Climate change and water supply adaptation: Lessons from domestic rain water harvesting in sudano sahelian Cameroon

Introduction

Water resources, in particular conventional rural water supply systems/sources are among the first to be impacted by climate variability. Predicted impacts of climate change include: changes in the frequency, intensity and spatial distribution of precipitation; increased or decreased amounts of precipitation; increased evaporation due to increasing temperatures; increased or decreased runoff ; increased or decreased ground water recharge rates; rise in sea level in coastal areas; increase in floods and droughts; and increased variability of water resources. According to MINEPDED and UNDP (2012a), the northern part of Cameroon will be the most impacted by climate change. The predicted risks in decreasing order of importance for the sudano-sahelien zone are: drought, erosion, high winds and flooding.

Inadequate access to safe water and decent sanitation has a considerable negative impact on human development. The impacts are felt on the economies, health, education and social well-being of the population. Despite this well documented fact, a significant proportion of the world's population still lacks access to improved water supply. According to UNICEF and WHO (2012), the Millennium Development Goal (MDG) target for drinking water was attained in the world in 2010 with an estimated 89 % of the global population using improved drinking water sources. However, 780 million people remain unserved with four out of 10 people without access living in sub-Saharan Africa (i.e. about 312 million people). Sub-Saharan is the region in the world with the lowest coverage of water and sanitation (61 %).The region accounted for six of the top ten countries in the world with the largest population without access to an improved drinking water source in 2010.Sub-Saharan Africa is therefore not on track to meet the MDG target on drinking water.

Most of the people unserved in sub-Saharan Africa are concentrated in rural areas and urban unplanned settlements (UNICEF and WHO, 2012). Even in areas considered served with improved sources of water, the quality is not assured and hence the proportion of the population with access to improved sources does not translate into access to safe water supply. In sub-Saharan Africa, even in towns with pipe borne water supply, the physical quality of the supplied water is sometimes found wanting and needs treatment to be rendered aesthetically pleasing. As such, there is potentially a much greater number of persons without access to microbiologically safe drinking water in Africa south of the Sahara.

In 2007 it was estimated that only about 44 % of Cameroonians had access to adequate drinking water (NIS, 2008). In urban areas, the situation is much better with a percentage access of about 75 %.The situation in rural areas is worse with a percentage access of 28 %. The percentage of the population with access to adequate sanitation is about 37 %; with 66.4 % access in urban areas and only 14.4 % access in rural areas. The national water utility company has a mandate to provide water only to urban centres with a population of at least 5 000 persons. In 2009, only 32% of such towns had a functional water distribution network (MINEE and GWP, 2009).

Description of Problem

Accessibility to portable water in the sudano-sahelian part of Cameroon is a course for concern given that the population relies mainly on springs, wells and boreholes for the supply of potable water in rural areas. Springs and wells which are more commonly used are however more vulnerable to climate change (Djakou, 2013). Boreholes are more resilient to climate change but are expensive to construct and the pumps are more difficult to maintain and hence frequently break down. The main climate risks to the water supply systems in rural areas are floods and droughts. The vulnerability of rural water supply means that springs and wells are increasingly drying up earlier in the dry season than expected. In addition, floods with increasing frequency are damaging or polluting water supply systems.

To reduce the vulnerability of the population in the short to medium term, domestic rain water harvesting is one option which has been explored where rainwater is collected, treated and stored for use in the dry season when other water sources dry out.

Objectives

The aim of this study was therefore to:

I. Document the experiences in the sudano-Sahelien part of Cameroon in the use of domestic rain water harvesting systems (DRWHS),
II. Draw lessons for up-scaling in Cameroon and other parts of Africa.

Institutional and environmental challenges

Cameroon has made a lot of efforts to attain the Millennium Development Goals as concerns water and sanitation (WatSan) but may not attain the target come 2015. This is due to a number of constraints confronting the sector:

I. **Insufficient financial resources:** considerable investments have been mobilized for the WatSan sector over the last couple of years. Most of the investments have been from external sources. Due to the financial gap required to meet the goals of the government in WatSan, more needs to be done to mobilize additional resources especially from indigenous sources.

II. **Inadequate coordination:** the efforts of the many stakeholders involved in the sector are not well coordinated leading to duplication of efforts, and inefficient use of existing limited resources. In Meri sub-division for instance, the rural council is not involved in the management of the structure making it difficult for a proper maintenance of the system to be carried out.

III. **Lack of national monitoring and evaluation:** the absence of a nationwide monitoring and evaluation system with a database to facilitate better targeting of resources to the most disadvantaged section of the population for greater impact.

IV. **Inadequate human resources:** because of a freeze in recruitment of civil servants over the years the number and quality of staff in the water and sanitation public sector is today very unsatisfactory. New staff has recently been recruited but their capacities need to be reinforced for them to be efficient.

V. **Sustainability:** A significant proportion of infrastructure constructed to improve coverage in WatSan break down prematurely a few years after completion. As a result, despite the significant amount of investment in the sector, the WatSan coverage is not improving as fast as expected.

VI. **Rapid urbanization** with rates of up to 6 % per year in some towns.

VII. **Water quantity and cost;** One of the major complaints from the population in Meri Sub-Division is that the quantity of the water is very small. Only 3 l/day/per person is previewed to be rationed. This is not enough especially for active adults working in the sun in the dry season. In some quarters, there are about 1200 persons for a single system. Douroum has about 40 000 persons but only has three such DRWHS, and the available wells have very high fluoride levels. As a result water harvested does not serve the population for up to three months as initially planned. It should be noted that the capacity of the system was initially meant to serve the needs of three families but the project was modified as a demonstration project to serve the entire community.

VIII. **Climate change:** the above problems already pose tremendous challenges to providing satisfactory water services to the population especially in rural areas with dispersed settlements. In this context, climate change represents an additional constraint to accelerating the access rate of WatSan for Cameroon to attain the MDG target.

Methodology

The descriptions of existing DRWHS were obtained from secondary data available from institutions responsible for their implementation and from existing reports. The information was complimented with observations made during a field visit in late August to early September 2013 during which the geographic location of each DRWHS was determined with a global positioning system.

In addition, a questionnaire was developed and administered to a cross section of stakeholders in some communities in Meri sub division where DRWHS had recently been installed. Key stakeholders to whom the questionnaire was administered included; members of the water management committee, traditional authorities, households and the head of the health centre. The objective of the questionnaire was to obtain information on the functionality of the water harvesting systems; the quantity and quality of water harvested, the maintenance and sustainability of the systems and finally, the impact of the project on the community.

Other methods used to achieve the specific objectives of the study were; analysis of water quality and field observation to assess the functionality of system as well as focus group discussions organized in six communities in Meri-subdivision.

Results and Discussions

Two projects carried out in the Meri sub-division by non-governmental organizations to combat water crisis in that region are described below.

a) Roof Top Rain Water Harvesting

The project, implemented by the African Indigenous Women's Organization- Central African Network (AIWO-CAN), is located in Meri sub-division in the Diamare division in the Extreme North Region of Cameroon. The project involved the construction of six domestic roof top rain water harvesting systems in the localities of Douroum and Mbozo. The systems comprise a collector with dimensions of 3.54 x 8.5 m made with aluminium sheets, raw water storage tanks (5 m^3 pvc tanks), a filter and 6 m^3 filtered/treated water storage tank. The filter is a 20 l plastic bucket filled with charcoal, gravel and sand. Ground grains of moringa previewed for disinfection were yet to be included in the filter. In Mbozo the storage tanks are constructed with steel while in Douroum, the storage tanks are made with concrete. The filtered water is rationed to members of the community during the rainy season. Distribution stops before the end of the rainy season in order to the water store for rationing again very late in the dry season in March and April when other water sources in the locality have dried up and when women usually have to travel long distances to fetch water of doubtful quality.

The project is planned to be managed by the communities themselves. However, since the project was completed in 2012 with a guarantee period of two years, all repairs and maintenance are currently carried out by AIWO-CAN and hence the effectiveness of the management committee is still to be tested.

Three sites in Mbozo went operational in 2012 since work was completed before the 2012 rainy season. In Douroum, the project was completed after the 2012 rainy season and thus went operational during the 2013 rainy season. Consequently, some minor defects like seepage in the storage concrete tanks, and leaky joints were only being identified and repaired in 2013. Because of this, the storage tanks at two sites were empty at the time of the field visit and thus no water quality analyses were performed for these sites.

Data on the cost of the various components of the system from AIWO-CAN are still expected. This information will make it possible to identify the most expensive components of the system so as to explore measures which could be taken to reduce cost, as well as make a cost comparison between steel storage tanks and concrete storage tanks.

The total cost of the project for the six sites was about 28 million Fcfa i.e. about 4.7 million fcfa per site. However variation in the cost is expected based on the material used, steel or concrete, for the construction of the storage tank. Information from AIWO-CAN suggests that the most expensive component is the collector supported by concrete columns. Figure 1 shows a Roof top water harvesting site in meri; one with a metal storage tank and the other with concrete.

It is worth noting that all the roof top rain water harvesting systems are in very good condition. This is partly because they were constructed just over a year ago and are still under a guarantee period of two years during which, all repairs and maintenance are being carried out by AIWO-CAN. The surroundings of the system are clean. However, the following deficiencies were noted which if corrected will greatly enhance the technical performance of the systems.

Figure 1: Roof top water harvesting site in meri; one with a metal storage tank and the other with concrete.

1. The raw water tanks do not include an over flow pipe. At the moment, when the tanks are full, the pipes leading into the raw water tanks from the gutter have to be disconnected. This is complicated and will lead to damages.

2. The raw water tanks do not include a first flush or "foul flush" mechanism. As such the tanks get very dirty after the first rains and will need to be thoroughly washed before use. This increases the labour required for its operation.

3. All the tanks do not have indicators for estimating the volume of water in the tank.

4. The material used for the pipes from the raw water tanks to the filters and from the filters to the treated water tanks is pvc. This is fragile and could be easily damaged.

5. The fence around the system is constructed with very light expanded metal and is fragile and hence very unlikely it is going to last for long. So too is the filter.

6. In the concrete tanks, the cover of the man hole is a concrete slab which has to be dragged along the top of the tank to open or close the inlet. This introduces dirt into the filtered water and hence water is exposed to contamination.

7. The concrete storage tanks are not water proof and hence are damp on the outside.

8. Moringa is currently not added to the filter to purify water as planned. The moringa plants planted to provide seeds for this purpose are still very small and hence the seeds are not available.

9. Some metal storage tanks in Mbozo are already showing signs of rusting in the inside. This will likely get worse with time.

10. Planned water management committees for each system are not yet functional and management is currently carried out by an AIWO-CAN technician since the project is still under guarantee till December 2014.

b) Rock Surface Rain Water Harvesting in Gougouling

Located in Gougouling in Mambza Zouggo village in the Mandara Mountains at an altitude of 825m, the rainwater harvesting system is one of three such projects executed by CARE Cameroon in the region was constructed in 1995.

Figure 2: Rock surface water harvesting system with a storage reservoir.

The system was designed based on a village population of 1260 and a rainfall of 600 mm and to ration supply to the population for the last three months of the dry season when all other water sources in the area have dried up. The surface area of the catchment is about 1125 m^2 while the storage reservoir has a capacity of 235 m^3 (Ajaga and Fonteh, 1998).

As shown in Figure 2, stone (which is very abundant in the mountain) was the main construction material used. The stones were neatly shaped and mortar used to construct a 40 cm high retaining wall limiting the catchment area, the reservoir, and the gravel-sand filter. The cost of the system was estimated to 16.3 million. The community contributed 2.2 million Fcfa in cash, materials and labour while the rest was provided by CARE-Cameroon.

However, in the past four years, the system has not been functioning as expected. Raw water (not filtered) is now carried directly from the storage tank with buckets. The reason being that the outlets from the sand filter (2 taps) used for carrying water by the population are damaged and have not been repaired. This is blamed on a non-functional water management committee because money collected from the population for maintenance and repairs saved in the nearby town of Mora in a financial institution by the head of the committee could not be accessed when he passed.

Water deficit, system cost and alternative technology

Table 1 provides an indication of the potable water deficit in selected sites in Meri sub-division based on the current system. The estimated cost to offset the deficit is huge. For example, to meet the potable water demand of the Mbozo Centre population for three months during the dry season will cost over 100 million FCFA to construct about 23 identical DRWHS.

Table 1 potable water supply deficit in Meri-sub-division

Name of Site	Population	Required volume of storage for three months, m^3)	Deficit, (m^3)	Ratio of supply to demand, (%)
Mbozo Centre	1000	270	258	4.4
Mbozo Debi	1000	270	258	4.4
Mbozo Makavaye	1500	404	392	3.0
Douroum Centre	7000	1890	1848	0.6
Douroum Wourokessoum	3000	810	798	1.5
Douroum Watergas	3000	810	798	1.5

It is worthy of note that the rock surface DRWHS in Gougouling has cost about 16 million FCFA for a capacity of about 235 m^3. This therefore suggests that roof top rain water harvesting on a large scale can be very expensive and thus less attractive from a cost stand point.

To satisfy the water needs of the population throughout the year, the construction of boreholes equipped with solar powered pumps to lift water into an elevated storage reservoir should be investigated. Before distribution to the population, the water should be treated to remove the high level of fluoride in the water to acceptable levels. This option will provide water throughout the year and will likely be more economic and hence needs to be further investigated.

Water quality

The tables and figures (source: Fantong Wilson, 2014) below, show the results of field and laboratory analysis of water samples from selected drinking water source in the project area. The tested parameters show that water from the Mboso domestic rainwater harvesting system (HR) is potable.

No	**Site**	**WT**	**EC (µS/cm)**	**pH**	**Wtemp (˚ C)**	**WD (meter)**	**At.T (˚ C)**	**Remark**
1	Djiddel	Bh	545	7.57	30.3	45	34.3	Unfiltered, and 8000 people
2	Mboso	HR	46	7.06	31.3	-	30.6	3500 people
3	Mboso	HR	99	7.42	32.1	-	30.6	
4	Mboso	SW	82	7.28	28.3	-	29.5	
5	Mboso	Bh	1766		30.8	-	-	Based on EC, Not

								suitable for drinking
6	Sedek	SW	825	7.02	31.2	12.3	34.4	Based on EC, Not suitable for drinking
7	Sedek	Bh	684	7.21	30	45	36.6	Based on EC, Not potable, with 7000 people
8	Messere	Bh	177	7.01	30.3	50	28	
9	Messere	SW	266	6.9	30	4	30	
10	Meri	SW	293	6.61	30.3	-	33	Observed fluorosis
11	Meri	SW	339	7.22	29.8	14	33.2	"
12	Douvanger	HR	103	7.16	28.8		33.1	Storge takn is 2.5 m deep and diameter is 7 m. Fluorosis observed
13	Meri	S	131	7.32	32.7		34	
14	NC	NC	NC	NC	NC		NC	
15	Djiddel	SW	608	7.01	31.2	14.7	36.4	Based on EC, Not potable . Signs of fluorosis observed
16	Maga	Dam water	65	7.36	30.2		36.4	Heavy human activities

Table 2: Field tested physical parameters of selected drinking water sources

WT= water type, EC= Electric conductivity, Wtemp= water temperature, WD= water depth, At. Temp=AtmosphericTemperature, UBh= unfiltered borehole, FBh= filtered borehole, SW=shallow well, S=stream, HR=Harvested rainwater, NC= not considered

Table 3 shows the results obtained from the laboratory analyses of the concentration (mg/l) of cations and anions in collected samples.

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Institut de Recherches Géologiques et Minières

Centre de Recherches Hydrologiques

LAGE

Laboratoire d'Analyse Géochimique des Eaux YAOUNDE

Date: 23 octobre 2014

Demandeur: GWP

Echantillon	Temp	pH	Cond	Alc	MES	CATIONS					ANIONS					
						Na^+	NH_4^+	K^+	Mg^{2+}	Ca^{2+}	F^-	Cl^-	NO_3^-	PO_4^{3-}	SO_4^{2-}	HCO_3^-
	°C		µS/cm	µE/ml	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
1Djiddel unfiltered borehole	/	/	/	5474	/	50.97	0	22.16	9.56	55.33	0.82	0.23	0.86	0	1.56	334
2 Mboso harvested rainwater	/	/	/	10	/	0.31	0	0.44	0.24	1.93	0	0.24	4.91	0	0.95	0.6
3 Mboso harvested rainwater	/	/	/	955	/	10.27	0	1.03	1.60	8.92	0.22	1.51	0.48	0	0.44	58.3
4 Mboso handdug well	/	/	/	788	/	8.62	0	1.38	1.13	8.75	0.28	2.51	0.62	0	0.56	48.1
5 Mboso unfiltered borehole	/	/	/	2420	/	165.62	0	6.43	18.39	235.22	0.07	0.83	0.05	0	838.87	147.6
6 Sedek handdug well	/	/	/	7133	/	99.24	0	2.63	12.44	77.13	0.02	1.55	5.63	0	5.77	435.1
7 Sedek unfiltered borehole	/	/	/	4368	/	28.50	0.28	9.02	11.30	97.32	0.92	10.51	3.05	0	16.52	266.4
8 Messere unfiltered borehole	/	/	/	1182	/	14.06	0	12.79	2.50	14.61	1.80	0.35	2.12	0	2.09	72.1
9 Messere handdug well	/	/	/	1238	/	23.31	0	2.33	5.38	25.66	0.12	1.55	9.58	0	1.83	75.5
10 Meri handdug well1	/	/	/	1927	/	30.11	0	1.59	4.87	32.15	0.57	0.93	1.05	0	2.00	117.5
11 Meri handdug well2	/	/	/	2390	/	32.91	0	0.83	4.79	37.21	4.01	3.65	0.55	0	1.25	145.8
12 Douvenger harvested rainwater	/	/	/	637	/	3.31	0	3.16	0.22	16.17	0.01	1.78	2.39	0	1.89	38.9
13 Meri stream	/	/	/	307	/	7.13	0.13	4.14	2.72	15.04	0.11	0.55	0	0	0.62	18.7
14 Djiddel handdug well	/	/	/	347	/	49.28	0.68	9.66	11.61	70.12	0.21	2.63	10.9	0	5.82	21.2
15 Magadam outlet water	/	/	/	829	/	3.76	0	2.47	2.29	6.46	0.07	0.14	0	0	0	50.6
16 Maroua (Zamay salty borehole)	/	/	/	3101	/	70.51	1.13	5.76	29.70	282.62	1.52	1.34	0.00	0	626.33	189.2
17 Sedek water filtered with defluoridization system	/	/	/	4184	/	64.55	3.96	74.38	25.89	42.17	0.17	24.75	95.43	0	28.57	255
18 Djiddel water filtered with defluoridization system 1	/	/	/	5145	/	49.89	0.82	13.88	10.52	46.30	0.20	2.91	6.70	0	9.97	314
19 Djiddel water filtered with defluoridization system 2				5141		49.11	0.81	13.35	10.50	45.99	0.19	2.84	6.68	0	9.90	313.6

Le Chef du Laboratoire

Mme Massussi Henriette

Potability of the water sources

The potability of the water sources is assessed based on the concentration of three parameters; NO_3, HCO_3 and F.

Based on these parameters (see Figures 3,4,5), all the Mboso domestic rain water harvesting system samples had concentrations below the WHO limits of 45 mg/l (NO_3), 300 mg/l (HCO_3) and the F concentration of 1.5 mg/l, and the local standard of 0.7 mg/l (Fantong et al., 2010). thus the water sources are good for drinking. However, regular monitoring of the sources is advocated.

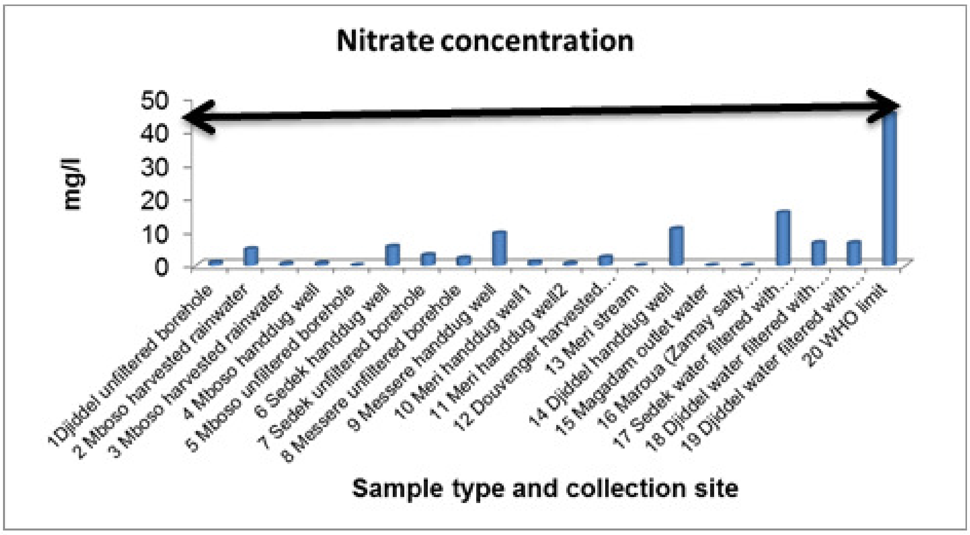

Figure 3 Variation of nitrate concentration in water sources that were sampled. The black doubled edge arrow marks the WHO upper limit

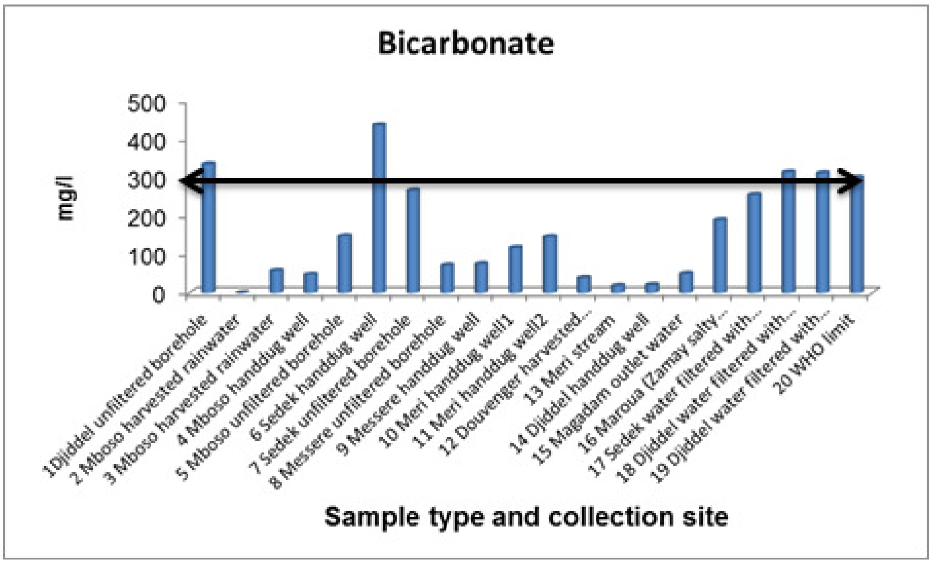

Table 4: Variation of bicarbonate concentration in sampled water sources . The black doubled edge arrow marks the WHO upper limit

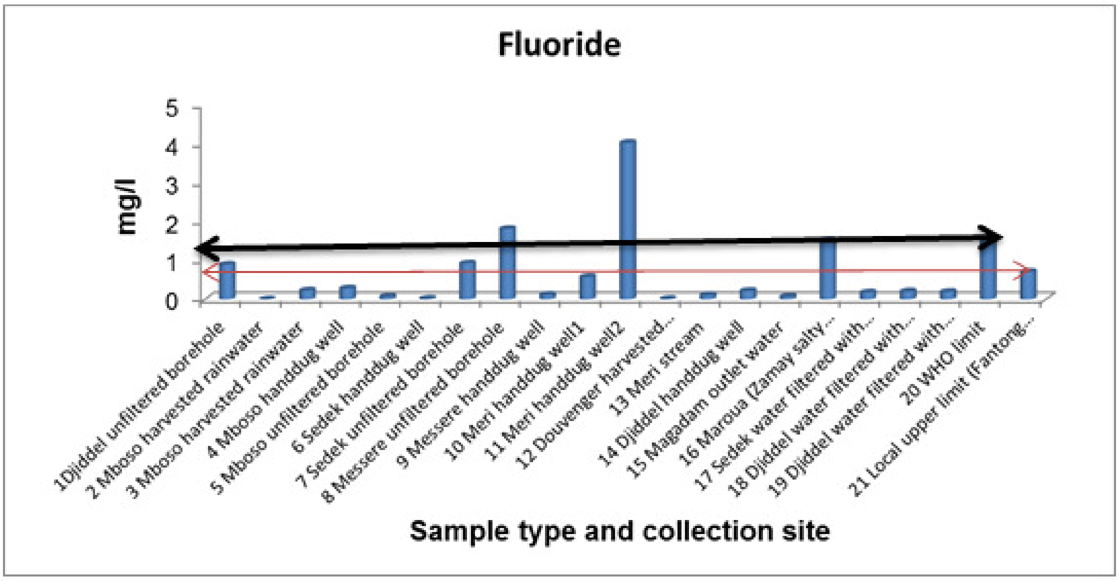

Table 5: Variation of fluoride concentration in water sources that were sampled. The doubled edge arrows marks the WHO upper limit (black) and the local upper limit (Red)

Manifestation of climate change and poverty in the region

Findings from focus group discussions suggest the following to be manifestation of climate change in the region.

a) Longer dry seasons and shorter rainy seasons.
b) Diminishing amount of rainfall
c) Higher temperatures
d) The seasons are more variable (people used to be sure when the rainy season starts and there was continuous rainfall during the rainy season but this is no longer the case).
e) In some areas e.g. Doroum at a higher altitude, there is no noticeable harmattan period in December to February (i.e. it's not as cold as it used to be).

The above manifestations were blamed for the following impacts on the population:

I. Rivers which were previously permanent now dry up in dry season.
II. Water sources especially wells are drying up earlier than before. This has been observed over the last 25 years.
III. Longer distances to walk to carry water (6-7 km) due to water sources drying up earlier than before.
IV. Falling water tables (in some areas used to get water in wells even on hills but now even in lower areas, need to dig deeper to get water in wells).
V. Greater consumption of water in dry season than before due to higher temperatures.
VI. Deforestation has increased.

VII. Longer dry seasons and water sources drying up leads to the consumption of water of poor quality.

VIII. Increased erosion. This is to be expected because of deforestation and drought leading to reduced soil cover which increases the erodibility of the soil.

IX. Decreasing agricultural productivity due to longer dry seasons, unpredictability of the agricultural calendar and increased erosion. This requires soil water management techniques like irrigation and soil water conservation or harvesting.

The participants observed that the ability of the community to adapt to climate change is very low. In their view, further changes or intensification of the same is likely to result to casualty.

Poverty is to be principally blamed for the poor level of adaption by the community. This is further exacerbated by climate change (falling agricultural yields even with application of fertilizer in some cases). This is made worse by absence of a grinding mill and a hospital in area. The stable diet is based on grains and in some cases the closet millet is located about 5 km, a distance that is usually covered after lot of time already spent to fetch water. In the dry season, this may mean on some days women may not have time to prepare food. The absence of health facilities in some localities also imply long distances have to be covered when people are ill, with push cart (where available) being the only mode of transportation.

Also, the poor access to water for multiple uses (domestic use and for crop and animal production) are major barriers to adapting to climate change. Due to longer dry season, the community can't keep big herds of cattle because of insufficient forage for livestock in the dry season.

Furthermore, inadequate knowledge on water management techniques such as water harvesting accounts for the inability of the population to adapt to climate change. This is mostly because most roofs are thatched and cannot be used to collect water. However, it was observed that even people with corrugated aluminium roofs are not collecting water either. There is therefore a problem of low level of awareness, which is typical throughout Cameroon, on water harvesting technology.

Lastly, insufficient income generating activities is another contributing factor to poor adaptation to climate change. Communities would like to plant fruit trees to generate some income but the longer dry periods mean trees will need to be irrigated in the dry season but then there is no water.

Based on the above, successful adaptation to climate change in the region should follow a holistic approach aimed at improving the overall well-being of the community. This requires not only domestic water supply but also water for agriculture (crops, animals, and fisheries), provision of health and educational facilities, income generating activities, availability of a grinding mill among others.

Adoption and Sustainability of the DRWHS Technology

According to Ajaga and Fonteh, 1998, the three key factors which influence the adoption of water harvesting technology in the sudano sahelien part of Cameroon are: the cost, culture, and the nature of the technology.

Cost: Although participants at the focus group discussion expressed a high willingness to pay for the operation and maintenance of the system, the cost of installation of the different components of the system is very high. This is even more so if the system is expected to satisfy potable water demand of the population even only the three driest months. The expressed willingness to pay should not be construed as ability to pay. Rather, it translates to the value of water to the community considering their collective perception of water scarcity as a common enemy. Even with external financing, the cost of the technology for adequate service delivery can be unattractive.

Culture: For a technology to be adoptable and sustainable, it should be integrated into the social structure of the region. From this point of view, there is no problem as the technology is culturally appropriate, as it satisfies a burning need of the community.

Nature of the technology: A key consideration is the technically appropriateness of the technology, that is, it is delivery as designed and expected? On this score, the technology is fine even though some refinements are needed to improve the performance. Other factors of the technology itself that influence its adoption are; its divisibility, its availability to potential users, relative advantage over other technologies, compatibility with existing value system and the complexity of the technology. From the point of the nature of the technology, it can be concluded that the technology is appropriate.

Despite the technological and cultural appropriateness of the roof top rain water harvesting system, its prohibitive cost when applied over a large scale suggests that the technology in its present form (requiring the construction of foundation, concrete pillars and a roof) is not adoptable and sustainable to meet the needs of large communities.

Outcomes

Despite the observed technical and cost challenges, the interventions have been of service to the population considering the provision of some water, though inadequate during the driest months of the year. Though inadequate, the available water has increased their living standards while at the same time curbing the rate of poverty in the region.

With the completion of the project, communities, now have water for religious activities (use for prayers; to be used during Ramadan) serve the drinking needs of passers-by as well as for other socio-cultural manifestations in the community during the dry season.

Furthermore, a reduction has been reported, by an official in the Douroum health centre, in the cases of water related diseases.

Finally, communities claim to have observed an increase in the rate of school attendance by children due to less time spent fetching water.

Lessons learned

The following lessons can be drawn from the interventions as well as the assessment

1) Interventions to reduce the vulnerability of sudano-sahelien communities to climate change should be adequately rooted within a holistic development context to improve the overall well-

being of the community with integrated water resources management (IWRM) as an important component only. Attention must be given to other contributing issues of poverty such as the provision of road infrastructure, schools, health facilities, electricity and a grinding mill to reduce the time needed to travel to mill cereals which are the staple diet of the region. Other measures required include reducing deforestation and catchment protection and management.

2) For a technology to be adoptable and sustainable, it should be integrated into the social structure of the region to satisfy the burning needs of the community.

3) It is important to associate the local municipalities or rural council (commonly called in Cameroon) to provide technical backstopping considering their mandate in community water service delivery.

4) Users/communities are likely to demonstrate a strong willingness to participate in water resource management interventions when it contributes in the improvement of their day to day life. Furthermore, stakeholders and partners become more willing to participate in projects when they see positive results and feedbacks.

5) Filtration of raw water is insufficient to render the water portable. There is therefore need for disinfecting or treating water with local plants like moringa so as to remove the high level of flouride to acceptable levels. It should be noted however that the water quality of DRWHS although marginal is considered to be many times better than water from alternate sources of water used by the population.

6) Lastly, projects of this nature (especially the roof top rain water harvesting system) which requires substantial financing for a limited population may not be attractive because of the cost of construction thus may not be scalable to meet the needs of large communities.

Challenges to Up-Scaling the Technology

Two major challenges were identified which constitute constraints to up scaling roof top DRWHS in the region:

<u>Cost of the system:</u> To meet the needs of the community even for only the three driest months of the year, the size of the collectors and storage tanks have to be greatly increased. This will make the technology in its current form economically inappropriate for a large village. The challenge then is how to reduce the cost of the technology to be able to meet the demands of a large community. The use of existing public buildings as collectors is one option which could be considered to reduce the cost of roof top domestic rain water harvesting systems.

<u>Awareness:</u> For DRWHS to have a major impact on improving the access to water supply in the region, awareness needs to be raised on the technology. Decentralised systems should be encouraged for clustered houses. Households with roofs made with corrugated metal roofing sheets should be encouraged to have their own systems. However, the high cost of the storage tanks will also constitute a challenge.

Importance for IWRM

1) Provision of domestic water supply alone will not result in significant and sustained reduction in the vulnerability of the community to climate change. For improved access to water to be affective as an adaptation measure to climate change, water security has to be enhanced i.e. water needs to be provided for socio-economic development. In rural parts of northern Cameroon; water is needed for uses like irrigation, animal production, and fisheries. In the long term, to ensure water security requires enhancing ground water recharge which in turn reduces runoff and hence reduces soil erosion so that springs and wells can be permanent. This is essentially what IWRM is all about.

2) While this intervention provides lessons for temporal relief, the scope of the project, the limited per capital water provided and the cost of the intervention suggest that this is not a scalable initiative from an economic stand point as well as operation and maintenance.

3) The case further demonstrates the need for active monitoring and evaluation in IWRM for the interventions aimed at reducing vulnerability to climate change. It further makes a case for an "IRWM discovery and innovative funds" that could allow "testing new initiatives" for climate change and water adaptation.

4) Finally, lessons learned through monitoring and evaluation can play a key role in informing and influencing "adaptive interventions" as seen in the on-going solar pump boreholes interventions in northern Cameroon.

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<u>For more information contact:</u>

1. Fidelis Folifac, PhD. International Developmentt Consultant –folifacfidelis@gmail.com
2. Yvonne Ndoping, Young Professional, GWP-CAf: ivyndoping@yahoo.co.uk
3. Hycinth Banseka, Regional Program Manager, GWP-CAf: hycinthb@yahoo.com
4. Luc Mamba, Coordinator, GWP-CAf: lucmamba@gmail.com