WWC, 2000). Nearly 80% of the people using water from unimproved sources are concentrated in sub-Saharan Africa and eastern and southern Asia (Hutton, Haller, & Bartram, 2007). Currently in sub-Saharan Africa, 56% of the population has access to safe water and 39% of the urban population is connected to piped water compared to 50% in the early 1990s (Manzungu, Mangwanya, & Dzingirai, 2012). Across Africa, water insecurity (inadequate access to water, access to poor quality water and insufficient water supply and distribution facilities) (Webb & Iskandarani, 1998) has led to outbreaks of waterborne diseases such as cholera in Zimbabwe which killed over 4 000 people in 2008-2009 (Manzungu & Chioreso, 2012; Mason, 2009), and rota virus in Botswana's Ngamiland District which killed 18 children under the age of 24 months in 2012 (Morokotso, 2012).

Households affected by water shortages and lack of supply usually devise coping or adaptation strategies to counter the situation. Poorer households usually use untreated water during periods of shortages or where water supply services do not exist (Kgomotso & Swatuk, 2006; Manzungu & Chioreso, 2012; Swatuk & Kgomotso, 2007). Wealthier households are better off in adapting to water supply problems by investing in private boreholes, storage tanks, and purchasing bulk water (Manzungu & Chioreso, 2012; Manzungu et al., 2012).

Coping denotes short-term actions responses by households to extreme events, such as storms, drought or water shortages, to ensure immediate survival but which often results in a long-term decrease in wellbeing (Few, 2003). Coping takes place in the absence of pro-active adaptation that reduces vulnerability of households to extreme water insecurity. There is autonomous coping which refers to responses implemented by households in the context of perceived or real water insecurity without intervention and/or co-ordination by regional, and national government and development agents (Bates, Kundzewicz, Wu, & Palutikof, 2008) and planned coping which refers to changes in policies and institutions with a focus on developing approaches which enhance household water security (Adeniji-Oloukoi, Bob, & Moodley, 2013).

Adaptation refers to the process or outcome of a process that leads to a reduction in harm or risk of harm, or realization of benefits associated with a phenomenon such as water insecurity (Bedsworth & Hanak, 2010). Adaptation is a planned and long-term process. There is reactive adaptation which refers to the immediate response to a risk often used to regain stability which is not capable of reducing the long term damage of a risk (Fussel, 2007; Smit, Burton, Klein, & Street, 1999). Proactive adaptation involves long-term decision-making which improves the ability to cope with future risk and reduces the long-term damage and vulnerability due to the risk (Adger, Arnell, & Tompkins, 2005; Smit & Wandel, 2006).

This paper offers some insights from research work and literature on how households in a semi-arid country devise short and long-term strategies in dealing with water insecurity. The analysis in the paper offers policy recommendations on the development of sustainable strategies for enhancing household water security in order to do away with unsustainable coping strategies, which the majority of households are adopting.

2. Analytical Framework

Household coping and adaptation strategies to water insecurity are analyzed using the actor-oriented approach (Long, 1988, 1990, 1992; Long & Van der Ploeg, 1994) and the concept of water security (Cook & Bakker, 2012; Grey & Sadoff, 2007; GWP, 2000; Lautze & Manthrithilake, 2012; Vörösmarty et al., 2010). Water security refers to access to enough safe water at affordable cost to lead a clean, healthy and productive life while ensuring that the natural environment is protected and enhanced (GWP, 2000). The concept of security broadly entails protection from the risk of water shortages, poor water quality and lack of water supply services. Strategy refers to a plan of action designed to achieve a specific aim (Kujinga & Manzungu, 2004).

The analysis is done using concepts of the actor-oriented approach, i.e., actor, agency, heterogeneity and lifeworlds. The term actor is a social and cultural construction and refers to individuals, households, groups and institutions performing actions individually or as a cohesive unit. Ensuring – for example in this context – that the household copes or adapts to water insecurity (Magadlela, 2000). The use of the approach facilitates the identification of different actors, their interests, objectives and organizing strategies (Magadlela, 2000). The household concept denotes an institution of two or more people (not necessarily permanent), whose primary feature is co-residence, eating and pooling resources together as well as involvement in the provision of essential resources required for a living (Rakodi, 1991; UN, 1976).

Actors live in a particular lifeworld, i.e. the actors' view of themselves and their everyday lives. This encompasses how they view the outside world and interpret new innovations using their conceptual tools acquired in their own world view (Magadlela, 2000). This also refers to how actors organize themselves in coping and adapting to a phenomenon such as water insecurity.

The concept of human agency attributes to the actor/s, the capacity to process social experience and to devise ways of coping with life, even under difficult conditions (Long, 1992). In difficult and seemingly hopeless situations they can have the agency to devise strategies or alternative ways of accessing water for domestic purposes.

Households facing insecurity can generate heterogeneous forms of coping and adaptation strategies as a result of the assets, income and networks they have (Long & Villarreal, 1994). The concept of heterogeneity helps to analyze different coping and adaptation strategies adopted in the same or different settlement categories by different households as they endeavor to reduce risk.

3. Materials and Methods

3.1 Study Area

The study was undertaken in the North-West District (commonly known as Ngamiland) in Botswana (Figure 1). The district's population at last census was recorded as 158 104 (Central Statistical Office, 2011). The district is administered by the North West District Council (NWDC) and is sub-divided into Ngami (administered from Maun Village) and Okavango (administered from Gumare) Sub-district Authorities. Maun Village, with a population of 60 263, according to the last census, is the district's main administrative center (Central Statistical Office, 2011). The region's main physical feature is the Okavango River system shared between Angola, Botswana and Namibia. On the Botswana side the river forms a large in-land delta-like feature (actually an alluvial fan) and an important Ramsar site, known as the Okavango Delta (McCarthy & Ellery, 1998; McCarthy, Ellery, Rogers, Cairncross, & Eller, 1986). The main commercial and economic activities in the district include tourism and livestock rearing (Motsholapheko, Kgathi, & Vanderpost, 2010). Households classified as poor (i.e. living below the poverty datum line) in the district constitute 37.6% of the population, while an estimated 15.3% of the adult population is unemployed (CSO, 2011).

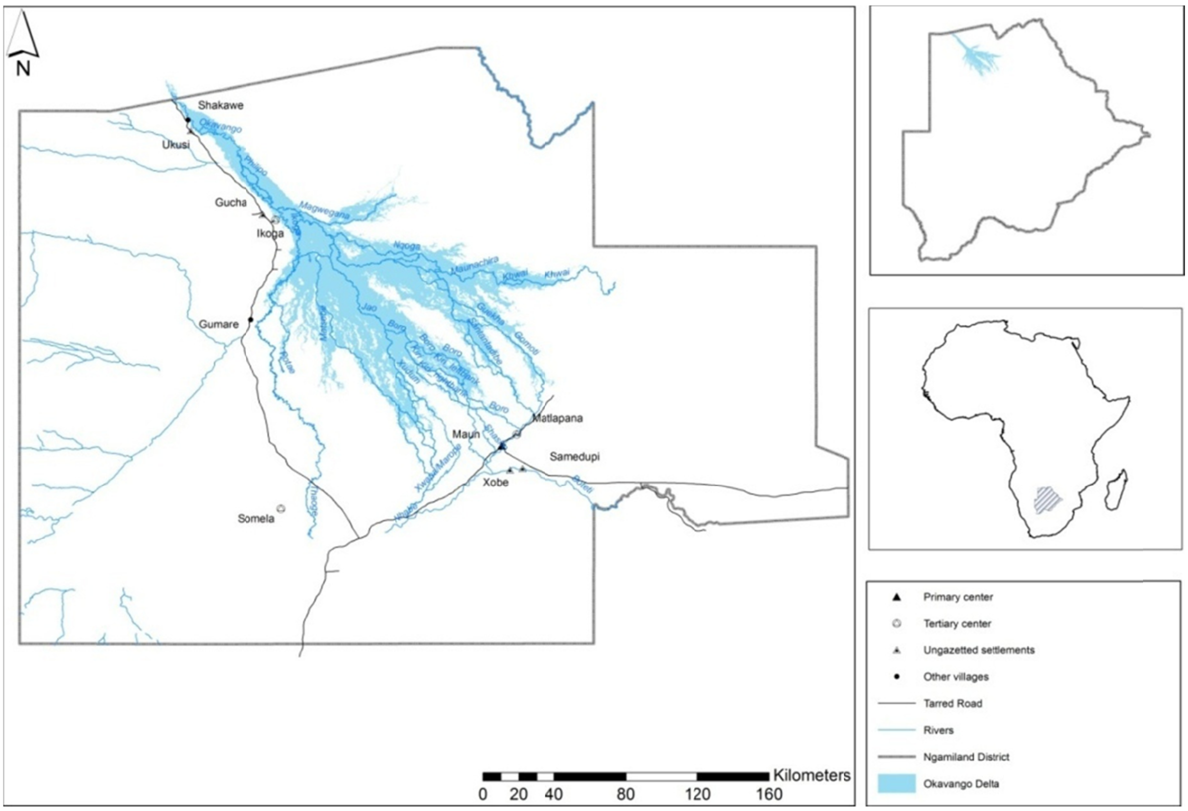

Figure 1. Study sites in Ngamiland

The study was undertaken in gazetted and ungazetted settlements. Gazetted settlements are formally recognized by the central government and receive services such as water supply, roads, schools, health and police (Government of Botswana, 2009). The establishment of gazetted settlements is based on population size, water availability, economic potential, employment generation among other factors (Government of Botswana, 1998). Gazetted settlements are ranked as either primary, secondary or tertiary centers (Government of Botswana, 1998).

Primary centers are subdivided into I, II and III mainly based on population size and services they offer (Government of Botswana, 1998). Primary centers I have a population of at least 100 000 (e.g. Gaborone) and are cities. Primary centers II have a population of between 50 000 - 99 999 and Primary centers III have a population range of 20 000 - 49 999 (e.g. Maun Village in Ngamiland District). Secondary centers are intermediate centers with a population range of 10 000 -19 999, e.g. Gumare in Ngamiland (see Figure 1).

Tertiary centers have population ranging from 250 - 9 999 people and are divided into sub-categories I – IV as follows:

(1) Tertiary center I, 5 000 - 9 999;

(2) Tertiary center II, 1 000 - 4 999;

(3) Tertiary center III, 500- 999;

(4) Tertiary center IV, 250- 499.

Tertiary centers sub-categories II – IV are the ones found in Ngamiland. There are no settlements which meet the criteria set for tertiary centers I.

Ungazetted settlements (mainly cattle posts) are informal and have populations of less than 250 people and are not entitled to service delivery.

3.2 Water Supply Services

Three institutions have been responsible for domestic water supply in Botswana, i.e. Water Utilities Corporation (WUC), Department of Water Affairs (DWA) and District Councils (Swatuk & Kgomotso, 2007). Until March 2013, WUC supplied water to urban areas, DWA to major villages and District Councils to small/medium rural villages. Water sector reforms, which commenced in 2009 identified WUC as the appropriate institution to supply water to all gazetted settlements nationally. The WUC took over water supply in Ngamiland in April 2013.

3.3 Methods

In order to ensure validity of results and avoid methodological artifact (Berg, 2004; Denzin, 1978; Denzin & Lincoln, 2008), the study used quantitative and qualitative data collection methods and water quality testing.

A structured household questionnaire, administered between May and August 2012, was used to collect quantitative data. These data included general household characteristics, household water sources, distance to the source/s, water shortages or supply experienced, extent of water insecurity and coping and adaptation strategies employed.

Qualitative methods were used to collect quality data on meanings, opinions, feelings and perceptions related to coping with and adaptation to water insecurity. The use of qualitative methods required that the researchers be immersed in the actors' lifeworlds in order to grasp what they experience, i.e. water shortages, lack of supply, poor water quality and how coping and adaption strategies are devised (Schwandt, 1994). Qualitative data collection took place between February 2012 and March 2014. The methods used include key informant and informal interviews, participant observation and focus group discussions (FGDs). Key informants interviewed include village development committee (VDC) members, ward councilors, traditional leaders and officials from WUC, NWDC and DWA. Ordinary community members attended FGDs. Participant observation was done in all the settlements including Matlapana where one of the researchers lived for 3 years.

Water samples were collected from household's water sources (i.e. private and public connections, borehole and river points) for micro-biology testing. Samples were collected before the onset of the rainy season in 2013 and after the rainy season of 2012/13. More samples were collected during the rainy season of 2013/14. According to Botswana water quality standards drinking water should not have any micro-biology counts per 100 milligrams of water (Botswana Bureau of Standards, 2009).

3.4 Sampling

The study was undertaken in 8 purposively sampled settlements, i.e. Maun (primary centre), Matlapana, Somelo and Ikoga (tertiary centers) and Xobe, Samedupi, Gucha and Ukusi (ungazetted settlements) (see Figure 1). These settlements were sampled for various reasons (Table 1).

The study uses the settlement and the household as units of analysis. A total of 554 questionnaires were administered through the assistance of enumerators. A 30% sample size was adopted (Table 1) using lists obtained from the national census, district council and local village leadership. Households in each settlement were listed and each was assigned a number. A random number generator selected households from which respondents were interviewed. Household members from 15 years (62% women and 38% men) and above, knowledgeable about the household's coping and adaptation strategies to water insecurity were interviewed.

Table 1. Sample sizes by settlement

Settlement	Settlement category	Population size (2011)	Total number of listed households	Number of households sampled	Reasons for sampling
Maun[1]	Primary center III	4105	933	295	The only primary center settlement in Ngamiland. Household and experience frequent water shortages
Matlapana A	Tertiary center II	1449	329	99	A settlement experiencing acute water shortages since 2009.
Ikoga	Tertiary centre III	673	153	46	Receives water supply from a surface water treatment plant
Somelo	Tertiary centre IV	600	136	41	Located 40 km away from surface water resources. Has saline groundwater resources
Gucha	Ungazetted	88	20	20	Located further away from a perennial water source
Samedupi	Ungazetted	286	65	20	Households are located close to a perennial water source
Ukusi	Ungazetted	261	60	19	Receives water supply services
Xobe	Ungazetted	260	60	20	Households are located close to a perennial water source
Total		7722	1571	554	

Sources: Central statistical Office 2011; Study settlements' records.

[1] Two wards in Maun (Boyei and Wenela) represented the Village. Boyei experiences extreme water shortages while the situation in Wenela is not serious.

Key informants were purposively sampled. The FGDs were attended by at least 16 participants from each settlement. Each group consisted of males and females from 15 years old and above. However, most groups had a ratio of 1:3 for men to women. The FGD participants were a mixture of household heads and other members.

Water samples for water quality testing were collected from sources where households access water (Table 2). Some of the sources such as public standpipes in Somelo did not have water at the time of sampling.

Table 2. Water samples collected from different settlements

Number of samples collected→	Gucha	Ikoga	Maun	Matlapana	Samedupi	Somelo	Ukusi	Xobe
Sampling points ↓								
Private standpipes	n/a	1	9	1	n/a	1	n/a	n/a
Public standpipes	n/a	-	n/a	1	n/a	1	1	n/a
Borehole	n/a	n/a	n/a	n/a	n/a	1	n/a	n/a
Untreated source	1	1	1	1	2	n/a	n/a	2
Water tanker	n/a	n/a	n/a	n/a	n/a	2	n/a	n/a

3.5 Data Analysis

Quantitative data, i.e. responses from the household survey questionnaire were analyzed using the Statistical Package for Social Sciences (SPSS) version 21. Six variables from the household survey, i.e. settlement category, settlement, household, income and main sources of water were selected as independent variables for analysis purposes. Non-parametric tests in general and Kruskal-Wallis 1-way ANOVA in particular was used in the analysis since the data was not normally distributed. Kruskal-Wallis 1-way ANOVA test was used as it can determine differences between attributes of non-parametric variables. The Pearson's chi-square test was used to determine association between variables, which include income and settlement, settlement and fetching of untreated water during times of water insecurity and settlement category and distance to untreated water sources. Cross tabulations were used to analyze interrelations between two variables (i.e. independent and dependent variables) and the interaction between them. Dependent variables analyzed, relate to short and long term strategies to household water insecurity.

Data from FGDs, key informant interviews and participant observation were categorized into broad themes of coping (short-term) and adaptation (long-term) strategies to water insecurity. Coping strategies were further sub-categorized into themes related to household water sources during times of water insecurity, methods used to fetch water, quality of the water, prioritization and storage of water during periods of water insecurity and buying of bottled water. Sub-themes related to adaptation strategies include drilling of boreholes and wells by households, harvesting water using proper equipment and connecting storage tanks to main water systems.

Water samples were analysed in the laboratory for three micro-biology parameters, i.e. faecal coliforms, faecal streptococci and total coliforms, and the results were compared against the requirements of drinking water specifications for Botswana (Botswana Bureau of Standards, 2009). Drinking water can be contaminated directly or indirectly, by human or animal excreta and microorganisms contained in faeces, harmful to health (WHO/UNICEF, 2013). Microbiology laboratory tests were used to determine faecal and total coliforms and faecal streptococci in drinking water. A faecal coliform is a facultatively anaerobic, rod-shaped, gram-negative, non-sporulating bacterium while faecal streptococci are germs present in the intestines of warm-blooded animals whose presence in large numbers in water represents contamination by excrement and possibly contain other disease-bearing pathogens (WHO, 2002). Total coliforms represents bacteria that are used as indicators of faecal contaminants in drinking water (WHO, 2002).

4. Results

4.1 Socio-Economic Backgrounds of Households

Across all the study settlements, there are more female headed (53%) households than male headed (47%). The majority of the household heads (99.6%) are above 18 years. The average household size across all the settlements is 5.9, as opposed to 4.4 for Ngamiland District (CSO, 2011). According to Pearson's chi-square test, there are no significant differences in terms of average household sizes among the different settlement categories.

Each household uses 69 L of water on average per day during periods of water shortages. This translates to 11.6 L per person per day. At least 20 L per person day of clean water is recommended (Aquaterra, 2008). An average of 250 L of water is consumed per day by each household if water is readily available. This translates to 56 L per person which is recommended by other water experts as being sufficient for an individual (Peter & Gelick, 1996). However, this is low compared to Botswana's national daily per capita of 150 L (UNDP, 2012).

In terms of household income (generated from formal and informal sources), there are significant differences across the different settlement categories (Figure 2). Income from livestock sales was not considered in the study as Botswana Meat Commission does not currently buy from Ngamiland farmers due to prevalence of the foot and mouth disease in the district. There is a strong statistical association between income and settlement category (Pearson's chi-square value = 303.060[a], degrees of freedom = 35, p = 0.000) significant at 5% level. Relatively higher incomes, (>BWP5,000[1]) are found in Maun and Matlapana while low incomes (<BWP500) are found in ungazetted settlements and some tertiary settlements, e.g. Ikoga and Somelo.

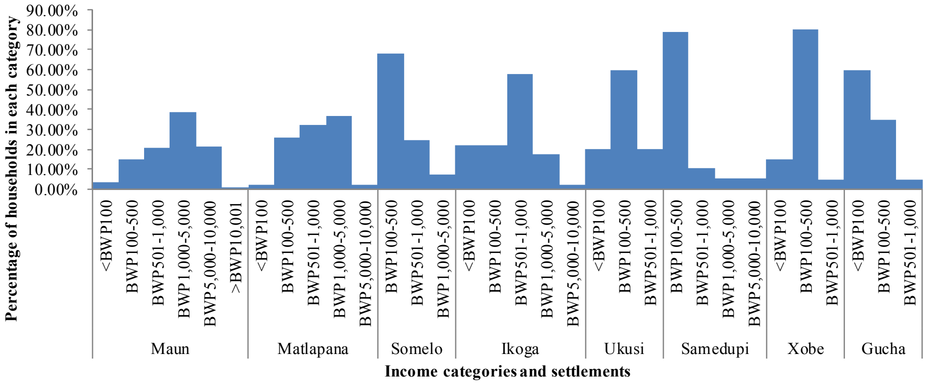

Figure 2. Household monthly income

The relatively low incomes in Ngamiland contrast markedly with the gross national income (GNI) per capita for Botswana (an upper middle income country) pegged at USD13,102 in 2013(UNDP, 2013).

4.2 Sources of Water

Eighty-eighty percent (88%) of the households in Ngamiland District, access water from improved water sources whenever supply is available (Figure 2). Improved sources of water in gazetted villages include public standpipes (23.1%), standpipe into yard outside the house (46.8%), standpipe inside the house (10.8%) and neighbour's standpipe (7.2%) (Figure 3). The 12% of households accessing water from untreated sources are mainly from ungazetted settlements. However, 30 ungazetted villages (e.g. Ukusi) that are located along water transmission lines receive water supply services in the Okavango Sub-district area. Members of parliament and ward councilors lobbied the Okavango Sub-district Authority during the late 1990s for water supply to such settlements since they are strategically located. However, Gucha does not benefit from a similar arrangement despite its location along a water transmission line. This is because the settlement came into existence after other ungazetted settlements had already been connected and a decision subsequently made by the sub-district Authority not to connect such settlements in order to discourage them from mushrooming.

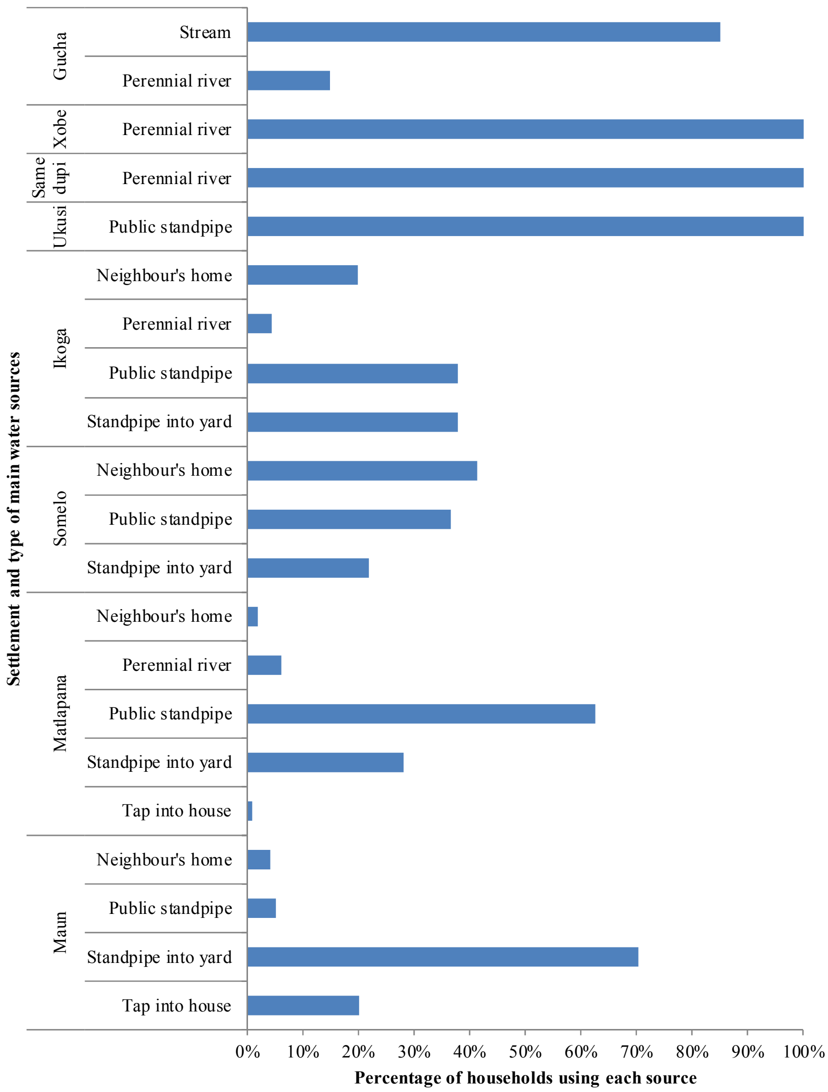

Figure 3. Main water sources for households

Households in Maun mostly have their own standpipes due to higher incomes, which enable them to afford the extra cost of private connections. Tertiary settlements, e.g. Ikoga, Matlapana and Somelo have a significant number of households with private water points while others use public water points as a result of variations in socio-economic status. Ungazetted settlements households, e.g. Samedupi and Xobe access water from untreated sources due to lack of improved water sources. Kruskal-Wallis 1-Way ANOVA test shows that there are significant differences (p = 0.000) in terms of water sources used in different settlements (Table 3).

Table 3. Comparison of water sources between settlements – Kruskal-Wallis 1-way ANOVA

Village to village relationship	F - statistic	Significance level
Maun-Matlapana	-151.120	0.000**
Maun-Ikoga	-161.410	0.000**
Maun-Ukusi	206.313	0.000**
Maun-Somelo	-220.432	0.000**
Maun-Xobe	-284.263	0.000**
Maun-Samedupi	-288.688	0.000**
Maun-Gucha	-317.588	0.000**
Matlapana-Ikoga	-10.209	0.714
Matlapana-Ukusi	-55.193	0.187
Matlapana-Somelo	-69.312	0.015*
Matlapana-Xobe	133.143	0.000**
Matlapana-Samedupi	-137.568	0.000**
Matlapana-Gucha	-166.468	0.000**
Ikoga-Ukusi	-44.903	0.336*
Ikoga-Somelo	-59.022	0.071
Ikoga-Samedupi	-127.278	0.001**
Ikoga-Gucha	-156.178	0.001**
Ukusi-Somelo	-14.119	0.631
Ukusi-Xobe	-77.950	0.058
Ukusi-Samedupi	-82.375	0.049*
Ukusi-Gucha	-111.275	0.028*
Somelo-Xobe	-63.831	0.039*
Xobe-Samedupi	4.425	0.921
Xobe-Gucha	3.325	0.767
Samedupi-Gucha	-28.900	0.846

**Highly significant at<p=0.001.

*Significant at p=0.05.

Most public standpipes in gazetted settlements are not functional (Table 4). According to the DWA and NWDC, residents vandalize public standpipes and expect them to be repaired at no cost to them. Households in Maun complained that DWA closed down public standpipes as a way of forcing them to invest in private connections. The WUC has plans to rehabilitate all public standpipes and install pre-paid water points.

Table 4. State of public standpipes

Settlement		Functional public standpipes	Non-functional public standpipes
Ikoga		2	7
Maun	Boyei	1	9
	Wenela	0	3
Matlapana		2	8
Somelo		1	2

4.3 Household Water Insecurity

Water security is perceived by households from different settlement categories as the continuous and uninterrupted availability and accessibility of good quality water from improved sources. On the other hand, water insecurity is viewed as unavailability of water from improved sources for a period ranging from 1 hour to years and availability of water of poor quality, i.e. discolored, bad smell or with some sediments.

Households from different settlement categories in Ngamiland report that they have been experiencing water insecurity for over 10 years, despite having improved water sources. Water insecurity in gazetted settlements manifests in the form of lack of supply from improved sources for prolonged periods of time ranging from one hour to days or weeks, and at some standpipes even months or years. This also includes supply of poor quality water, which has a bad taste, odor, visible sediments or discoloration. In ungazetted settlements, water insecurity manifests in the form of lack of improved water sources and use of poor quality water.

Water shortages problems experienced in Maun are captured in a petition presented to the Minister of Minerals, Energy and Water Resources on 14 March 2011 by the residents. The petitioners complained to the Minister that the DWA in Maun has failed to reliably supply adequate domestic water to the Village for over 10 years as they experience chronic water shortages which could last for a month and the water being supplied was of poor quality (Residents, 2011). However, no reply came from the Minister responsible regarding this matter.

Sixty percent (60%) of the households across all the settlement categories faced episodes of serious water shortages between 2005 and 2011. Twelve months (i.e. June 2011 and June 2012) preceding the survey, 74% of households across all the settlements experienced extreme water shortages. Thirty-three percent (33%) of the households experienced cut-off in supply within the previous 24 hours preceding the survey and 32% did not have water supply from their main sources at the time of the survey.

All (100%) households from Matlapana and Somelo last had water from their main sources in 2009. Disruptions to water supply to households in Maun Village and Ikoga could last for more than a month.

All households from ungazetted settlements, i.e. Gucha, Samedupi and Xobe, use untreated water accessed from rivers and streams, polluted by wild and domestic animals through their droppings. People who either bath or do laundry at these sources also pollute the water.

4.4 Factors Behind Water Insecurity in Ngamiland

Key informant interviews and FGDs established that Botswana's policy of providing water services to gazetted settlements at the exclusion of ungazetted settlements represents a policy-related factor to water insecurity.

Key informants from the DWA's hydrology section in Maun highlighted that Ngamiland has limited surface water resources as it receives low average annual rainfall of 450 mm. Rainfall is also erratic, and when coupled with high evapo-transpiration rates, there is often little water for domestic use. The environment is also unsuitable for dam construction because of its fragility and the potential high evaporation rates. Water sources for Ikoga, Maun Village, Matlapana and Somelo are either located on floodplains (e.g. boreholes) or on the river banks (e.g. treatment plants) and their operations are negatively affectedby periodic flooding, as they become inaccessible.

Officials from the DWA and the NWDC highlighted that over the years, their organizations have been encountering financial constraints, as they depended on financial resources from central government for water supply services. This negatively affected water supply services as there has been limited investment in water supply, including the operation and maintenance of infrastructure. Moreover, both the DWA and the NWDC supplied water as a social good, with no financial charges, to public standpipes in gazetted settlements, and costs have therefore not been met by the consumers. Population growth and urbanization of Maun have put pressure on the existing infrastructure, which has not been upgraded in more than 30 years.

4.5 Coping Strategies to Water Insecurity

Coping strategies being employed by households in Ngamiland require little planning, and few financial and material resources.

4.5.1 Fetching of Untreated Water

Households from across all settlement categories demonstrate their agency by accessing untreated water from perennial rivers whenever they experience water shortages or when they do not receive any services. There is a strong statistical association between settlements and fetching untreated water by households during times of shortages (Pearson's chi-square test value = 152.029[a], degree of freedom = 7, p = 0.000), significant at 5% level.

Households from Maun Village (35%), Matlapana (96%) and Ikoga (93%) access untreated water from nearby perennial rivers.

The Thamalakane (accessed by Maun and Matlapana households) and Boteti (Samedupi and Xobe households) Rivers are generally perennial but sometimes dry up, for example, in the years between 1995 and 2005. During this period, households from Samedupi and Xobe dug unprotected wells in the floodplain to access water for domestic purposes. Ikoga village households access water from Ikoga River while Gucha households access water from Kweenokore stream whenever.

There is a statistical association between settlement category and distance to untreated water sources (Pearson's chi-square test value = 173.313[a], degree of freedom = 36, p = 0.000) significant at 5% level. Untreated water sources are located further away for ungazetted settlements households than the gazetted ones (Figure 4).

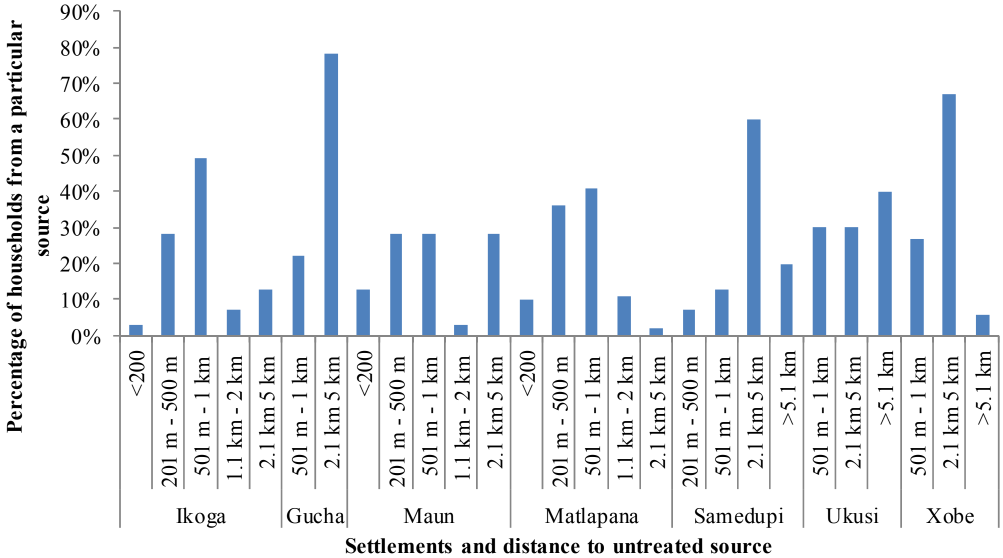

Figure 4. Distance to untreated water sources

Kruskal-Wallis 1-Way ANOVA test show significant differences in terms of distances to water sources between gazetted and ungazetted settlements (Table 5). There are no significant differences in terms of distances to untreated water sources between gazetted settlements.

Table 5. Comparison of distance to untreated water sources between villages – Kruskal-Wallis 1-way ANOVA

Village to village relationship	F - Statistic	Significance level
Matlapana-Maun	13.792	0.263
Matlapana-Ikoga	-16.861	0.175
Matlapana-Xobe	-72.779	0.000**
Matlapana-Gucha	-73.468	0.000**
Matlapana-Samedupi	-77.546	0.000**
Matlapana-Ukusi	-82.179	0.000**
Maun-Ikoga	-3.070	0.831
Maun-Xobe	-58.988	0.002*
Maun-Gucha	-59.676	0.001**
Maun-Samedupi	-63.754	0.001**
Maun-Ukusi	-68.388	0.000**
Ikoga-Xobe	-55.918	0.004*
Ikoga-Gucha	-56.607	0.002*
Ikoga-Samedupi	-60.685	0.002*
Ikoga-Ukusi	-65.318	0.002*
Xobe-Gucha	-0.689	0.975
Xobe-Samedupi	-4.767	0.838
Xobe- Ukusi	-9.400	0.667
Gucha-Samedupi	4.078	0.855
Gucha-Ukusi	8.711	0.675
Samedupi-Ukusi	-4.633	0.832

**Highly significant at $<p$=0.001.

*Significant at p=0.05.

4.5.2 Fetching Water From Neighbors' Taps

During times of water shortages, some private properties in Maun and Ikoga continue to have water available from their standpipes. Ikoga village has one such property and the owners allowed their neighbors to fetch water during shortages because cost implications were low, since they paid BWP4.75/month until January 2014. In February 2014, the WUC installed a water meter on the standpipe and the property owners started denying their neighbors access to their standpipe fearing high water charges.

In Maun, some households always have uninterrupted water supply during times of shortages. Such households usually assist those experiencing acute shortages. In most cases those who are assisted are not charged, though some of them are said to be charging BWP5 for each 20 L container.

4.5.3 Sourcing Water With Light Vehicles

Light vehicles are used to source water by 16% (i.e. 14% in Maun and 2% in Matlapana) of households during periods of water shortages from workplaces, DWA offices, and other residential wards. Such households devise other coping strategies when the vehicles used to source water are not available or unable to go and source water. Some households in Maun pay BWP30 for hiring taxis to transport 20 L or 25 L containers.

4.5.4 Bulk Water Market

Due to the prevailing water shortages, a bulk water supply and buying market emerged around 2000 in Maun and Matlapana. Bulk water is bought by households earning BWP5,000 and above and is put in storage tanks ranging in size from 2.5 m^3 to 10 m^3. The suppliers abstract water from Thamalakane River, private boreholes or buy from WUC and then put a mark up. Most of the suppliers abstract water directly from the Thamalakane River and supply it in its raw state. Transportation is done using ordinary trucks with storage tanks or proper water tankers. The average charges are approximately BWP80/m^3 (BWP150 for 2.5 m^3, BWP300 for 5 m^3 and BWP600 for 10 m^3). Water abstracted from the river is said to be of poor quality by households buying it, since it is supplied untreated. It is also very expensive compared to what WUC charges, i.e. BWP1.50/0-5 m^3 and BWP1.25/0-5 m^3 which households in Matlapana and Maun pay respectively.

4.5.5 Bulk Water Hauling

Service providers (i.e. NWDC and DWA) resorted to bulk water hauling since 2009 using tankers to enable households to cope with water shortages in gazetted settlements (i.e. Maun, Matlapana, Somelo and Ikoga). In Maun, the DWA put in place 10 m^3 plastic storage tanks in 2012 at strategic points in wards where water shortages were experienced. The tanks were filled with water twice a day. However, residents complained that the water hauled was inadequate since it got finished within a short space of time.

Though Matlapana village started experiencing water shortages in 2009, bulk water hauling by the NWDC commenced in October 2012. The VDC and the ward councilor put pressure on NWDC to haul water to the village and six storage tanks of varying sizes, i.e. 5 m^3 and 10 m^3, were put in place at different points. These were filled by a tanker once a day. This prevented households from using untreated water of poor quality from the river. However, the service was stopped when WUC took over water supply and no reasons were given. Households were compelled to resort to fetching untreated water from river again.

Water is hauled to Ikoga village from other sources in the sub-district whenever there is a supply problem. In 2011, the treatment plant was submerged by floods and a tanker hauled water to the village twice a day for three weeks. In January and February 2014, the village had water hauled by a tanker since there was no supply from the treatment plant.

Somelo village, located 70 km from Maun has relied on water hauling since 2009 when its borehole, located on a floodplain 40 km away, was submerged by floods. An NWDC 10 m^3 tanker is supposed to supply the village with water twice daily and WUC has continued water hauling to the village. Households in Somelo have no other coping alternatives since a borehole in the village yields saline water. However, water hauling to the village is unreliable due to constant breakdowns of the tanker, resulting in households going for more than a week without water at times. During such times, households are forced to use saline water for domestic purposes.

4.5.6 Traditional and Improvised Rainwater Harvesting

Sixty-three percent (63%) of the households practicing rainwater harvesting as a way of countering water shortages. There is a strong statistical association between water shortages and the practice of rainwater harvesting, (Pearson's chi-square value = 25.629^a, degree of freedom = 7, $p = 0.001$) significant at 5% level. Households practicing rainwater harvesting (94%) employ their agency by using open containers, which range in sizes from 20 L to 100 L to collect rainwater from rooftops. The practice is simple because not much investment costs are involved. Households as actors are knowledgeable and capable as they are aware that when they harvest rainwater they are able to reduce trips to the river or to other sources. Several households (66%) in different settlements can harvest more than 200 L from one heavy rainy event. Eighty-nine percent (89%) of those households harvesting water believe that its quality (i.e. in terms of taste and color) is very good.

One percent (1%) of the households in Maun, Matlapana, Somelo and Ikoga have improvised rainwater harvesting systems which enable them to harvest water using storage facilities ranging from 0.210 m^3 - 0.5 m^3 tanks. Water from the rooftops is channeled into polythene or polyvinyl chloride (pvc) pipes into the storage tanks. These storage tanks are usually emptied once they fill up so as to harvest more water from subsequent rainy events.

4.5.7 Water Quality

Microbiology tests for water from the study areas show that the water is below the national standards required for drinking water as specifications for drinking water for Botswana state that the presence of any pathogens renders water unacceptable (Botswana Bureau of Standards, 2009). Water samples from private standpipes in Matlapana, Ikoga and Somelo show high counts of total coliforms while counts for the other parameters, i.e. faecal coliforms and streptococci are relatively low except for Matlapana and Somelo respectively (Figure 5).

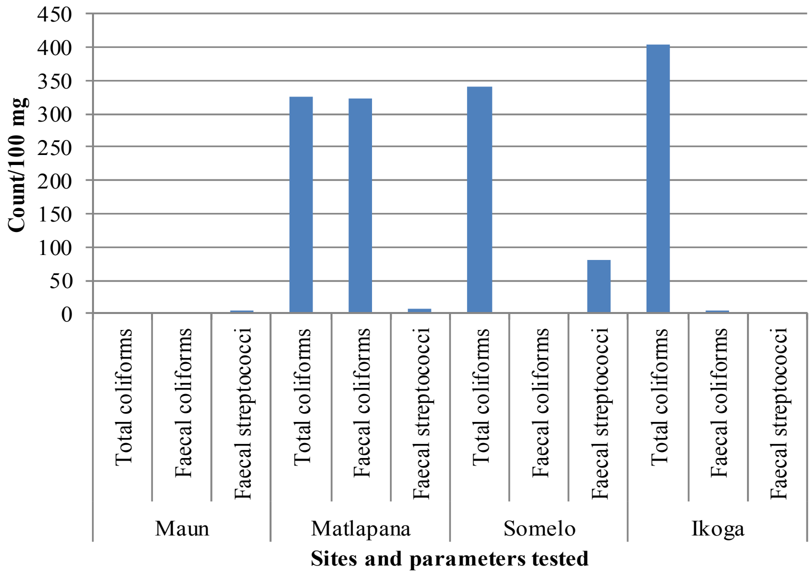

Figure 5. Water quality results for private standpipes

Water quality results from public standpipes from Ukusi village shows high levels of total and faecal coliforms while results Somelo shows unacceptable high levels of total coliforms (Figure 6).

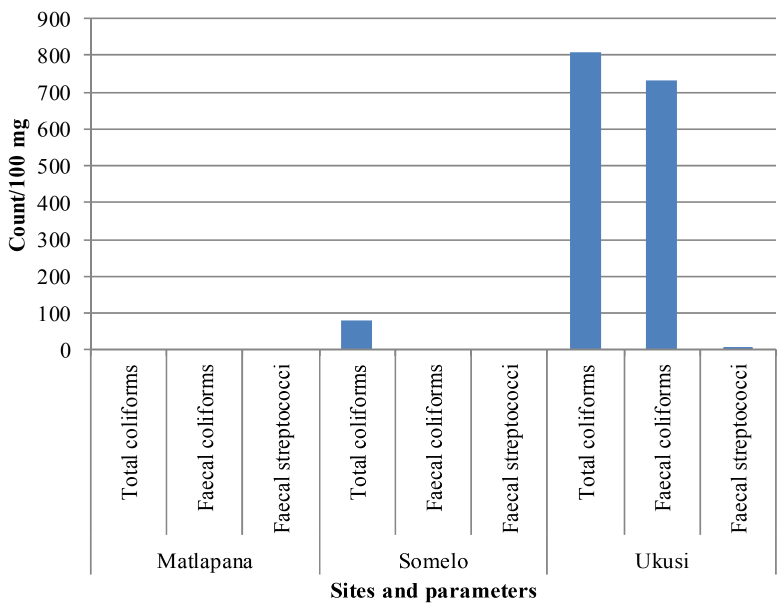

Figure 6. Water quality results for public standpipes

Water from untreated sources shows unacceptable levels of all microbiology parameters (Figure 7).

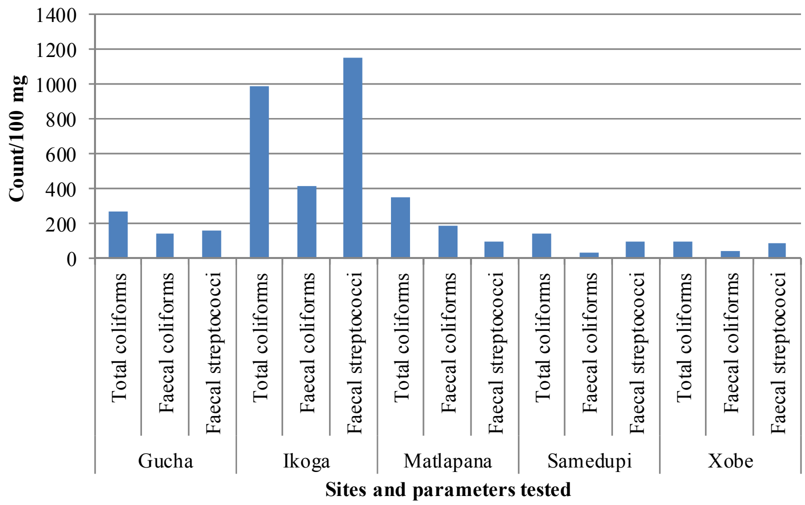

Figure 7. Water quality results for untreated water sources

Water quality from rainwater harvesting tanks from Ikoga and Matlapana and from a borehole in Somelo, show that the water has some unacceptable microbiology counts (Figure 8).

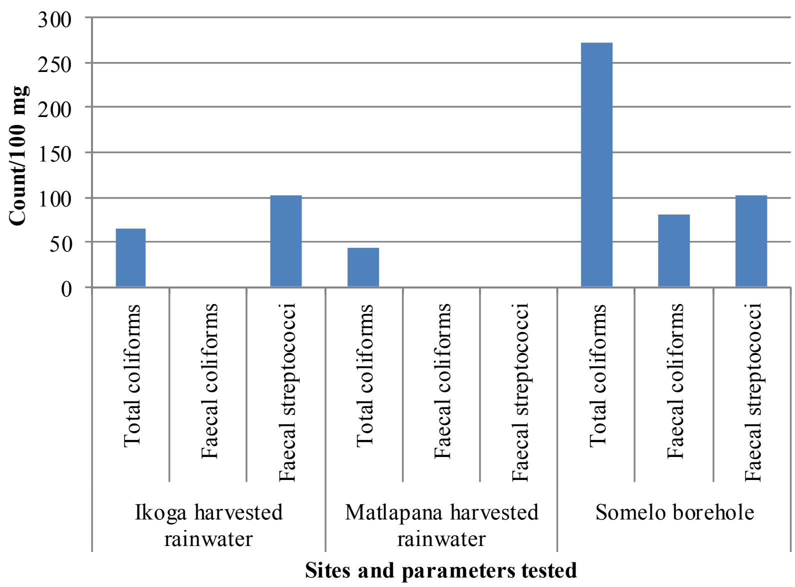

Figure 8. Water quality results for rainwater tanks and borehole water

Despite evidence that water from several sources is of unacceptable quality for drinking, 55% of households from gazetted settlements are satisfied with the quality of water from their main sources. Forty-five percent (45%) of the households view water from their main sources as being of poor quality because it is discolored, smells unpleasantly and has visible sediments.

Households from Gucha (85%), Xobe (80%) and Samedupi (63%) confirmed the water quality results presented in Figure 7 as they complained that the water from their sources is muddy and discolored as a result of pollution caused by domestic and wild animals. Some household members sometimes contract waterborne diseases such as diarrhea.

Across all the settlements, where there is evidence of poor water quality, 90% of the households do not treat their water to make it safer to drink. Households from Samedupi (80%), Xobe (90%), Gucha (90%), Matlapana (70%), Maun (92%) and Somelo (100%) drink the water from the unprotected sources without boiling.

4.5.8 Prioritizing Water Use for Different Activities

During times of water shortages, all households (100%) across the different settlement categories ranked water uses, starting with the most important use as follows: cooking (100%), drinking (100%), bathing (98%). Other water use activities such as laundry and general cleaning become peripheral during such times.

Bathing in 72% of the households is determined by water availability. When there is less water, household members either have to reduce the frequency of bathing per day or the amount of water used, or do not bath at all. In Somelo, household members can go for 5 or more days without taking proper baths.

Laundry is usually done fortnightly by the majority (72%) of the households when water is scarce. Households members from settlements located closer to rivers, wash their laundry there. In Somelo, households have either to wait for the water tanker or use saline water to do laundry.

4.5.9 Storing Water in Containers

The majority (97%) of households across the different settlement categories store water in containers, i.e. 20 L or 25 L for current and future use. These containers are preferred for storing water mainly because they are easily accessible and can also be carried by adult household members from different water sources to the homestead. The average number of containers owned by different households across the different settlement categories is 6. In Somelo, the average number of 20 L containers owned by each household is 11.

4.5.10 Buying Bottled Water

Fourteen percent (14%) (12% from Maun and 2% from Matlapana) of the households purchase bottled water for drinking. The water is mainly purchased by households with monthly incomes of at least BWP1 000. An average of 15 L is purchased every week by each household, at a cost of BWP45. Sixty-one percent (61%) of the households, purchase bottled water because it is safer to drink while 29% do so because it is readily available and 10% do not trust the quality of water from other sources.

4.6 Adaptation Strategies

A few households have been able to adapt to water shortages through various strategies to ensure uninterrupted water availability for household use. Adaptation strategies are mostly implemented by households earning at least BWP10,000 per month.

4.6.1 Boreholes and Well Points

Two percent (2%) of households from Maun and Matlapana have been able to drill their own boreholes and well points along the Thamalakane River floodplain or riverbed, equipped with electric pumps and motors. Fresh groundwater resources are only available in floodplains as it is saline in other locations. Some of the households have been pumping groundwater for over twenty years. Major costs involved are the initial investment (e.g. BWP8,000) and running costs especially electricity (e.g. BWP500 per month or more). All households with boreholes or well points have storage tanks of between 2.5 $m^3$and 10 m^3into which water is pumped.

4.6.2 Rainwater Harvesting

Five percent (5%) of the households (i.e. 3.4% in Maun, 1.2% in Matlapana and 0.4% in Somelo) practice rainwater harvesting using proper rooftop gutters which channel water into storage tanks of different sizes, i.e., 2.5 m^3 to 10 m^3. The harvested water usually lasts up to the following rainy season from around March as it is only used when there is no water from the main sources.

4.6.3 Connecting Storage Tanks to the Main Water System

Direct observation in Matlapana and Maun revealed that some of the households have connected storage water tanks of varying sizes, i.e. 2.5 m^3 to 10 m^3, to their main water systems. A minimum of BWP6,000 is spent on such connections. Informal interviews with members from such households indicated that the main water systems are meant to fill up the tanks when water is available for use in times of shortages. Households in Wenela ward with such connections, can access water from the tanks for more than a month if there is a shortage. Water supply to the ward is intermittently cut, and as a result, the households are able to deal with the regular water shortages.

7. Discussion

Data presented in this paper demonstrates that water insecurity is a challenge for households in different settlement categories of Ngamiland, Botswana as they experience water supply and quality challenges. The presented results are consistent with those of other studies in Ngamiland (Kgomotso & Swatuk, 2006; Mazvimavi & Mmopelwa, 2006; Ngwenya & Kgathi, 2003). The phenomenon is not unique to Botswana as it is common in other developing world countries such as Ethiopia, South Africa, Tanzania and Zimbabwe where households go for prolonged periods of time without any supply or have water of poor quality supplied to them (Manzungu et al., 2012; Penrose, de Castro, Werema, & Ryan, 2010; Pritchard, Mkandawire, & O'neill, 2007).

Households in gazetted settlements go for prolonged periods of time without water despite the fact that they have improved water sources while households from ungazetted settlements do not receive any water supply services. Water insecurity is experienced by households in Ngamiland despite the fact that Botswana is one of the few sub-Saharan African countries with 97% of the population with access to improved water sources (WHO, 2013). Access to improved water sources is closely associated with reasonable access to an adequate amount of water from a source such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection (WHO/UNICEF, 2013; World Health Organisation, 2013). There are currently no mechanisms in place to monitor reliable water availability from improved water sources. As a result, the mere presence of such a water source is usually taken to represent water availability for households (WHO/UNICEF, 2013). Households with access to such sources can go for prolonged periods of time without water supply (Kujinga, Vanderpost, Mmopelwa, & Wolski, 2013). Using the presence of improved water sources to define access to water, usually does not take into consideration the quality of the water. As shown by the results from Ngamiland, water quality across the different settlement categories is unsuitable for drinking regardless of where it is drawn from. Water security, which takes into consideration access, quantity, quality, availability and affordability of water could be a better measure for access to water.

The use of an actor oriented approach in this paper helped to understand water insecurity at the local level in lifeworlds where it is assumed that there is water security. Despite the fact that eighty-eighty percent (88%) of the households in Ngamiland district have access to improved water sources (presuming security), water insecurity is still a major challenge to many households in Ngamiland. The approach also allowed analysis of how actors cope and adapt to water insecurity in their lifeworlds through their own agency. Consistent with findings from other studies, households in Ngamiland are not homogenous but heterogeneous regarding the strategies that they implement in coping and adapting to water insecurity (Long & Villarreal, 1994).

Households facing water insecurity in developing countries tend to employ autonomous coping strategies (Adeniji-Oloukoi et al., 2013). Coping strategies such as bulk water buying, traditional rainwater harvesting and prioritization of water use, are common in other developing world countries such as Zimbabwe, Tanzania, Nigeria, Sudan and Kenya (Adeniji-Oloukoi et al., 2013; Manzungu & Chioreso, 2012; Manzungu et al., 2012; Opryszko, Huang, Soderlund, & Schwab, 2009). Though households are able to show their agency in a lifeworld of water insecurity, this agency is mainly limited to autonomous coping for the majority, as they fetch water from untreated sources or use other unsustainable methods such as use prioritization, fetching water from neighbours with running water and relying on bulk water hauling by service providers.

The ability of households to cope with water insecurity depends on the socio-economic status of the household as relatively high income households invest in strategies that are more long-term compared to low income households. Few households are able to adapt to water insecurity mainly by having their own water supply sources such as boreholes or effective rainwater harvesting systems (Manzungu & Chioreso, 2012).

It is imperative for governments where water insecurity is experienced to adopt planned intervention approaches (Long & van der Ploeg, 1989) by formulating policies and implementing strategies that enhance water security based on research. Water policies, strategies, financial investments under the Water for Good Plan for South Australia were informed by research and this enabled the state to achieve water security (Government of South Australia, 2008). Strategies to deal with water insecurity need to be divided into short, medium and long term for effective implementation. In the context of Botswana, water policies and strategies have to focus on all the different settlement categories including ungazetted settlements. Botswana's vision 2016 recognizes the importance of access to safe and clean water to all settlements (Presidential Task Force Group, 1997). Water supply to some ungazetted settlements by the Okavango Sub-district Authority shows that with proper planning, the service can be extended to more such settlements.

In the short-term, water hauling can be done as a stop gap measure to gazetted settlements facing water shortages. To improve water quality, there is need for training and awareness programmes among households on different water treatment methods (e.g. straining, boiling, chemical disinfection, solar disinfection) which can be used at the household level (IFRCS, 2008; UNICEF, 2008). Households need to be made aware that access to water from an improved source does not mean that it is safe for drinking as demonstrated in the paper. Treating water at the household level is an effective and cost-effective means of preventing waterborne diseases and it allows households to play a role in enhancing water security (UNICEF, 2008).

Rainwater harvesting constitutes a short-term strategy which households in Ngamiland can be encouraged to embark on. However, research has to inform the type of infrastructure that can be used as well as strategies for encouraging uptake by households. Rainwater harvesting from rooftops is simple, cost-effective and on-site supply of water to the household with little treatment (Garrison, Kloss, & Beckman, 2011). It reduces strain on existing water supply sources. Incentives such as tax rebates, subsidized equipment, e.g. storage tanks and other collection materials can be offered in order to encourage uptake. Australian states such as South Australia and the Australian Capital Territory have laws requiring private property owners to install at least a 5 m^3 tank for rainwater harvesting purposes (Government of South Australia, 2008).

Mid-term strategies underpinned by research could focus on Maun Village for the implementation of strategies such as stormwater harvesting and wastewater recycling. Stormwater can be harvested from storm drains around the Village before being purified and used for non-drinking purposes like it is done in Australia (Sidney-Water, 2013). Wastewater recycling will involve removing solids and certain impurities and then use the water for toilet flushing, laundry, fire fighting, building construction, car wash and industrial machine and plant cleaning (Sydney Water, 2012). This helps in reserving purified water for drinking and cooking. The city of Sydney in Australia does water recycling with a considerable degree of success and it projects to recycle 70 billion liters of water per year (i.e. 12% of Sydney's needs) by 2015 (Sydney Water, 2012).

Long term strategy for achieving water security for Botswana would be to ensure that all settlement across the different settlement categories receive clean water supply services reliably and sustainably as enshrined in the Vision 2016 (Presidential Task Force Group, 1997). It is important that the already existing water supply infrastructure in gazetted settlements provides water on a reliable basis. Research aimed at influencing policy and planning can focus on the possibilities of establishing solar powered village water treatment plants in scattered ungazetted settlements and villages like Somelo. Such treatments plants can be operated and maintained by trained villagers.

Strategies identified above will have to be informed by research and underpinned by policy, legislation, a sound financial package, appropriate technologies and political will. It is imperative for the international community through organizations such as the World Bank, International Monetary Fund and the African Development bank to advance financial packages for the enhancement of water security in countries like Botswana. Developed countries which have been able to achieve a higher degree of water security went through a process which involved refining their water supply policies, committing financial resources to the provision of clean water and investing in appropriate technologies for water supply (UNDP, 2006). Such an approach will go a long way in assisting households in different settlement categories of Ngamiland from adopting unsustainable coping strategies to water insecurity.

8. Conclusion

The majority of developing countries including those classified as middle income, are facing water insecurity. Botswana in general and Ngamiland in particular, is also experiencing this phenomenon. This is despite the fact official statistics highlight that 97% of the population has reliable access to water through improved sources. In the context of water insecurity in Ngamiland, households are mainly compelled to use autonomous coping strategies that are unsustainable, such as getting untreated water, making them vulnerable to waterborne diseases. A few economically better off households are able to adopt adaptation strategies that are long-term, reducing their vulnerability to risks associated with water insecurity.

The state through the Water Utilities has to adopt more effective planned intervention approaches that will enhance household water security in different settlement categories. This can be done through the formulation of policies and strategies (i.e. short, medium and long term) for water security underpinned by research. Water policy has to emphasize on the implementation of different strategies aimed at achieving household water security such as rainwater harvesting, stormwater harvesting and wastewater recycling. Moreover, water security which takes into consideration issues of access, quality, quantity, availability and affordability need to be adopted as an appropriate measure for access to water as opposed to the mere presence of improved sources.

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Endnotes

[1]USD1 = BWP8.83

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