



# Canadian Journal of Tropical Geography Revue Canadienne de Géographie Tropicale

CJTG (Online) / RCGT (En ligne)  
ISSN: 2292-4108  
Vol. 6 (2):1-8  
<http://laurentian.ca/cjtg>



## Catchment management and the sustainability of urban water supply. Evidence from Bamenda, Cameroon

*Gestion des bassins versants et la pérennité de l'approvisionnement en eau en milieu urbain : cas de Bamenda, Cameroun*

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### Abstract:

Water is one of the most important resources for humanity. Its regular and sufficient supply remains human's basic requirement. This paper investigates catchment management and its implications for sustainable urban water supply in Bamenda. We systematically sampled 200 households from five neighborhoods in Bamenda. Furthermore, we obtained secondary data from published and unpublished materials. Using SPSS (Version 10.2), we employed the Chi square technique to analyze the results. The findings revealed that natural and anthropogenic factors play a great role in the supply of water; with population growth (80%) being the main cause for anthropogenic factors and sedimentation (41%) being the dominant natural challenge. In addition, the findings reveal that due to inconsistent water supply, coping strategies such as the reliance on other water sources (30.3%) has become commonplace. There is an urgent need to sustain these water sources through sustainable management options such as water metering, water regulation, the construction of more dams around catchment areas, the extension of community water schemes, watershed protection, pressure management and water pricing.

### Résumé:

L'eau est l'une des ressources les plus importantes pour l'humanité. Son approvisionnement régulier et suffisant est d'une grande exigence pour l'être humain. Cet article examine la gestion des bassins versants et ses implications pour un approvisionnement régulier en eau en milieu urbain à Bamenda. Deux cents représentants des ménages qui proviennent de cinq quartiers de Bamenda ont été échantillonnés. De plus, données secondaires ont été obtenues à partir de documents publiés et non publiés. En utilisant le SPSS (Version 10.2), la technique du Chi carré a été retenue pour analyser les résultats. Les résultats ont révélé que les facteurs naturels et anthropiques jouent un rôle important dans l'approvisionnement en eau ; la croissance de la population urbaine domine les facteurs anthropiques à 80%. La sédimentation contribue aux causes naturelles à 41%. En outre, les résultats révèlent qu'en raison de l'approvisionnement inégal en eau, des stratégies d'adaptation comme la dépendance à d'autres sources d'eau (30,3 %) sont devenues monnaie courante. Il est urgent de maintenir ces sources d'eau grâce à des options de gestion cohérente telles que le comptage de l'eau, la régulation de l'eau, la construction de nouveaux barrages autour des bassins versants, l'extension des réseaux d'aqueduc, la protection des bassins versants, la gestion de la pression et la tarification de l'eau.

### Keywords / Mots clés

*Catchment degradation, water management, sustainability, urban water supply, water pricing  
Dégradation du captage, gestion de l'eau, durabilité, alimentation en eau de la ville, tarification de l'eau*

Article history/Histoire de l'article  
**Received / Reçu:** March 28, 2019

**Accepted/Accepté:** June 25, 2019

**Published online/Publié en ligne:** December 25, 2019

## INTRODUCTION

Water is one of the most important resources for humanity. Its regular and sufficient supply remains a human's basic requirement. The supply of adequate and clean water to any community remains the base of building a healthy and prosperous society. The United Nations Environment Program estimates that all human activities require a minimum of 1,700 cubic meters per capita per year (m<sup>3</sup>/capita-year) to live freely from water stress (Water Resources Institute, 2000). Many countries, including India, Germany, Saudi Arabia, and all of Northern Africa, already have far-less water than that available in

groundwater and surface water sources. Water is necessary to support all "biological life, natural processes, communities, the economy, society, and future generations" (Arnold 2009, p. 843). The current water consumption practice in Bamenda is seemingly unsustainable, required effective interventions. To meet the demand for water supply in the future, the growing population of this city needs to conserve and reallocate existing water catchments.

Catchments are instrumental in the effective functioning of hydrological systems, as they ensure ground water recharge and

a steady supply of water for multiple uses (Kimengsi et al., 2018). Despite their importance, it accounts for less than 0.001% of the global water balance with just 0.3% in rivers and lakes (Smithson et al., 2008). Catchment management is the process of formulating, and carrying out a course of action involving the manipulation of resources in the catchment to provide goods and services without adversely affecting the soil and the water base (Gray, 2010). Usually catchment management takes into consideration the social, economic, and institutional factors operating within and outside the catchment. According to Zimmermann (1996), catchment management involves planning, implementing, monitoring and evaluating a course of action over many years, involving a series of interventions to provide water resources that are desired and suitable to the consumers of water. However, this can only hold where the catchment is used by a single community because in a situation of shared water catchments, the communities have to design and implement policies related to their user rights and benefit sharing so that through transfer pricing and other mechanisms, both parties will derive benefits from the exploitation of water resources. Watershed management principally involves identifying and defining the natural resources within the watershed, defining the desired objectives based on local problems, and formulating strategies to achieve the objectives using community participation (Pasaribu, 2000). Multiple-use catchment management may be aimed at management of water, timber, crops, forage, wildlife or minerals on the land for irrigation, pulpwood, food, etc. (Brooks et al., 1991). One important step in determining the condition of a catchment is the assessment of its health. Sheng (1990), considered a degraded watershed as one that has lost its value over time, including the productive potential of land and water resources. It is usually accompanied by marked changes in hydrological behavior of a river system resulting in inferior quality, quantity, and timing of streamflow. This may have resulted from the interaction of physiographic features, climate, and poor land use, deforestation, inappropriate land cultivation, disturbance of soil and slope by mining, construction and improper diversion, storage, transportation, and use of water. A healthy watershed (catchment) is one that can recover from perturbation, being economically viable and environmentally self-sustaining.

Applying efficient and effective measures to manage catchments is of prime importance to the continuous supply of water (Perrens et al. 1984). Most of these measures dependent on the organization of the relief, the stream network as well as the geology of the area. Thus, there are many linkages between these elements and consequently development. Such developments would mainly consist of water supply for domestic, agricultural, general purposes and the generation of energy. However, in a good number of cases, development options are often antagonistic or conflicting. Farming for example may impair water resources and intensive logging may affect water and soil resources. Therefore, a careful analysis of the catchment is a gateway towards sustainable exploitation of resources. Such analysis maybe tailored towards sound management or sustainable soil exploitation for agriculture. The analysis may focus on land suitability and land capability assessments, to determine the combination of physical attributes of the landscape which are suitable for particular land use types (Zeitoun, 2007).

A great number of water catchments (Warner, 2007) characterizes African water resources. Most countries in Africa share water basins. For example, the Nile and Congo transcend several countries (Petrella, 2009). In Cameroon, there are many regional and locally shared catchments. Examples include the watersheds of the western Highlands of Cameroon (Amawa, 2009, Ndenecho, 2007), Adamawa plateau (Amawa, 2009), the Northern Lowland, Sanaga Basin and the southern plateau (Neba, 1999). At the local level, several communities depend on water resources, requiring proper management. Therefore, balancing economic growth and development with water resources is essential. Over the years, considerable efforts have been made to protect catchments in order to ensure a continuous supply of potable water.

Despite all the efforts to match water demand to supply most communities and technical professionals have difficulties from moving from traditional water management concepts towards tangible sustainable water management policy and practices. Because of this, water management has become more and more complex (Walmsley et al, 2002). Therefore, it is essential that existing water resource be managed efficiently and equitably in terms of both quantity and quality, at local, regional and national levels. While a number of studies have explored urban development and land use change issues in Bamenda (Kimengsi et al., 2017; Balgah and Kimengsi, 2016), there is very little information on the implications of catchment management on city water supply in the primate city of Bamenda.

## STUDY AREA AND RESEARCH METHODOLOGY

Bamenda city (Figure 1), one of the towns in the North West Region of Cameroon, is located in Mezam Division. It is located between latitude 5056' and 5058' North of the equator and longitude 100 08' and 100 10' East of the Greenwich Meridian (Neba, 1999). It occupies a surface area of 3,125 hectares (Achou-Chi, 1998). Bafut to the North, Tubah to the East, Santa Sub-Division to the South and Bali and Mbengwi to the West bound it. Around 1899, the town of Bamenda suddenly emerged as the largest urban area in the Western Highlands of Cameroon. This emergence and the sustained population growth which has taken place since then, owes much to its location in the heart of the Grass fields as well as to its location in relation to the city states of Calabar and Enugu in Eastern Nigeria. Its central location and accessibility from the colonial regional city of Enugu were major considerations in the choice of Bamenda as the headquarters of the North-West Province of Cameroon (Achou-Chi, 1998).

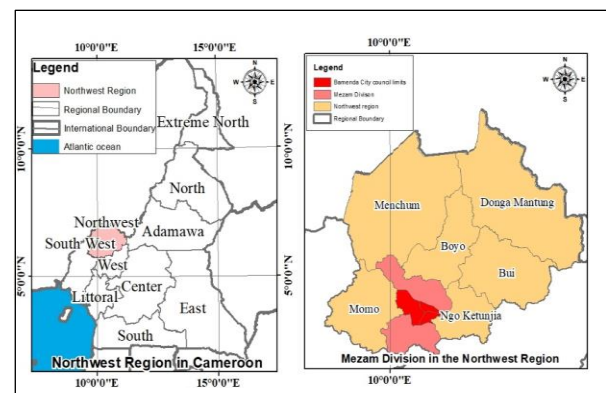


Figure 1: Location of Bamenda in Cameroon

Two hundred household representatives were sampled on catchment management and its impact on sustainable water supply. This study made use of the stratified random sampling techniques whereby five neighborhoods were randomly chosen for the study in order to determine water supply challenges and sustainable management options. The Chi square analytical technique, a non-parametric test, was applied to establish the relationship between hours of water flow and quantity of water consumed. The test was also applied to verify the relationship that exist between inadequate domestic water supply and other sources of water. The result obtained from the calculation were tested at 95% confidence level (0.05 level of significance).

### SPATIAL DISTRIBUTION OF WATER RESOURCES IN BAMENDA CITY

The Bamendankwe Highland is the main watershed of Mezam Division in the North West Region of Cameroon. The city of Bamenda is endowed with a litany of catchments, rivers and streams which are scattered all over the surface area in the different Municipalities (Figure 2). Most of these watersheds, rivers and stream take their rise from Bamenda I (the up station escarpment).

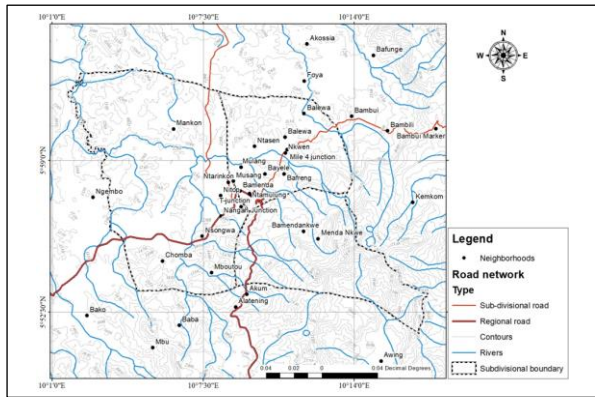


Figure 2: Hydrological map of Bamenda (Modified from the base map of National Institute of Cartography, Cameroon, 2017)

This area has the highest elevation with a height of 2600 m above sea level. While these sources serve as common pool resources, they are usually open to contamination caused by urbanization. In Bamenda city, water supply is the concern of Camerounaise des Eaux (CDE) in corporation with CamWater, Councils and some NGOs. However, today due to the failure recorded by these organizations to supply water, many communities have harnessed their own water supplies from streams or springs (Table 1).

S/N	Organization	Status
1	Ministry of mines, Water Resources and Energy (MINMEE)	Government service
2	SHUMAS Cameroon	Local - NGO
3	Heifer Cameroon	Local- NGO
4	Green Care Cameroon	Local - NGO
5	SURUDEV	Local -NGO
6	The Ntankah Village Women Common initiative Group	Common Initiative Groups
7	Green Cameroon	Local-NGO
8	FEDEV	Local-NGO

Table 1: Active Water Management Organization in Bamenda

### CHALLENGES OF WATER SUPPLY IN THE CITY OF BAMENDA

Both natural and anthropogenic problems stand on the way of effective and efficient exploitation and management of water resources in Bamenda city. The natural factors include climate, geology and difficult topography as well as erosion and sedimentation. Anthropogenic factors include conflicting land use types, deforestation, inadequate finances, and pollution.

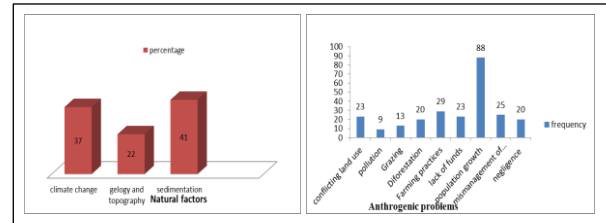


Figure 3: Natural and Anthropogenic factors affecting potable water supply

It is observed from Figure 3 that 41% of the respondents indicated that sedimentation is the main natural factor affecting the supply of water followed due to unsustainable farming practices that are carried out besides the streams and rivers. This is equally followed by climate change (37%), and geology and topography (22%). It is also from anthropogenic factors that population growth 88% is the main factor affecting potable water supply and pollution being the least factor with 9%. Table 2 shows that there was a significant relationship between inadequate domestic water supply and other sources of water; Chi square value ( $\chi^2$ ) = 31.576; significant at  $P = 0.01$ . A greater proportion of the respondents were dissatisfied with the amount of water they needed for domestic consumption because of this, they had to use other sources of water such as rainwater, boreholes, wells, spring and streams for water.

		* Water Source Cross tabulation					
		boreholes	Rainwater	Wells	Both Spring/St ream	Total	
Do you have Adequate Water for Domestic Use?	Yes	Count	2	4	8	5	19
	% within Do you have Adequate Water for Domestic Use?		10.5%	21.1%	42.1%	26.3%	100.0 %
	No	Count	35	9	7	80	131
	% within Do you have Adequate Water for Domestic Use?		26.7%	6.9%	5.3%	61.1%	100.0 %
Total		Count	37	13	15	85	150
		% within Do you have Adequate Water for Domestic Use?	24.7%	8.7%	10.0%	56.7%	100.0 %

Chi square value ( $\chi^2$ ) = 31.576; significant at  $P = 0.01$

Table 2: Relationship between amount of potable water stored and length of water flow

From the results above on Table 3, it is clear that there is a significant relationship between consumers' perception on the hours of water flow and the quantity of water consumed per day per household; Chi square value ( $\chi^2$ ) = 33.206; significant at  $P = 0.01$ . A greater proportion of the respondents (37.0% and 45.5%) who were able to carry water amounting from 200 litres and above respectively were in the category of those who complained water flows just weekly. This explains the fact that in situation where water flows only once in a week, consumers tend to consume relatively higher quantity of water compared to situations of constant water flow.

Quantity of water	How often Do you have Potable Pipe Borne Water?				
	Few Hours	Constant Flow Everyday	Weekly	Monthly	Total
50 Litres	0	0	0	2	2
	0.0%	0.0%	0.0%	100.0%	100.0%
80 Litres	6	2	4	2	14
	42.9%	14.3%	28.6%	14.3%	100.0%
150 Litres	7	10	10	0	27
	25.9%	37.0%	37.0%	0.0%	100.0%
200 Litres	5	6	10	1	22
	22.7%	27.3%	45.5%	4.5%	100.0%
250+ Litres	37	16	24	8	85
	43.5%	18.8%	28.2%	9.4%	100.0%

Chi square value ( $\chi^2$ ) = 33.206; significant at  $P = 0.01$ .

Table 3. Relationship between quantity of water consumption per day and the length of time the water flows in a given time

## CATCHMENT MANAGEMENT PRACTICES

### PROTECTION FORESTRY

Populations adjacent to the catchment areas have been prohibited by water authorities' from carrying out any form of logging or deforestation in or around these areas. As forests are cleared and the land becomes increasingly degraded through misuse, this affects the flow of water. In an environment with vegetative cover, the soil acts like a gigantic sponge, storing a vast quantity of water that is used by plants and trees or released gently into streams and rivers. Vegetation depletion reduces the storage capacity of this sponge, leading to water shortages during dry seasons. During the wet seasons, brief destructive floods occur. This strategy is therefore used to prevent unsustainable farming and logging, Pollution of soil on which forests grow as well as expanding city development caused by population explosion and the resulting urban sprawl as seen on (Figure 4).



Figure 4: Thorny shrubs for protection against its accessibility to animals and humans

### PRODUCTION FORESTRY

Forests production has a great role to play in enhancing water quality. Studies in Nigeria, Indonesia and other countries have shown that, when the forest is removed, minerals and nutrients that trees absorb or recycle make their way, unchecked, into drainage water. Apart from the disadvantage of losing minerals and nutrients from the immediate area, the extra nutrients in the water enhance the growth of oxygen-depleting organisms on canal and riverbeds. Forest buffer zones around lakes and streams act as a filtering system, reducing the amount of sediment, agricultural chemicals and pesticides in the watercourses. The loss of this filtering system results in high levels of sediment and dissolved minerals in rivers and streams,

which reduce crop growth and disrupt fisheries. Therefore, reforestation on unstable land and around streams have been used to help increase the water-retention capacity of land and improve water quality (Figure 5).

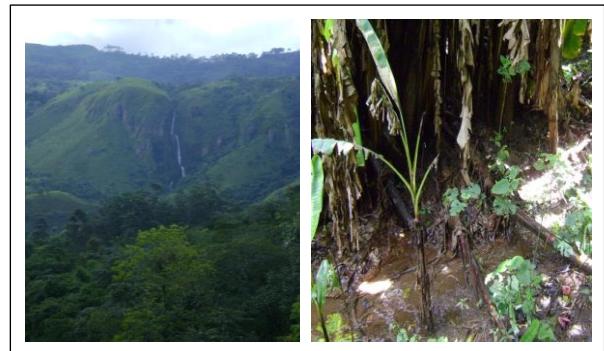


Figure 5: Catchments covered with waterlogged trees

### GULLY CONTROL WORKS

Gullies are an important part of the soil erosion process and their occurrence and development may cause serious problems to a region's economy. Gully erosion produces channels larger than rills. These channels carry water either after and during rains (Schwab et al, 1981). It is caused by improper land use, overgrazing, improper land development, road construction, livestock and vehicles trail. Gully control regulate the runoff and peak rates, prevent diversion of runoff water upstream the gully area.

### ZERO OR MINIMUM TILLAGE

Improperly managed agricultural activities may influence surface water by contributing nutrients, pesticides, sediment, and bacteria, or by altering stream flow (Figure 6). Since agricultural activities often comprise a significant proportion of land use in catchment areas, and thus constitute an issue that must be addressed as part of an integrated catchment management approach (ICM), zero or minimum tillage has been used to reduce the sediment entering a river, by greatly reducing sensitive cultivation practices. Management techniques include, ploughing, planting along the contour, which reduces soil loss from a slope, prevent sediments from leaving buffer strips to watercourses.



Figure 6: External view of the Catchment site with minimum tillage

Figure 7 shows that catchment management practices such as protection forestry (53%), production forestry (21%), zero or

minimum tillage (19%), and gully control works (7%) as the key practices in the study sites.

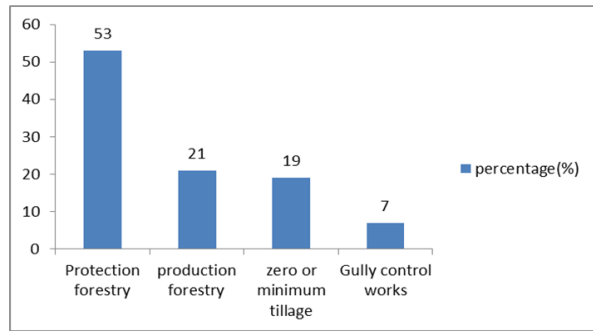


Figure 7: Percentage distribution of the catchment management Practices

## MARKET GARDENING AND URBAN AGRICULTURE

Market gardening is an activity that is characterized by the cultivation of fruit and vegetables for commercial and subsistence purposes. It is common in urban areas. In the case of Bamenda city, it is carried out to serve the markets with fruits and vegetables all year round. Crop planted here include onions, parsley, tomatoes and other fruits. Given the fact that the dry season affects soil moisture for such an activity it then becomes a problem to supply market gardening products all year round (Figure 8).



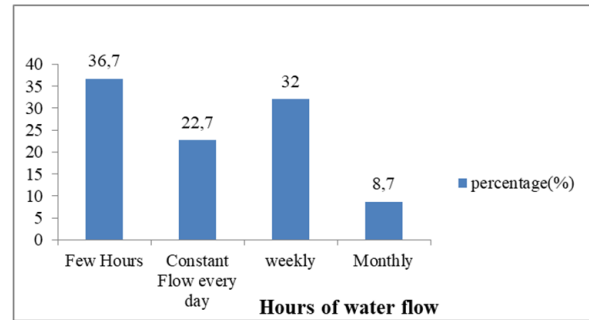
Figure 8: Market gardening along riverbanks

Market gardening as an activity affects water supply especially when it is done around catchment areas. Consequently, pollution of surface and ground water by intensive agriculture is a major issue.

## IMPLICATION OF WATER SUPPLY CHALLENGES

### DOMESTIC CONSUMPTION

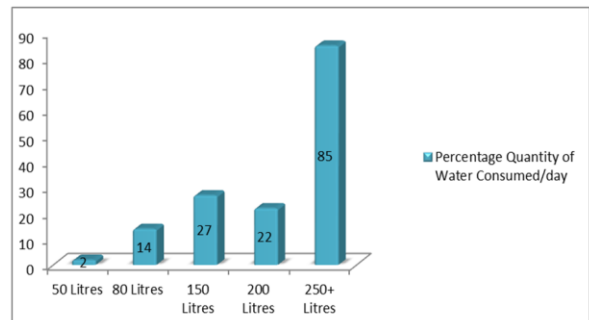
Water shortage has a serious effect on domestic consumption in Bamenda. Most of inhabitants do not have enough water for domestic water consumption and other water uses. Figure 9 reveals that 13.0% of the respondents appreciated the fact that they have enough water for household consumption while a majority of them (87%) said they do not have sufficient water for domestic consumption.



Source: Field Work, 2017

Figure 9: Respondent perception on the hours of water flow

As a result, communities have resorted to accessing polluted water sources for domestic consumption a possible medium for the transmission of water borne diseases such as cholera, typhoid and dysentery. A water stress condition is a result of unsustainable household or domestic water consumption patterns. In the 1980's, water consumption increased to about 300 liters per day. Recent study indicates that the average water consumption per person in urban centers is about 500 liters per day. Equally, a water stress condition is a result of unsustainable household or domestic water consumption patterns (Figure 10).



Source: Field Work, 2017

Figure 10: Percentage of quantity of water consumed per day

It is observed from Figure 10 that a majority (56.7%) of the respondents consume more than 250 liters of water per day. Furthermore, 18.0% were able to limit daily household water consumption to 150 liters. Close to 15% consumed up to 200 liters daily, while 9.3% consume 80 liters. The least consumption unit for water by household was 50 liters with a percentage respondent of 1.3%. As a result, communities will resort to accessing polluted water sources for domestic consumption, which act as a possible medium for the transmission of water borne diseases mentioned above.

### GENDER IMPLICATIONS

The concept of gender equality is a much-embraced concept in the third Millennium. The World Bank defines gender equality in terms of equality under the law, equality of opportunity (including equal rewards for work and equality of voice (the ability to influence and contribute to the development process)). The gender implications of water shortages in Bamenda city stems from the fact that women and children have to cover long distances to fetch water in streams which are far off especially as the stand pipes dry up during the dry season (Figure 11).

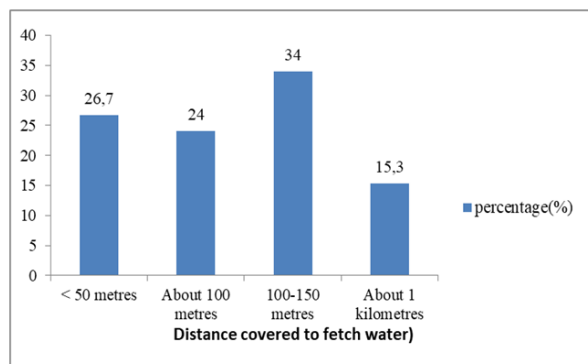


Figure 11: Respondent perception on the distance covered to fetch water

Figure 11 shows that a greater percentage of the respondents (34.0 %) covered a minimum distance of 100 – 150 m to fetch water, while 15.3 % of the population were able to cover close to a kilometre just to have potable drinking water. Again, 26.7% were fortunate to have potable drinking water at close proximity of less than 50m away from their residence while 24 % moved for about 100 m to access potable water within their localities in the Bamenda Municipalities. This is a common phenomenon in the North West region where women are left to take charge of most activities. This reduces the productivity of that society since the people tend to travel long distances to obtain water. Therefore, gender consideration need to be looked upon when making decisions on community water projects.

#### COPING STRATEGIES IMPLEMENTED

In other to management the problem of inconsistent water supply in the area. Various stakeholders including the government, the municipal councils, NGOs and the local communities have adopted friendly humanitarian services to cope with water stress in the study area as shown on Figure 12.

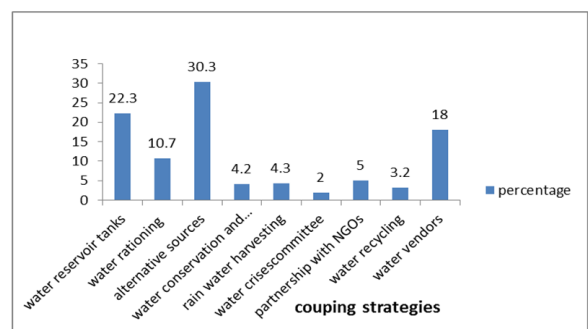


Figure 12: Coping strategy in the changing supply of water in the city of Bamenda

As a coping strategy, the findings revealed that 22.3% of the respondents use water stored in tanks, 30.3% depend on alternative water sources such as boreholes, wells, vendors or walk long distances to fetch water in other neighborhoods. 10.2 % depend on water rationing, 4.2% on water conservation, 4.3% on rainwater harvesting, 2 % on water crises committee, 5% on NGOs and finally 3.2% on water recycling. As shown on Figure 13, 15.2% of the respondents are for watershed protection, 15.8% for replacement and promotion of staffs, 12.5% water utility measures, 10.3 % information and education, 10.7% water pricing, 9.3% for pressure management, 8.3% for water metering, 7.2% for water use regulations and 5.7% encourage

community water and 5% construction of dams at catchment zones.

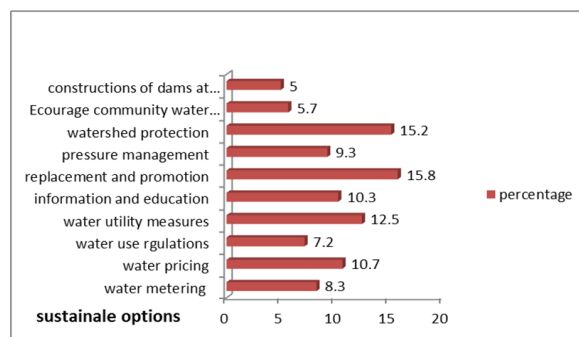


Figure 13: Propose Measures for Sustainable Water Management

## CONCLUSION AND RECOMMENDATION

Bamenda municipality is endowed with water resources which if harnessed and properly managed will go a long way to improve the potable water situation of Bamenda. The following conclusions can be drawn firstly at 0.05 level of significance there is a relationship between inadequate potable water supply and other sources of water. Therefore there is a need to improve management and potable water supply utilities. Secondly at 0.05 level of significance there is a relationship between quantity of potable water stored per day and the length of time the water flows in a given time. There is therefore the need to improve the length of time water flow as most respondents complain there are not able to store enough water for consumption.

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#### To cite this article

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##### Electronic reference

Nancy Fulai Chiaga, Jude Ndzifon Kimengsi and Balgah Sounders Nguh, (2019). « Catchment management and the sustainability of urban water supply. Evidence from Bamenda, Cameroon ». Canadian journal of tropical geography/Revue canadienne de géographie tropicale [Online], Vol. (6) 2. Online in December 25, 2019, pp. 1-8. URL: <http://laurentian.ca/cjtg>

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