



Evaluation of Current Issues in Water Supply Systems and Implications for Sustainable Urban Water Management in Limbe, South West Region of Cameroon

Baba Adamu^{1*}, Ndi Humphrey N.² and Balgah Sounders N.¹

¹Department of Geography, University of Buea, P.O.Box. 63 Buea, Cameroon.

²Department of Geography, the University of Yaoundé, Cameroon.

Authors' contributions

This work was carried out in collaboration amongst all authors. All authors read and approved the final manuscript.

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ABSTRACT

Water supply system has played a significant role in the growth, development and wellbeing of cities. Until now, meeting the need of city residents in terms of availability, reliability, and access to a good quality water supply is a major challenge facing many denizens of the 21st Century due to unprecedented urban growth and urbanization rates. This study is out to examine the current issues and challenges to water supply systems in Limbe. The study adopted the mix method approach which involves triangulation of quantitative and qualitative methods of data collection. Primary data were obtained from field observations, interviews and the administration of 383 questionnaires to households and stakeholders. Secondary data were obtained from relevant official documents, published and unpublished sources relevant to water supply systems. Satellite imageries and ArcGIS were used to describe the pattern of growth in built-up areas between 1986 and 2019. Data from the questionnaire were entered using Epi Data Version 3.1, analysed using the Statistical Package for Social Science Standard version 21.0 and Microsoft Excel and presented in the form of tables, figures, plates and maps. Findings revealed that, although the water supply accessibility by utilities has improved significantly, the reliability, distribution, flow frequency, supply, price and quality are still low. The inaccessibility and unreliability in the water supply have turned most households to alternative sources with poor quality. Unsustain urbanization and urban growth are occurring through infills in city remaining open spaces and 'out spill' and expansion at the outskirts

*Corresponding author: E-mail: Babaadamu17@gmail.com;

without a concurrent increase, upgrading or extension of water supply infrastructural systems resulting to congestion, conflict over allocation, long-distance trekking to source water, deterioration of basic social services, pollution, inaccessibility amongst to ensure efficient water supply systems and sustainable urban water management. The paper, therefore, calls for the rehabilitation and renovation of dilapidated water supply structures, extension and upgrading basic services, limit urbanization and urban growth, encourage the construction and use of alternative water sources, community participation amongst others for sustainable urban water supply management.

Keywords: *Water supply systems; urbanization; urban growth; challenges; sustainable water management; Limbe.*

1. INTRODUCTION

In the dawn of the 21st Century, cities and towns in both developed and developing world are becoming a metropolis of thousands and millions or more inhabitants. This has led to diverse challenges ranging from electricity, housing, education, security, health to water supply systems and waste management [1]. The future of these challenges could be unprecedented given the view that by 2030, over 2/3 or 60% of the world's population will live in towns and cities [2-5]. Hence, human population growth accompanied by climate change is putting pressure on the world's most precious resource (water supply systems) [6].

Water security, or having the right amount and quality of water in the right place at the right time, fosters social, and economic progress of humankind [7]. Water supply systems consideration should therefore include the source of supply if they are safe and sufficient enough or reliable to meet the per capita water demand, accessible and regular, convenient and available at an affordable price [7,6]. It is imperative for city stakeholders to maintain drinking water supply systems and operate them more efficiently, rationally and sustainably.

According to SDGs 6 on clean water supply and sanitation of the United Nations (2030) on "*ensuring availability and sustainable management of water and sanitation for all*", some 10% of the worlds' population live without clean drinking water supply and 1/3 lacks a basic sewage system [8]. As a result, the health and socio-economic consequences on groundwater and the economy are serious [9,10]. Although water supply problems are centered around issues of accessibility and flow frequency, water distribution, allocation, reliability, quality, affordability amongst others also play a significant role towards efficient and sustainable urban water supply system management for the

growing city inhabitants of both developed and developing world [10].

Therefore, city life is not tantamount with improved standards of living in terms of provision of social services like water supply based on standard models and values [4;7]. This is often a battle for survival in awfully polluted squatters and slums neighbourhoods of some developing countries. Here, public utilities and social services such as water supply, energy and health care are a luxury or inadequately supplied due to limited capacities, infrastructures, investment, corruption, rapid urbanization and population growth [5]. In such situations, it is difficult to enforce policies aimed at preventing or at least adapting to growing challenges of unsustainable urbanization, environmental changes and/or water pollution.

The rate of urban growth in developing countries is a mismatch with the rate of population growth and service provision due to limited forward spatial planning [11,12]. According to [13,3] over 700 and 800 million people in Sub-Saharan Africa (SSA), that is some over 60% and 65% of the entire population of the region, still have limited or no access to adequate water supply services. This means that the region has the world's highest water supply accessibility, reliability, quality and affordability gaps than any other developing region in the world, according to the World Commission on Water for the 21st Century. This is due to mismanagement, population explosion and rapid urbanization. [4,14] further expresses concern and warns that by 2030, around 87% of the inhabitants of the world with no access to the water supply will be living in SSA. This dilemma adversely affects other realms of life ranging from health, education, employment and life expectancy. Thus, these have significantly increased the burden on utilities and policymakers towards sustainable urban water management [15].

In Cameroon, the water crisis is virtually common and critical in all urban areas due to rapid urbanization and urban growth. The rate of urbanization in Cameroon moved from 28.3% in 1976 to 55% in 2016, with a population growth rate of 2.5% and urban population growth rate at 4% per year [16]. The urbanization process in Cameroon can be attributed to natural increase, rural-urban migration and transformation of rural land into urban land. CAMWATER utility networks are unreliable, intermittent and in most cases degraded or inaccessible to the majority of the population. Thus, a high dependency on unsafe supplementary sources of water supply (wells, springs, boreholes, rivers) by local communities [17,9] which are susceptible to water-borne diseases, the most common being dysentery and typhoid fever. Also, congestion, conflict, delays at water sources, high prices and long-distance trekking by residents mostly children and women constitute other constraints of inadequate water supply systems in Cameroonian cities and towns [9]. Significantly, in Cameroon, constraints to water supply systems and related services are evident due to inadequate infrastructures and water supply, power failures, corruption, high illiteracy rate and limited investment. Water availability also varies with seasons [9,15]. [18] observed that about 60% of urban residents in Cameroon lacked access to improved drinking water. With the number of water resources available to the country's South, water shortages should ideally not be a problem for the nation's developed especially in Limbe [19] an emerging city labelled as a "water empire."

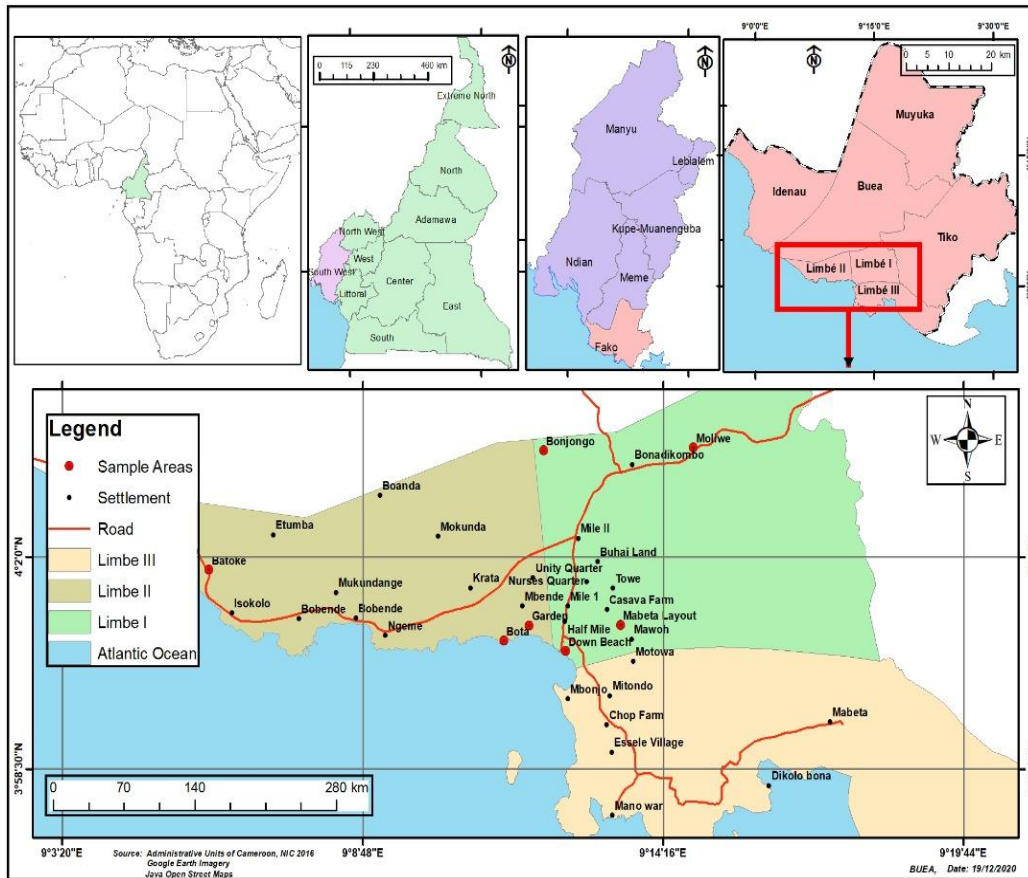
Limbe the epicenter of this study characterized by inadequate quality and quantity of water supply is amongst the fastest growing cities in Cameroon with an average population growth rate of 4.2% [20]. It is a primate city in the Fako Division and amongst the first three in the South West Region after Buea and Kumba. The city plays a major significant role in the political, economic and social spheres of the country and therefore attract a huge number of migrants from other parts of the country. The city also provides a plethora of opportunities that attract further migrants (7000 yearly) especially the youthful population [21]. Due to inadequate access to safe, affordability, reliability and conventional urban water sources for the teeming population, necessity could push urban populations to seek alternatives sources or buy water at high prices. Already, in Limbe, human water use could exceed annual average water replenishment due

to human and non-human exigencies. This emanates from unsustainable urbanization and rapid urban growth. The implications of this scenario could have increased pressure and consequences on the potability, accessibility, reliability and quality of water supply. Furthermore, with high prices for water consumption, denizens could be forced to developed unimproved alternative sources of water supply or trek long distances to water sources. These could add to their health and wellbeing difficulties. It is for this reason that this paper seeks to examine the current issues in water supply systems and focused on urbanization and urban growth as the major challenge to the adequate and efficient water supply system. It also seeks to propose sustainable urban water management strategies. These are imperative for both water managers and city planners to design proper policies and programmes for the city of Limbe as well as other cities in Cameroon toward solving the problem.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

Limbe -the Fako Divisional Headquarter is located in the south-west region of Cameroon between 3o 90' and 4o 05' Latitude and 9o 29' and 9o 06'E Longitudes (Map 1). It is a coastal region that has approximately 50.0km of Atlantic Ocean coastline to the southwest. This acts as a "dead-end" to spatial urban growth and expansion of the city. The city consists of over 27 communities with an estimated population of 224418 inhabitants and a total surface area of about 248.6 km² giving it a population density of about 1,78 persons per km²[21]. Limbe is made up of three Sub Division (Limbe I, II and III) bordered in the South by the Atlantic Ocean, in the North and North-East by Buea and Tiko Subdivisions respectively and in the West by the Idenau Subdivision. The annual rainfall is high, with yearly precipitations varying from 150 to 6000mm in the last 34 years from different stations while the average daily temperature ranges from 26.5°C - 28°C [22;23]. The undulating relief ranges from 0-300masl [24]. The continuous rock outcrops in the city make it difficult for urban development and controls to take place. It creates extra costs due to the difficult terrain and this has inhibited urban planning consideration and water management projects and controls to effectively take place. Residents are left with no option than to move down valleys and lowland to fetch water for their survival.



Map 1. Limbe in Fako Division, South West Region of Cameroon
 Source: [25]

Limbe is an important hub for Cameroon's Development Agenda in the 21st Century, that is the implementation of the Emergency National Development Plan (2020-2030) of the Cameroon Government. The city is therefore called upon to provide many socio-economic and heavy capital investment in the construction, agricultural, mining industries and many other informal activities. These socio-economic functions are attracting and will continue to pull huge population numbers from migration into the city for job creation leading to natural increase and urban growth. This beyond doubt could pose significant direct/indirect effects on urban water supply systems and related services.

2.2 Data, Sample and Variables

This study adopts the social science methodology including both qualitative and quantitative research designs. A triangulation approach was adopted in this study and this involved the combination of research methods

(or approaches). Triangulation focused on the collection and analyses of qualitative and quantitative data [26,27]. In this regard, two different types of mixed methods were employed in this study. The concurrent transformative mixed method and the concurrent triangulation method. In the same study, some indicators were better verified through a qualitative approach while others needed a quantitative approach. As part of the qualitative design, primary data were obtained from field observations, photographs, interviews with officials and a semi-structured questionnaire administered to households and detailed descriptions (thematic-content analysis) of indicators like urban regulations, water supply systems strategies and infrastructures were undertaken. Interviews, variables were identified and incorporated in the questionnaire administered to households.

To ensure validity and reliability, a pre-test of the questionnaire was conducted involving 20 households selected at random from some

neighbourhood in Limbe. Based on the nature of their responses; the questions were adjusted and modified to obtain proper info from the respondents. As a justification for the retrospective views, data from secondary sources were obtained from the Internet World Wide Web, websites of National and International organizations such as World Health Organization, World Bank, United Nations Environment Programme (UNEP), Water Aid, Project websites, libraries and Journal articles, books and unpublished sources.

2.2.1 Population samples

The target population for the survey were residents of Limbe who have lived in the city for over 10 years to be able to make a better appraisal of the current water supply systems and changes in water supply quantity, quality, distribution, affordability and changes in population and urban growth over time and space. The study made use of a stratified random sampling technique. Limbe was stratified into three strata following the three Sub-Divisional council areas. After getting a list of all the neighbourhoods, the selection of neighbourhoods for the household survey was done by assigning numbers to all the neighbourhoods and later dropping them in a box. From this, the neighbourhoods were drawn at random. The sample size of the study was selected from the number of households in the different neighbourhoods obtained from the results of the 2005 population (This was considered as there exist no clear data on current census data for the city) and housing census. This was estimated using sample calculated for one proportion with the support of Epi Info 6.04d [26,27].

$$n = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)} \quad (1)$$

This formula is used to determine the number of housing units from which the sampling size for this study was determined.

Where

- N= Total targeted population here considered being 55,226 households.
- Z= Z value corresponding to the 95% confidence level.

Z α /2 = Level of significance = 1.96.

P= prevalence; the prospected prevalence used is 50% assuming an optimal sample size.

d= Absolute precision set at 5%.

n = sample size

The sample size estimated is 423 households with a minimum expected return of 383. Based on this, 12 neighbourhoods were selected from Limbe I and Limbe II respectively followed by 5 Neighbourhoods in Limbe III. Table 1 presents the distribution of respondents in Limbe.

Most importantly, promises of confidentiality and strict academic usage of responses added assurance to the respondents who were required to provide personal or demographic information to this study. Meanwhile, some officials had to share their opinions on sensitive urban planning and water supply management issues. As such, the instruments did not request the names of respondents while for average monthly incomes, for instance, ranges or subgroups were provided for the respondents to identify their range without actually stating their exact personal information. Moreover, for most officials, the researcher submitted a formal application letter explaining the importance of the study while attaching a copy of the Departmental research authorization which made the officials more comfortable participating in the study.

2.3 Data Analysis

The data generated from the questionnaires were subjected to statistical analysis to descriptive and inferential statistics. Responses from the open-ended items were analysed qualitatively using the thematic approach. Data was entered using EpiData Version 3.1 and analysed using the Statistical Package for Social Sciences (SPSS) Standard version, Release 21.0 and Microsoft Excel. Data clean-up (content clean-up and exploratory statistics), was done through Exploratory Statistics. Frequency distributions presented in the form of tables and figures were used to describe and evaluate the current issues of water supply systems of respondents and stakeholders. Satellite imageries for two time periods; 1987 and 2019 were downloaded, ArcGIS was used to generate a map describing changes in urban built-up in Limbe.

Table 1. Distribution of questionnaire to respondents in Limbe

Municipality	Neighbourhoods	Population	Number of Households	Sampled Respondents	% of Respondents
Limbe I	Down Beach	4,949	1234	22	9.6
	Mawoh	4,456	875	10	4.4
	Cassava Farm	8,345	1105	20	8.8
	Unitary Quarters	6,479	943	15	6.6
	Moliwe	14,205	9043	28	12.2
	Bojongo	16,890	2121	13	5.8
	Bonadikombo	13415	443	17	7.5
	Towe	6,632	876	19	8.3
	Wotutu	2,422	9041	7	3.1
	Dock Yard	6,999	1232	20	8.7
	Church Street	2,909	1654	25	11
	New Town	12,345	1321	32	14
Total for Limbe I		84,792	28,567	228	100
Limbe II	Batoke	14,000	3212	12	11.4
	Ngeme	2,074	2121	19	18.0
	Krata	1,042	321	5	4.7
	Mbende	1,001	9904	7	6.6
	Gardens	14,205	2432	26	25
	Bota Land	2,234	1342	7	6.6
	Kie	1,673	321	6	5.7
	GRA	1,673	654	6	5.7
	Limbe Camp	4,255	453	4	3.8
	Wovia	1,042	2123	6	5.7
	Cite SONARA	2,256	345	3	2.9
	Cite SIC	4,346	567	4	3.7
Total for Limbe II		45,455	22,883	105	100
Limbe III	Kaduna	1,843	456	12	24
	Mboko	1,743	896	2	4
	Mbonjo	8,354	1100	20	40
	Big Campo	6,479	1123	14	28
	New Land	3,846	201	2	4
Total for Limbe III		22,265	3,776	50	100
Total		152512	55226	383	100

Source: Fieldwork, 2020

3. RESULTS AND DISCUSSIONS

3.1 Current Issues of Water Supply Systems in Limbe

This section examined the current state of affairs of water supply systems in Limbe in terms of water supply distribution and infrastructure, accessibility, frequency, affordability, reliability and quality.

3.1.1 Nature, functionality of water supply and distribution infrastructures

In Limbe, the water production and distribution infrastructure have been stretched beyond its capacity. For instance, during the redevelopment of the water reservoir tank at Mile 4 in the 1960s, it was estimated to meet the need of only 986,300 inhabitants but today, according to the [20] population estimate, the population has grown to over 200,0000 inhabitants without a

corresponding increase in water supply capacities. The water production deficit in Limbe in November 2018 was 230,000m³. This was the result of a shortage of electricity for the water production plant, limited skillful human resources and investment. When the pipes run dry, water collected from the reservoir tank is supplied through a single tanker to various neighbourhoods in Limbe (Plate 1.). Averagely, over 52,000 liters of water is supplied to households through the tanker each day. Despite this, the water is scarce because residents do not only need it to domestic purposes such as drinking but also for other uses ranging from industrial, agricultural and recreational uses.

The study critically assesses the level of satisfaction with water distribution systems characteristics in Limbe. The results of populations responses summarized in Fig. 1 reveal that 60% of the respondents were dissatisfied with the water distribution systems

because of the limited capacity of the reservoir tank which has not been expanded by the water utilities to meet the growing demands of the people. They were also dissatisfied with treatment plants which divert the policy of treatment to consumers using local households' technique and tools (filtering, boiling, heating or chlorination). The following ideas were captured in this category: the distribution line do not follow the transportation lines with a respondent rate of (80%), followed by distribution do not covers the entire city (70%), distribution systems do not avoid water quality deterioration after treatment (60%), nor are they separated from the sewage systems (48%), the layout of distribution systems do not minimize water lost during repairs (45%) and distribution lines were laid above roads pavements (24%). A significant minority of the respondents (30%) were clustered around satisfied with the distribution systems exceptionally high for distribution lines was laid below road pavement and not above (67%). However, about 10% of respondents were self-reliant and do not care about the distribution system in Limbe as being good or bad (Fig. 1.). These perceptions as opined by interview data reveals that the water distribution situation is precarious in Mabeta and Bojongo high-altitude settlements and new layout (NLOs) areas respectively because of poor coordination. Hence, there is no follow up by the authorities to investigate the quality of the water or the flow frequency specifically if it remains the same after being treated at the reservoir tank are affected by diverse urban geographies and environmental changes. This means that, if settlements like Mile

4, Bojongo and Mile 2 have a breakage in the water distribution line, the entire city might be affected until the situation is regularized due to planning deficiencies. This affects not only the households' use of water but also non-residential users. This is often the case when out-missions' allowances are given to plumbers by the utilities (CAMWATER) before the systems are maintained or hardly maintained. Information is hardly given to the water utility company due to poor communication between them to ensure efficiency and good quality of water supply. Despite arrangements in the water distribution, CAMWATER can only meet the demand of a very tiny but about 45% of Limbe's population. Moreover, limited provisions are available for fire-fighting services resulting in significant fire damages costing millions of FCFA yearly to the economy of Limbe. The few available functional infrastructures operate below capacity and hardly meet increasing demands. Therefore, planners have failed to optimized the water supply infrastructure to meet the current need of the population in Limbe. Findings reveal that a significant proportion of the stakeholders' views indicated that, 53% of urban water supply infrastructures in Limbe were above 60+ years of their life span, 31% were about 21-60 years old and only a few proportions of the water supply infrastructure were less than 20 years. This, however, was above the minimum required life span for urban water infrastructure of 15 years signaling a serious need for planning adjustment to limit health and socio-economic crises. Table 2 presents the nature of taps in some neighbourhoods of Limbe.



Plate 1. A: Water collection by a truck from CAMWATER head office at mile 2 B: Subsequent distribution to inhabitants facing acute water scarcity in Mabeta, Limbe

NB: Water collection vessels are line up according to the time of arrival of the residents at the collection unit to avoid conflict with a significant majority of women at the collection point

Source: Fieldwork, 2020

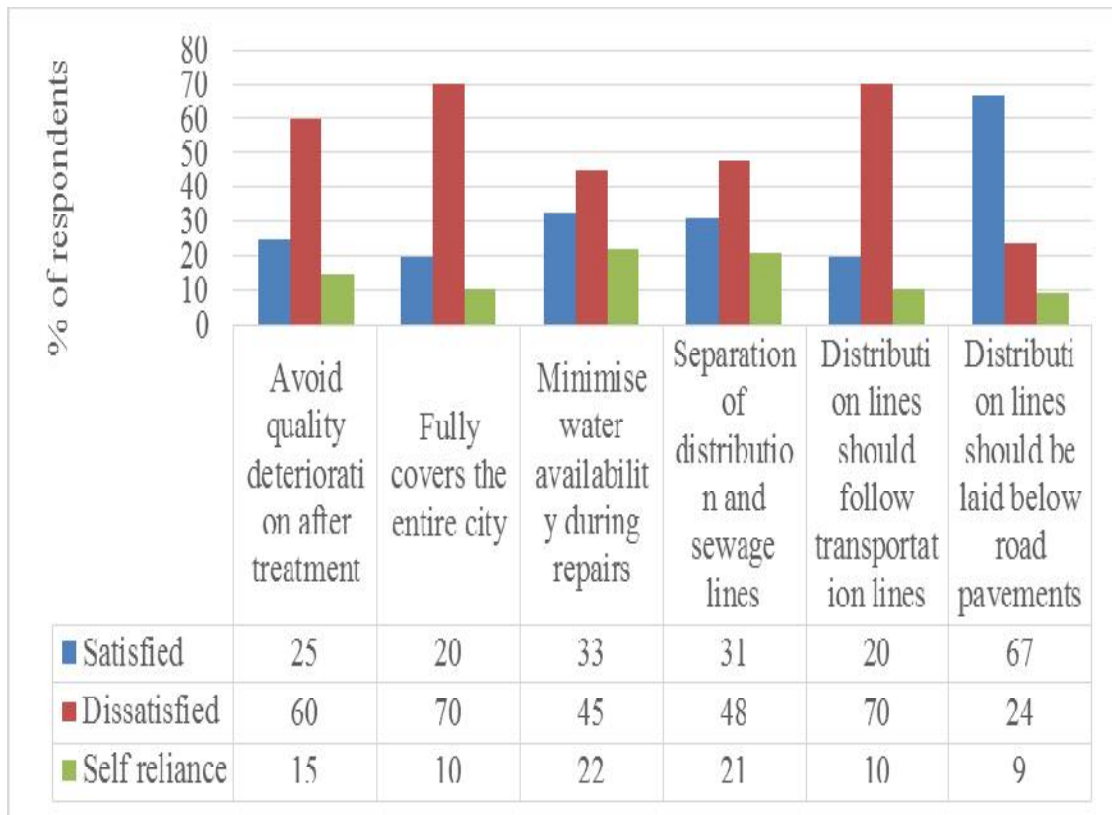


Fig. 1. Respondents' perceptions of water distribution parameters in Limbe
 Source: Fieldwork, 2020

Table 2. Nature of taps in some selected neighbourhoods in Limbe

SN	Sampled neighbourhoods	Number of functional Taps	% of functional Taps	Number of non-functional taps	% of functional Taps	Total Number of Taps	%
1	Down Beach	4	57.14	3	42.86	7	100
2	Limbe Camp	6	85.71	1	14.29	7	100
3	CDC Camp	6	66.67	3	33.33	9	100
4	New Layout	3	60.00	2	40.00	5	100
5	Cite SIC	1	100.00	0	0.00	1	100
6	Cite SONARA	1	50.00	1	50.00	2	100
7	Botaland	3	100.00	0	0.00	3	100
8	Middle Farms	1	25.00	3	75.00	4	100
9	Limbola	2	33.33	4	66.67	6	100
10	Mile II	3	75.00	1	25.00	4	100
11	New Town	3	33.33	6	66.67	9	100
12	Mokundange	2	50.00	2	50.00	4	100
13	Mbende	1	14.29	6	85.71	7	100
Total		36	52.94	32	47.06	68	100
Max		6	100	6	85.71	9	100
Min		1	14.29	0	0	1	100

Source: Fieldwork (2020)

As presented in Table 2, there are a total number of 68 taps of which 52.94% (63) are functional and 47.6% (68) are non-functional. The maximum number of functional taps based on the sampled neighbourhood was recorded in Limbe and CDC Camp with 6 taps each while the minimum functional taps with gross severity were recorded in Mbende, Middle Farms, Cite SONARA and Cite SIC neighbourhoods each having one functional. For non-functional taps, the maximum number by neighbourhood was found to be in Mbende, New Town, Middle Farms and Limbola and CDC Camp each registering 87.71%, 75%, 66.67% non-functionality respectively while the minimum number of non-functional taps were recorded in Bota land neighbourhood with 100% functionality. Going by neighbourhood, it is revealed the maximum of taps are found within New Town and CDC Camp (9) with 66.67% (6) and 33.33% of them being functional respectively while 33.33% (3) and 66.67% (6) respectively are non-functional. On the other hand, the lowest number of taps are found within Cite SIC and SONARA, which have 01 and 02 taps of which only 01 is functional. This study corroborates that of [11] who observed variation in functional and non-function stand post in Buea.

Significantly, the metering system, one of the most important components of the water supply system infrastructures, is lacking in many neighbourhoods. CAMWATER carryout the metering process and installation to improve the quality and reliability of water supply to their customers following prescribed norms and standards. To the city residents in Limbe, water metering is unimportant as they cannot afford the meter rent. A significant majority of respondents (57.5%) perceived that the meter was functioning properly. As for the 42.5% who indicated that metering system was not functioning properly attributed the following reasons: advanced damage of meters representing 66.2%, outdated water system 63.5%, over the flow of the meter systems 47.3%, and illegal connection by neighbours 9.5%. Furthermore, the populations living in high rise buildings complained that because of the low pressure of water flow more than 3/4 of their meters do get bad, yet they are not exempted from exorbitant bills. Likewise, the functionality of taps and showers, flushing toilets in Limbe has hovered over the years to around 70% as explained by officials at CAMWATER, while many systems considered functional do not provide safe water supply round the clock as explained by the respondents due to electricity

failures or worn out/outdated infrastructures. Plate 1. presents the diverse nature of water supply infrastructures in Limbe characterized by functional non-functional infrastructures, alternative water sources, congestion at water sources amongst others.

Moreover, illegal connections by recalcitrant individuals, high-income individuals, celebrating events or mismanagement result in un-functional water supply infrastructures. Plate 2 shows the extent to which the water supply system and tap are exposed to wear and tear. Most of these meters are not certified or cited following prescribed urban planning regulations or norms put in place or properly managed. As such, they tend to be damaged by children playing, vehicles or flash flooding which causes eroding particles to collide with the metering systems since they are not protected.

3.1.2 Access to improved water sources

The perceptions of residents on access to water sources are diverse. The results are summarized and presented in Fig. 2.

Fig. 2. shows the percentage of respondents with access to diversified improved water sources in Limbe. A significant majority of respondents are increasingly relying on public taps and this was represented by 94.5% (361) of the total respondent's views. This was followed by the use of a stream/rivers (27.1%) by respondents. Private home connection was also significantly higher (64.8%) for respondents in Limbe. However, access to harnessed spring and community water supply sources did not vary significantly as represented by 45.4% (172) and 44.9% (172) respectively. Hand pumped wells represents 39.2% (149) of the sampled respondents, Boreholes 35.5% (136), rain-water harvesting represent 31.3% (120) while bottled (sacked) water represent 20.6% of the sampled household respondents in Limbe.

Significantly access to water sources by residents in Limbe varies due to diversities in relief, population composition, government priorities and level of income among individuals and residential types. According to CAMWATER, there were over 15750 subscribers to piped water connections in the various households in Limbe in 2019. However, households in Limbe rely on an estimated 193 functional public tap connections. Accordingly, a stand post should be provided where household water supply is not

possible with an output of at least 12 liters per minute. This was not consistent in Limbe as the average output recorded were 6.5 and 4.2 liters per minute respectively. Generally, one tap is estimated for every 250 persons [24]. This is seldom the case in Limbe as the respondents continue having acute access to the water supply as presented on Table 3.

From Table 3. although the use of water from these public sources (taps) should be freely provided according to most (79%) of the respondents, only respondents in Wotutu and Wovia have the highest level of water accessibility in Limbe. The rest of the neighbourhoods have poor accessibility and therefore need more water supply infrastructures in terms of planning adjustments by the city authorities. The situation, although expected to be minimal, Down Beach and Limbe Camp have high accessibility to taps to the standard average of 250 persons per stand post as stipulated by the [27] (Table 4). Likewise, water vendors

collect water from fissures or broken pipes and later sell it to the households who cannot access formal water supply. The handling of such water is often very doubtful. Conversely, respondents indicated that they use unimproved water sources as a backup to the unreliable water supply from CAMWATER. These alternative water sources are not well ensured by the water management authorities or the utility to ensure good quality water as prescribed by norms. To the respondents, this was often due to limited coordination and supervision. This was evidenced by poor water supply infrastructures observed during a field survey in Limbe. The more well-to-do respondents also backup their supply with wells and boreholes. More than 60% of households now have or are planning to have a borehole representing approximately 1km² of the entire surface area of Limbe giving an average of 0.5 boreholes per km². This was an attempt by the city authority to make water supply accessible to the population by determining areas of shortage and abundance.



Plate 2. Nature of water supply infrastructures in Limbe

Notice functional and non-functional taps/stand-posts, unprotected catchment reservoir, degraded metering system, unprotected well, congestion at a borehole water source and illegal water collection via fissures by school pupils in New Town, Mabeta, Bota Land, Ngeme, Gardens and Wotutu respectively

Source: Fieldwork and Google.com, 2020

Significantly, in settlements like Mabeta, a total absence of piped water (unreliable and rationed) means that all water would have to come from unregulated and highly contaminated springs and wells over boreholes. Thus, to satisfy the goals of universal access to water as declared in Agenda 21, all squatter households would need to drill a private well and install a proper cover or boreholes to ensure safe water. This, however, involves a significant cost and many households cannot afford the cost of procurement unless subsidized by the government. For instance, over 79% of interviewed household heads in planned settlements reveal that it could cost an average of about 1.5 to 2 million FCFA but not less than 1 million for a household to install a borehole. This however varies significantly depending on the relief configuration of Limbe. Hence, boreholes are prohibitively expensive for many city dwellers of Limbe especially for those in the poorer neighbourhoods. There are no government subsidies to ensure that respondents of Limbe have access to the water supply through borehole development or ensure their quality control and protection as prescribed by the decentralization process in Cameroon which calls for capacity building and enhancement of community development. The limited ones in unplanned settlements are shallowly built, poorly developed and cited near septic tanks. This

constitutes a long-term source of environmental pollution affecting human health. As a solution to this, wealthier householders in such settlements have extended 'yard taps' to their neighbours for which they usually charging them either periodically or by volume of water harvested. Moreover, in unplanned zones, poor households depend on locally developed wells that have stood the ordeal of time, ranging from 10 to 60 years with little or no rehabilitation. Many new settlements are now evolving up without provisions for public water supply systems (stand post). Even where they are available, they are not functional due to unreliable water supply.

Water collected from these sources is hardly treated thus posing substantial health risks, especially in informally high dense settlements. The springs and shallow wells located in the valley bottoms of these areas are prone to flooding and contamination due to heavy rains. This was the experience for many respondents in Dock Yard and Molowe which must deal with floods affecting water supply sources during the rainy season. Rainwater supply through an unimproved water source is also common as reported by respondents of these areas. Collected from house roofs, this source is an important backup source in the poorer unplanned sections of the city.

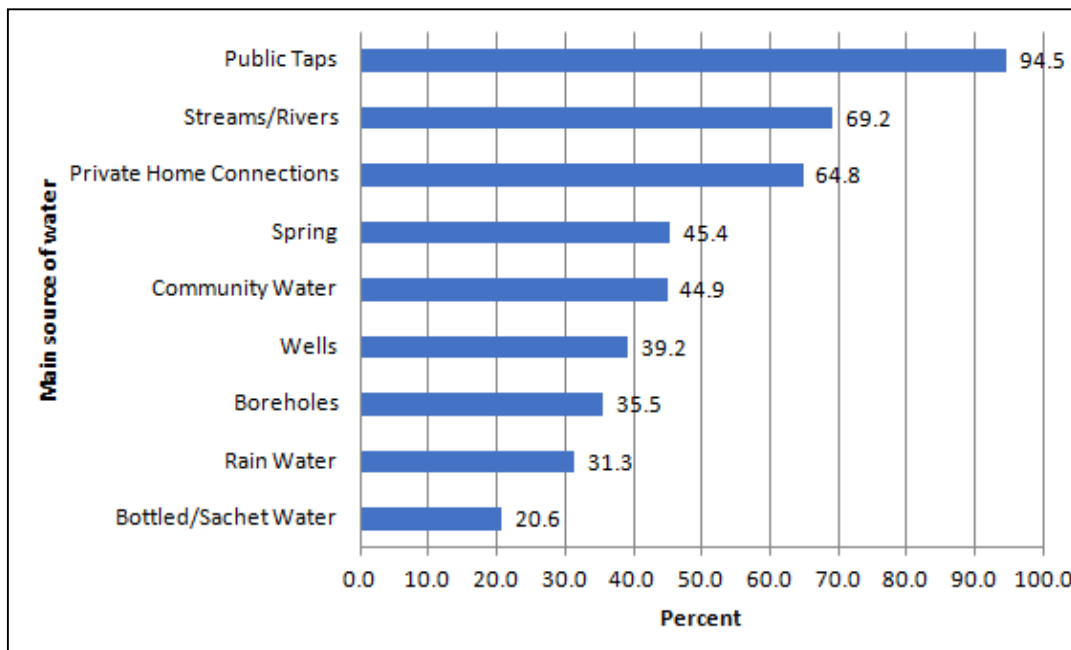


Fig. 2. Perception of respondents' access to improved water sources in Limbe
 Source: Fieldwork, 2020

Table 3. Average number of persons per standpipe in some selected neighbourhoods

Location (a)	Total No taps (b)	Population (c)	Water access situation (Average persons/tap) $d=(c/b)$	Deviations from UN Standard (250 persons/tap) $e=d-250$	Neighbourhoods by level of access to water (based on d) (f)	No of taps to be provided $g=e/250$	Rounded values (h)
Wototo	13	2,422	186	-64	1 st	-0.25	0
Wovia	5	1,042	208	-42	2 nd	-0.17	0
Ngeme	7	2,074	296	46	3 rd	0.19	1
Batoke	27	14,000	519	269	4 th	1.07	2
Church Street	5	2,909	582	332	5 th	1.33	2
Bojongo	29	16,890	582	332	5 th	1.33	2
Mabeta	13	8,354	643	393	7 th	1.57	2
Bebone	2	1,673	837	587	8 th	2.35	3
Molowe	14	14,205	1015	765	9 th	3.06	4
Mawoh	4	4,456	1114	864	10 th	3.46	4
Dock Yard I	5	6,999	1400	1150	11 th	4.60	5
Motowoh	4	9,654	2414	2164	12 th	8.65	9
Cassava Farm	3	8,345	2782	2532	13 th	10.13	11

Source: Fieldwork, 2020

3.1.3 Frequency of water collection

Frequency is the number of times a phenomenon occurs and in this case number of times used to collect water from the source in Limbe. Findings reveal that 43.4% of the respondents fetched water over four times a day, 36.1% do so three times a day while 20.5% collect water twice or less in a day as shown in Table 4. Unlike what obtains in the developed world, the number of times water is collected by households is a strong indicator of quality health and wellbeing. This goes beyond the average limit of twice per day by [28].

The results based on Chi-Square computations revealed no significant difference in the water collection frequency by subdivisions within Limbe (χ^2 -test: $\chi^2=0.228$; $df=2$; $P=0.892$). The variability in collection periods is seen even during the 2019 flooding episode in New Town, Mabeta and Bojongo, where respondents underwent a successive round trip of more than five times per day to collect water at Church Street and Mutengene. Failure to undergo these round-trips means that respondents would consume polluted water. Relief Aid- an NGO - tried to redress the situation through water distribution in tankers and Super Mont bottled water but their strategy met stiff resistance from the municipal authorities. All too often, water use at different times as a resource availability varies with season, poverty and population densities which cause respondents to use supplies that are not fit to drink and are given an unreliable discharge.

3.1.4 Distance covered to the main water source

According to [29], the geographic access to potable water is measured by the fraction of the populace with access to a sufficient volume of clean water situated in or at a distance not far away from the user's dwelling or home, that is, at a convenient distance of at least 200 meters to acquire the water when it is not present within the residential areas. The distance set by TPL regulation is at less than 50m from any house or residential areas, camping field or stadium. When the effluent generates some odor, the distance is extended to 100 m. The distance is even less than for the catchment area for drinking water and 50m from the water bank as per the principle of the design specification for Town Planning Laws stipulated by Law No. 2204/003 in Cameroon. The land allocation

within the forbidden zone shall be designated as public land. The prescribed zone according to the LCC is between 30m. This average distance might depend on the character of the respondent's neighbourhood (location, geography, relief and accessibility). Moreover, stand post/handpumps, boreholes or harness springs connected to pipes should not be more than 500m from the targeted households [28]. Field evidence reveals that a significant majority of households cover more than 101-500m to source for water and this was perceived to be high (34.1%) by respondents from Limbe I than those (24.6%) from the Limbe II and III. The distances of water sources from the premises are shown in Table 5.

There is no statistically significant difference between municipalities and time taken to fetch water from the source if not connected to piped water sources ($\chi^2=4.265$; $df=5$; $P=0.512$). However, the geographic access to water sources outside residential areas is thus considerably bad for the city dwellers of Limbe. According to the respondents' views, 3/4 of the sample respondents do not have access to water outside their homes. They are forced to trek over long distances to fetch water. This activity in Limbe is mostly practised by women and girl children contrary to what prevails in other countries. This distance of water sources from premises in Limbe does not correspond to the international standard distance to source for water which should not be less than 200m or 500m for taps of the user's dwelling as per [27] standards regarding measures of accessibility to water supply sources.

3.1.5 Revenue collection and marketability by utilities

Revenue from water consumption is an important indicator of the urban water supply system and urban planning processes in Limbe. About 3/4 of the respondents of Limbe due to high prices for water consumption do not pay for water utilities and this has significantly affected the productivity of the urban systems unless alternative planning strategies in terms of subsidies are implemented by the central authorities. Payment for water services was significant across subdivisions in Limbe (χ^2 -test: $\chi^2=1.097$; $df=1$; $P=0.295$). So too was the level of satisfaction ($\chi^2=1.671$; $df=2$; $P=0.434$) which was limited to many respondents (49.8%) in Limbe III. According to CAMWATER, the collection efficiency for metered water in Limbe was between 35% and 40%. Out of the 90,560 bills that are sent out quarterly, only

35,000 were making full or partial payments. Likewise, in terms of marketing coverage, there are no hopes for future optimism by CAMWATER to save all the residents in Limbe. Despite an increase in the market demand for water over the years from 40% in 2010 to 60% in 2015 and 70% in 2019, CAMWATER coverage is only around 30% of the entire Limbe. Therefore, CAMWATER does not need to only increase production capacity, distribution efficiency, cost recovery and energy use but has to install facilities, encourage alternative providers and reduce the rate of unaccounted for water (24%) across settlements in a bit to ensure reliable and equal access to the water supply. The issues of payment for water services are yet to be fully efficient resulting in persistent conflict over water pricing between the consumers and the utilities due to limited formulation or implementation of norms and values related to subsidies and tax reductions.

3.1.6 Water supply affordability

Critically, water rates from various systems are a strong determinant for policies related to investment, cost and uses (Table 6.). It could be well planned by the city authorities to meet the goals of minimizing the cost of production, maximizing profit and averting consumer and supplier conflict. This is more especially as most

of the water supply system cost has to be shifted to the consumers in the form of fee charges which the majority could not afford. Findings reveal that the average respondents could afford to pay 7906 FCFA every month for public taps use and 9,772.73 FCFA for yearly use. However, it was more economically for the household to make a yearly payment if they were considered to pay monthly as represented by 814.3942 FCFA. With regards to monthly water connection payment for water use, a significant majority of the household indicated paying up 7670.87 FCFA.

Even though their yearly payment is only 8166.67 FCFA, they felt that it was economical if the monthly sum is calculated as they will pay a lesser or cheaper amount. Low income respondents using taps, vendors and kiosks pay much time more than respondents medium and high income of Limbe who use boreholes and private home connections. This corroborates the situation in Asian and Latin American cities where informal dwellers pay 20 USD per month for 6m³ of water, whereas the rich informal settlement pays 4 USD per month for 30m³ of water. Hence, the poor pay 25 times more per 1m³ than the rich and for a much worse service [30]. The high cost of sourcing water has also further impoverished Limbe residents.

Table 4. Frequency of water collected in Limbe

Municipalities	Stats	Number of times water is collected per day in Limbe			Total
		Twice a Day or Less	Three Times a Day	> Four Times a Day	
Limbe I	N	9	17	18	44
	%	20.5%	38.6%	40.9%	100.0%
Limbe II	N	16	27	35	78
	%	20.5%	34.6%	44.9%	100.0%
Limbe III	N	8	18	56	82
	%	11.2%	26.3%	62.5%	100%
Total	N	33	44	53	130
	%	20.5%	36.1%	43.4%	100.0%

Source: Fieldwork, 2020

Table 5. Distance covered to the main water source in Limbe

Municipality	Stats	Distances covered to the main water source						Total
		<30m	31-50m	51-100m	101-500m	501-1km	1km+	
Limbe I	N	5	13	6	15	3	2	44
	%	11.4%	29.5%	13.6%	34.1%	6.8%	4.5%	100%
Limbe II	N	11	16	18	19	7	7	78
	%	14.1%	20.5%	23.1%	24.4%	9.0%	9.0%	100%
Limbe III	N	8	18	35	16	27	16	120
	%	11.2%	26.3%	44.9%	20.5%	34.6%	20.5%	100%
Total	N	24	47	54	50	37	25	236
	%	13.1%	23.8%	19.7%	27.9%	8.2%	7.4%	100%

Source: Fieldwork, 2020

Table 6. Affordability payments for water consumption by improved water sources

Water Sources	Amount paid for water use (FCFA)		
	Monthly	Yearly	Yearly/12
Public tap	7906	9772.73	814.3942
Borehole	7820.83	9136.36	761.3633
Bottle water	6233.23	5375	447.9167
Community water	7687.47	7906.25	658.8542
Own connection unmetered	8608.04	8866.67	738.8892
Own connection metered	7670.87	8166.67	680.5558
Water kiosk	8276.64	13437.5	1119.792
Neighbours' connection	7323.05	5833.33	486.1108
Total	61526.13	68494.51	5707.876

Source: Fieldwork, 2020

Significantly, the cumulative amount of a year divided by the total number of months of water payment in Limbe is constant, cheaper and more cost-effective for households than those paying monthly or yearly from all the sources. For instance, in Limbe electricity consumption due to water pumping represents a significant portion of water production cost in the water supply system that needs to be covered through water payment. However, the optimization of the water supply system using optimal network controls could reduce energy consumption and improve efficiency.

3.1.7 Reliability and quality of water supply

Findings from the study reveals that pipe-borne water supply frequently fails in Limbe. That is many parts of the city lack water supply mainly for drinking especially during the dry season (Fig. 4.). Reliability of water supply is a complex indicator due to failure of the physical components of the water supply systems in terms of pipes, reservoir tanks, electricity supply amongst others. These may result from poor management, fundamental inadequacy, natural and anthropogenic forces like rapid urbanization and environmental degradation without which infrastructures should be reliable to supply adequate water need of the population. Within the framework of the government, the city of Limbe operates a utility company CAMWATER under the direct control of the Ministry of Water Resources and Energy (MINEE) which is responsible for water supply and distribution. The system is however unreliable for all the city surrounding as presented in Fig. 3.

Findings on Fig. 3. reveal that pipe-borne water fails frequently in Limbe with a proportion of 37.6% (144) followed by 31.9% (122) for households who indicate water fails occasionally,

18% (69) for never flows and 8.6% (33) for those who indicate that water never falls. The limited reliability of water supply if not regularized could be estimated to cost hundreds of thousands of FCFA in access time, health, education. These impacts are expected to increase in the future. As a rule, it was observed that the lesser the reliability of the water supply, the greater the volume of storage required by the respondents. The residents are forced to be supplied with drinking water from drilled wells, boreholes or springs Hence, one of the biggest concerns to urban planners and city authorities at the household and the city levels remains that of water contamination and the consequent impact on health and city development. Because water supply and sanitation are two key drivers of public health as real by Goal 6 of the SDGs (UN, 2030), the water supply crisis impact on public health in Limbe is dire. Indeed, it could put the city population at risk of diseases like dysentery, diarrhea, typhoid and schistosomiasis just to name but these. Testing of all the water quality parameters by utilities in Limbe based on national and international standard quality for drinking water are less frequent due to limited knowledge, technology and investment and therefore there are multiple routes of transmission of pathogens. The contamination of the water supplies (non-point pollution and point pollution) results from multiple sources as presented on Fig. 4.

From the figure, the main causes of water pollution in Limbe is flooding as represented by 60.3% (231) of the respondents, followed by poor waste management 56.7% (217), poor water infrastructure 52.2% (200), chemical fertilizer application in farms 34.7% (133) poor septic tanks 23.8% and the least deforestation with only 9.9% (38) of the respondents during the field survey. Because of these factors, a significant majority (43.2%) of respondents in Limbe

acknowledge being sick due to water contamination while 33% acknowledge that their reasons for being sick are not associated with water contamination but other outlining health issues not related to water contamination. Hence, findings reveal that the common water-borne illnesses suffered by the respondents of Limbe were typhoid fever (33.3%), diarrhea (27.7%), cholera (16.2%), dysentery (10%),

schistosomiasis (8%) worms (4.8%) as presented on Fig. 5. Also, long-term storage of water in unprotected containers is a cause of water-borne ailments for many household residents in Limbe. In such cases, the respondents were not encouraged by health officials to store water for long periods because the people and authorities could not trust system safety.

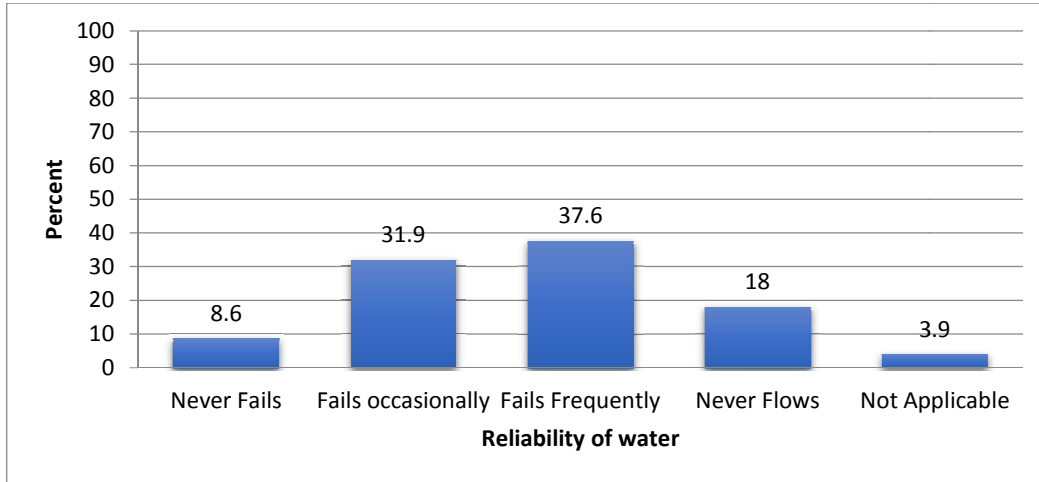


Fig. 3. Perceived reliability of water supply systems in Limbe

Source: Fieldwork, 2020

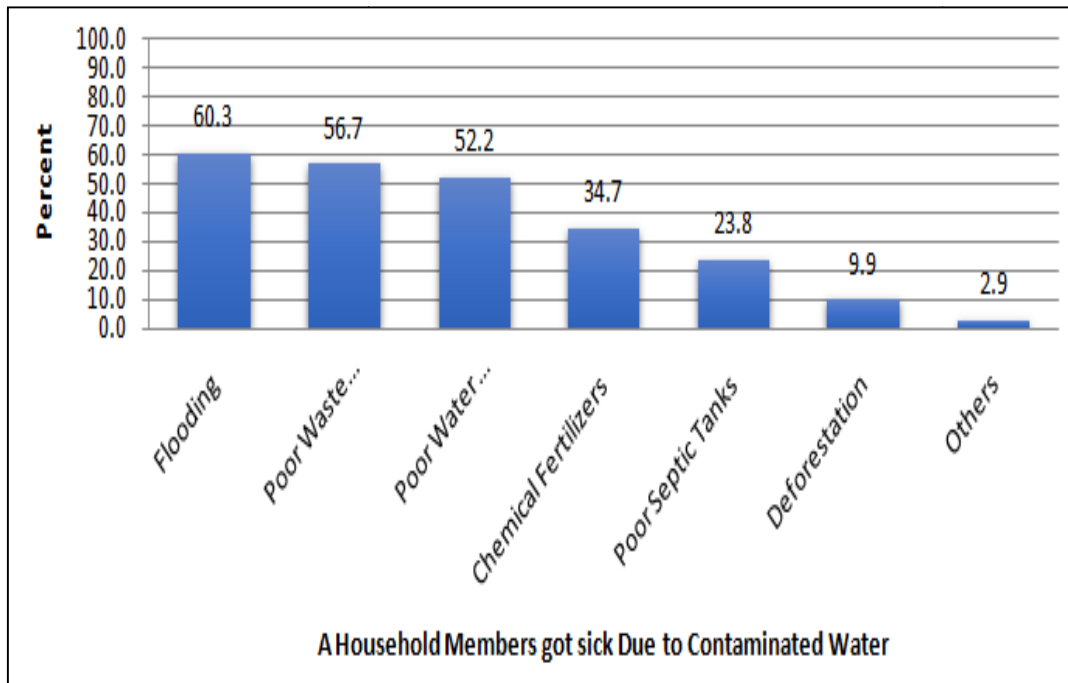


Fig. 4. Distribution of the major sources of water pollution in Limbe

Source: Fieldwork, 2020

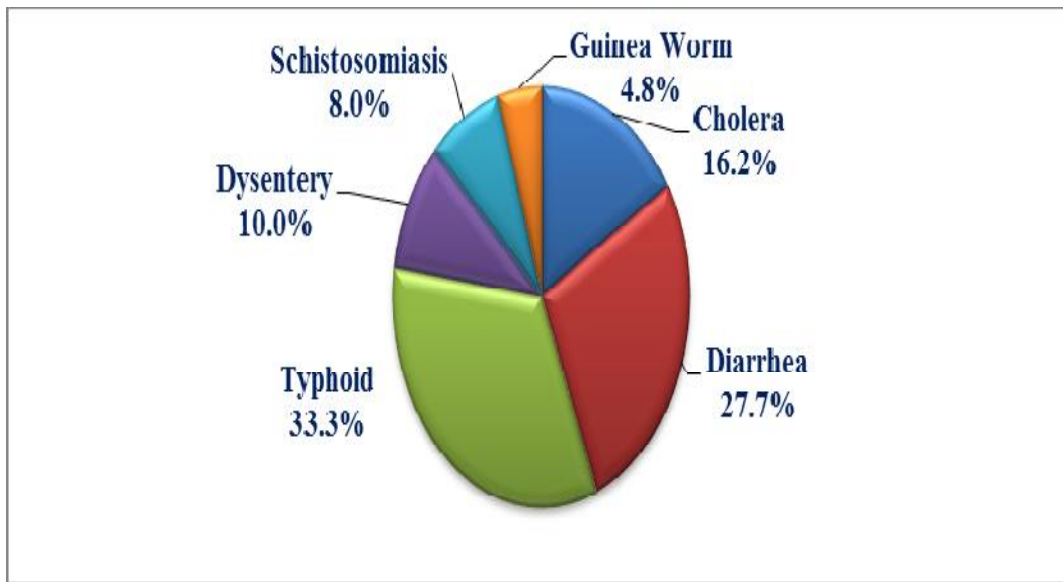


Fig. 5. Distribution of illnesses linked with poor quality of water in Limbe

Source: Fieldwork, 2020

The recent analysis of pipe-borne water supply shown by this study in the city reveals that occasionally, the quality of the water is far below the safety standards stipulated by WHO. The microbiological analysis of water samples from Limbe river shows that the water was highly polluted due to solid waste dumping, poor farming practices and flooding. For instance, the coliform count at the upper course was 46 and 61 for dry and rainy season compared to the WHO limit of 0.00cfu/100ml. The lower course was all greater than 100cfu/100ml for the dry and rainy season. This is the reason why a significant majority of the respondents (43.2%) usually get sick as a result of water contamination while only 33.2% of the sampled household got sick due to other causes different from water contamination. This study corroborates a study by [31,25,11] on physical-chemical and biological analysis of water supply in Dchange, Limbe and Buea Municipalities respectively.

3.2 Urbanization and Urban Growth Challenges

The urbanization process in Limbe is occurring at an unprecedented rate without a correspondent increase in the provision of social services. The population of Limbe has more than doubled in the last few decades, and hence the demand for basic social services especially with an increasing standard of living and purchasing power of people, so that, the increased

productive activities generated by such demands have had a tremendous impact on the water demand. The urban population of Limbe could be put 58% while the rural population is only 42% [20]. The sex ratio of Limbe's population is reflective of that of the nation characterized by a ratio of 48:52 for male and female respectively. The population pyramid of Limbe is a progressive one characterized by 51% of youths of less than 12-18 years [20]. Sex and age variations of the population structure in Limbe is a strong indicator for continual growth in the population with consequential pressure on social service deliveries in both the short and long-run. The rate of urbanization in Limbe has increased from 3.4% in 1990, 3.8% in 2010 and to 4.2% annual change in 2019 amongst the highest in the country [32,33,19]. The urban population is unevenly distributed amongst the different neighbourhoods with the bulk of it concentrated in Limbe I and II Sub Divisions unlike in Limbe III. Most of the population is made of youths engage in sustaining activities like trading, farming and schooling. Hence, the most important socio-economic activity in the area is farming through tourism, industrial activities are also gaining prominent accounting for high rates of water demand resulting to conflict over water allocation for domestic and non-domestic users. Compared to the Independent and Unification eras of the 1960s and 1970s, the population of Limbe has increased from 3310 inhabitants to 12586 inhabitants in 1978 to 141325 inhabitants in 2005

[34]. Population census statistics put the population of Limbe at 167606 inhabitants in 2010 and presently the population of Limbe stands at 224418 inhabitants (BUCREP, 2019). In 2015, the population growth rate of Limbe was estimated at 2.6% annually and with a population growth density of 235 people per square kilometer in 2016 and projected to increase to about 369 by 2022 (Table 7) [31].

The increase in the urbanization (over 50%) especially with the current Anglophone crisis (2016-2010) [35]. More specifically population of Limbe comes as a result of not only birth rate, advancement in health care services, early marriages amongst teenagers (20-25 years), low sensitization on population control measures, cultural norms and behaviours or reduction in infant mortality rate but due to immigration from other parts of Cameroon where individual influx to Limbe for multiple purposes (education, job opportunities and agriculture provided by rich volcanic soil of the Mount Cameroon) as presented on Fig. 6. This finding corroborates that of [36,16,37] who observed that natural increase and net migration are major drivers of population growth in developing countries. As a result, migrant over 7000 inhabitants yearly [20] settled with the indigent in Limbe because of peaceful coexistence while other relatives and friends usually follow suit. The city of Limbe in this regard is known as *“the city of friendship”*. Increase in in-migration, and population increase from natural increase has triggered a rise in the demand and need for basic social services like water supply and electricity. Consequently, population pressure could eventually put immense pressure on the limited unexpanded, rehabilitated or extension programmes for water supply infrastructure. Intense water demand for diversified usage as a coherent consequence of increased urbanization may intensify the problem as observed by [38]. The water supply to

population falls short of the need of the growing population in Limbe. Unfortunately, the stakeholders are unable to formulate and implement important measures or policies towards sustainable urban water management in Limbe due to limited power supply, degraded infrastructures, limited investment amongst others.

Most of the inhabitants of Limbe are low-income earners unable to afford basic social services. Fig. 6. shows that 26.9% of the sampled respondents were involved in skilled worker involved in formal with major activities being hairdressing, technicians, tailoring and carpentering activities, small trade, farming, hunting and fishing. Informal activities amongst the respondent’s population in Limbe was high although the income level of households is limited as presented in Table 7.

It is evident that from Table 7 a significant majority of residents (45%) earns <100,000 FCFA while the less earn >200,000 FCFA. This implies that the majority of the denizens of Limbe are low-income earners unable to meet their basic needs in terms of social services provision which the stakeholders continue to undermine. Consequently, the increase in potable water demand over supply resulting from population increase has led to the use of alternative but doubtful sources of water. This has become an obstacle to future sustainable urban water management of water supply and sanitation hard wares and infrastructures for all by 2030 which include improving water quality, reducing the levels of pollution, illuminating the dumping of waste, halving the proportion of untreated waste, increase recycling, safe use of water, increase water-use efficiency across all sectors and ensure the sustainable withdrawal of water among others.

Table 7. Population change and density for Limbe from 1966 and projections for 2022

Years	% change	Population density (km ²)
1966	-	41
1976	10.9	87
1986	7.4	151
1996	0.6	160
2007	1.4	184
2010	3.0	201
2013	2.7	218
2016	2.6	235
2022	9.5	369

Source: [32]

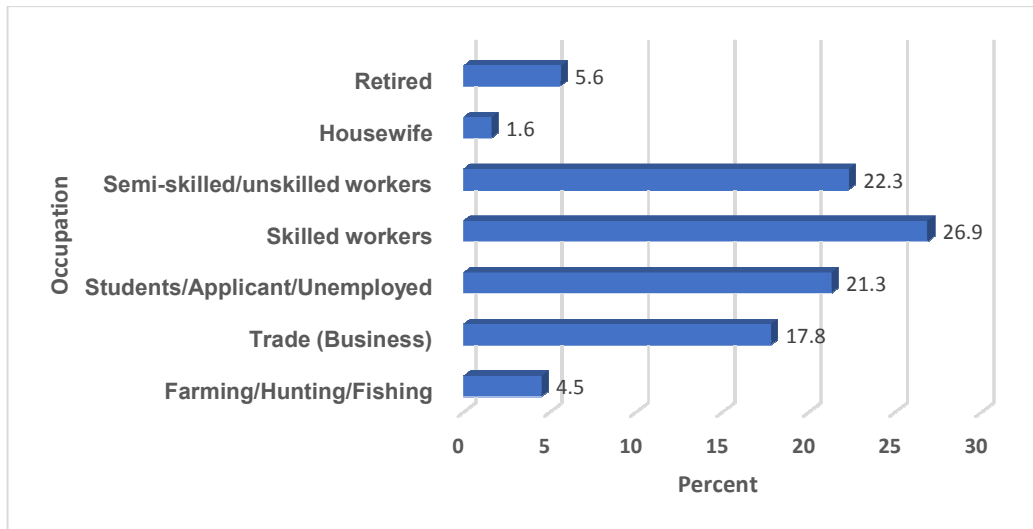


Fig. 6. Distribution of the principal occupation of respondents in Limbe
 Source: Fieldwork, 2020

Table 8. Distribution of monthly income among respondents

Monthly Income Level FCFA	Frequency	Percentage (%)
< 100,000	173	45
100,000-150,000	127	33
150,000-200,000	53	14
200,000+	30	08
Total	383	100

Source: Fieldwork, 2020

Significantly, demographic growth in Limbe has, in turn, initiated land-use changes and provided the needed threshold for both the public and private sectors to extend their provision of urban amenities including water supply although seldomly implemented due to poor city planning. Map 2 presents the rapid growth in the built-up area of Limbe between 1987 to 2019. With a total surface area of 8.5km² built-up land occupied in 1987 to 13.9km²(increasing at a rate of 0.31km²per year. and almost tripled 31.0km² in 2019 with a magnitude change and a yearly change of 1.08km². This exponential rise in the built-up areas beside infilling and outward sprawling of old settlements that have been established since the 80s have threatened the sustainability of water supply systems in Limbe as evidence by the spatial expansion of settlements into water recharge zones like catchments and wetlands. Entirely, new settlements have emerged due to the government efforts of ceding lands from the Cameroon Development Cooperation (CDC) leading to dominants of buildup areas over other land uses including water resources. This

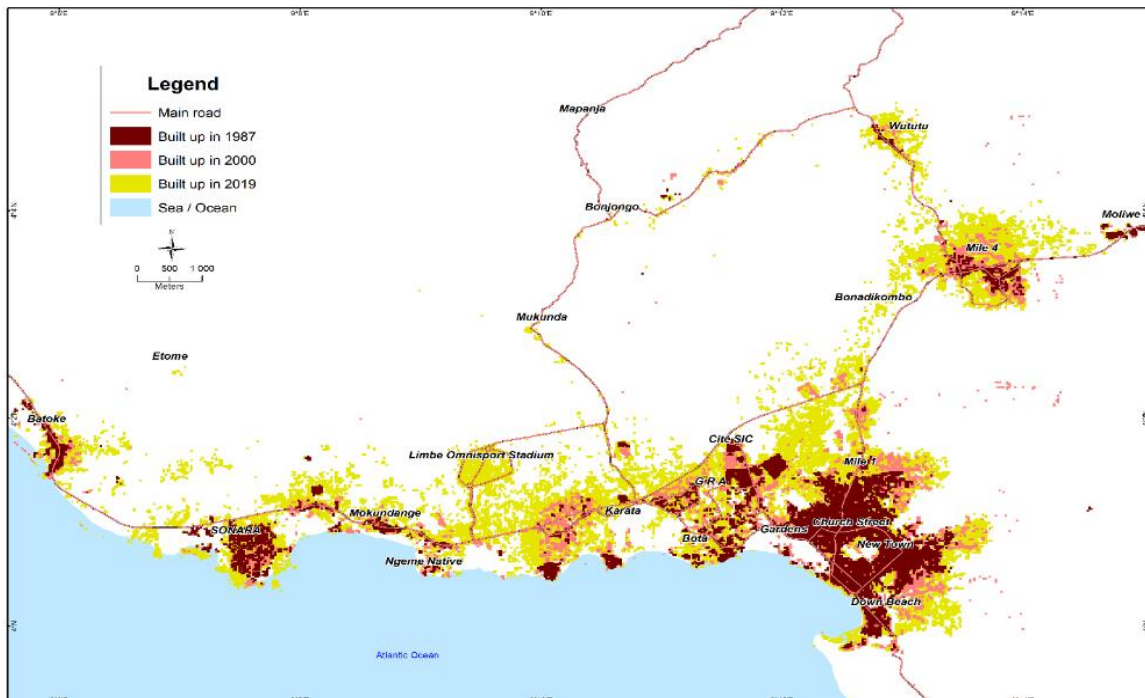
corresponds to the study by on the implications of urban growth on water supply systems in urban spaces of Bamenda [36] resulting in conflict over water allocation. It is empirical that as the urban population increases, the demand for water supply also increases. Drinking water is becoming more limited due to the limited expansion of the supply network to meet the current demand-supply gap created by increasing urban growth and high demand by the utility (CAMWATER) especially in new sentiments of Limbe that are rapidly emerging. Congestion is also seen as the most severe problems of urban growth as water sources are exploited more than their carrying capacities resulting in rationing, conflict over water allocation as well as water scarcity. Significantly there are other vices like children missing classes and school periods to search for water, quarrelling at water sources, loss of valuable hours for household activities and businesses for many residents in Limbe.

Also, the risk of consuming water for alternative but doubtful sources is significantly high. The

urban poor and vulnerable neighbourhoods and communities are the most affected as they cannot afford the means of obtaining basic social services or payment for water from other neighbours or vendors. Urban growth also exacerbates the problems of poor waste disposal, drainage and flooding resulting to surface and underground water contamination. Material carried during runoffs and flooding result in water contamination, breakage of the water supply infrastructures and siltation of water reservoir tanks. This finding aligns with that of [33,39] on the challenges of urbanization on urban development and urbanization and the vulnerability of wetlands in Bamenda Urban Space respectively.

As such it is necessary to rehabilitate existing infrastructures most of which have stood the test of time, extend existing networks to new settlements, peri-urban and unplanned settlements that lacks behind the urban expansion and population growth and encourage the realization of large scale connection via integration of water supply management systems

into urban planning strategies. The level of unaccounted for water, poor quality and siltation via constant monitoring and evaluation of the system infrastructures are also significantly high due to northward and eastward urban expansion of the city characterized by difficult relief and topography (Map 2.). Most of human settlements (Mbonjo, Mutowoh, Wovia, Ngeme, Botaland, and a host of others) are round the coast with only few neighbourhoods situated above 200masl (Towe 162masl, Mabeta 321masl). This therefore warrant spatial urban planning and management through coordination and collaboration amongst city agencies. This spatial disparity also results from social and political disparities in water supply systems depending not least on the social status and income of respective settlements. Furthermore, the additional risk may result from the dangerously high concentration of chemical substances from poor land-uses in high altitude neighbourhoods or industrial activities precipitated by settlement changes which result in a high accumulation of naturally occurring chemical in water sources -a significant danger to human health.



Map 2. Urban growth in Limbe (1987 and 2019) showing rapid urban expansion through ‘infill’ of the remaining open spaces in already built-up areas and ‘out spill’ in areas previously in non-urban use due to population growth

Source: Limbe City Council, Landsat ETM for 2019, Google Earth Images and Fieldwork, (2020)

4. CONCLUSIONS

This study has discussed the current issues of water supply systems in Limbe in terms of the nature of water supply/distribution and infrastructures, accessibility of water sources, reliability, affordability, frequency, quality amongst others. Although the utilities have managed to increase the per capita water quantity supplied to the population, a significant majority of denizens in Limbe do not have access to adequate and regular quality and quantity of water supply affordable to all the segment of the population due to degraded infrastructures. This quagmire has forced the denizens to depend on alternative water supply sources of poor quality coupled with trekking long distances, poor drainage and waste management, conflict over water allocation and high prices. The challenges of addressing these dilemmas are exacerbated by Limbe's unsustainable urbanization, population growth, inadequate investment, corruption, mismanagement and inadequate policy implementation by stakeholders and environmental degradation amongst others. These challenges are directly or indirectly correlated. For instance, poor land-use activities along with inadequate watershed regulations result in degradation of the environment which affects water supply systems reliability, quality and quantity. In most cases, rapid urbanization and urban growth are not usually accompanied by improvement or increase in the provision of basic social services like water supply leading to water scarcity, high prices for water and water contamination amongst others.

IMPLICATIONS FOR SUSTAINABLE URBAN WATER MANAGEMENT

Sustainable urban water management emanated from the Sustainable Development (SD) following the report of the World Commission on Environment and Development (1987) shortly referred to as the Brundtland Report and the Rio Conference in 1992 on the same topic [40]. In line with this study, sustainable urban water management is viewed from an ideal position of an equal distribution of resources in time and space. Based on this, therefore, to ensure efficient sustainable urban water supply systems while breaking the barriers of rapid urbanization and urban growth amidst others stressors, stakeholders could implement the following strategies:

Harness spring could be encouraged and used as an additional low-cost water supply by the city residents especially those in outlying new settlements where the utility supply networks could not be assessed and monitored by MINEE and CAMWATER. More specifically boreholes must be drilled in these neighbourhoods by the municipal councils to provide clean affordable and good quality water supply to meet people demand. Also, the use of alternative sources like rain-water harvesting and protected wells should be encouraged and regulated by municipal authorities and the government in terms of treatment and use for domestic and non-domestic uses. The city and municipal councils should take into consideration their priorities as well as carry out spatial planning via monitoring and evaluation to ensure efficient delivery and allocation of basic social services to the local population.

They should be a strong political commitment, policy consistency, local participation, adequate and timely release of funds, and deep execution capacity by the government agencies and authorities in the context of decentralization. Indeed, these measures are key requirements for timely completion of identified projects and successful delivery of quality drinking water to the population of Limbe in the face of unsustainable urban growth and urbanization.

The extension of water supply infrastructures into slum neighbourhood by the government agencies could improve the health condition, support socio-economic activities and ease the sourcing of water by low-income denizens. More significantly, heavy water pumping equipment is needed to efficiently pipe water to hilly neighbourhoods while projects to repair, expand, replace or rehabilitate old and broken reservoir, pipes could drastically reduce non-revenue water and increase cost recovery for investment by the water supply authorities.

In the wake of climate change and variability triggered by unsustainable impacts of urban growth and urbanization, the study recommends the promotion of integrated social-economic activities, catchment management, investment, planning and management by relevant city stakeholders (The council and the Ministry of Environment and Nature Protection) in association with relevant civil society (CBOs and NGOs) to preserve and protect water sources/catchments from degradation and pollution (buffer zones), protect vulnerable

groups, regulate price control measures, partnership amongst city agencies, subsidies and reduce conflict over water allocation. These could result from outreach, education, capacity training and policy implementation.

Digitizing the water supply and distribution systems and the network could be enhanced by CAMWATER and MINEE in partnership with technical experts and consultancy firms. This is the most efficient and effective way to gain the insight required to deliver a continual supply of high quality and affordable drinking water from the source to taps amidst the growing challenges of rapid urbanization and urban growth in Limbe.

Policy strategies related to urban growth, urbanization, family planning, water treatment, hygiene and sanitation by the government authorities and related ministries need to be reviewed and updated every after 3 years to ensure progressive management of water supply systems based on available data, investment and technical know-how. This should include the evaluation and forecasting of population and service provision equilibrium, rate of urbanization and urban growth and the carrying capacity of the population to ensure both present and future generation benefits. Based on this, the public could be sensitized and is their duty to have basic knowledge or at most be aware of issues relevant to their life and livelihood.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. International report on the state of corruption across the globe. Konrad adenauer-stiftung. [Auslandsinformation.de fb.com/international reports](https://www.auslandsinformation.de/fb.com/international-reports/); 2019.
2. UNEP. Annual report summary of activities in 2007 on the fight against climate change; 2007. Available: <http://hdl.handle.net/20.500.11822/7647>.
3. UNEP the UN-Water status report on the application of integrated approaches to water resources management (WRM); 2010.
4. Water Aid. Turning slums around. The case of water and sanitation. Discussion paper; 2008. Accessed July 2019.
5. Water Aid. Water scarcity. Human Development Report UNDP; 2010. Available: <http://wri.nmsu.edu/other/fed.html> Accessed January 2014
6. DHI. Water supply distribution challenges: Integrated solutions in the delivery of high-water quality from sources to taps; 2020.
7. World Bank. Sharing smart solutions in water supply management. Diego J. Rodriguez Schuring, Nansia Constantinou's; 2013.
8. Bilfinger C, Eitzze J, Kaise M, Lenz S, Rieck CE, Weck W. Agenda 2030: Basic law of sustainability. Konrad-Adenauer-Stiftung e.V., Sanht Augustin/Berlin. Infoflip; 2019.
9. Fube EM. Insufficiency of potable water supply and typhoid endemicity in Dschang, West Region, Cameroon: A Health consequence of rapid urban growth; 2009. Accessed: July 2019.
10. Baba A, Balgah SN, Pamboudam C. Patterns of pipe-borne water supply in the Buea Municipality: Challenges and way forward; International Journal of English Literature and Social Sciences (IJELS). 2019;4. Available: <https://dx.org/10.22161/ijel.2.3.25>
11. Kimengsi JN, Amawa SG. Accelerated urbanization in the Buea Municipality: The quest for sustainability in the provision of sound social services. international conference on sustainable cities in Cameroon; 2009.
12. Kimengsi JN, Amawa SG. Water rationing in the Buea Municipality: Patterns, effects and coping strategies. African Journal of Social Sciences. 6(3). Accessed: December 2017.
13. UN-Water& FAO. Water scarcity: The importance of water access; 2007.
14. World Bank. Reducing water loss in developing countries using performance-based service contracting; 2015.
15. WHO. Safely managed drinking water; 2011. Accessed: June 2019.
16. Fombe LF, Balgah SN. The urbanization process in Cameroon: Patterns, implications and prospects; NOVA Science Publishers Inc. New York; 2012.
17. Mafany GT. Impact of geology and seawater intrusion on groundwater quality in Douala; Unpublished M.Sc. Thesis, University of Buea, Cameroon; 1999.
18. MINEE, Plan d'action Nationale de Gestion inte'gee des ressources en Eau (PANGIRE): Etat Des Deux du Secteur Eau et environment; 2019. Accessed: July 2019.

19. Lambi CM, Kometa SS. An evaluation of water resources in the Eastern slopes of Mount Cameroon. *Journal of Human Ecology*. 2009;28(1):47-55.
20. BUCREP. Troisiemerecensements general de dopulation et de l'habitat : Rapport de présentation des résultats définitifs. Bureau central des recensements et des etudesdépoulation. 2010 ;66.
21. LCC. Ville de Limbe -Cameroun protection de zones urbanisescontres les risques d inondation et de glissement de terrain sur le bassin versant de la rivierwomange expertise prealable. hydraulic sans frontier, LCC, Limbe, Cameroon; 2013. Available: <http://limbecitycouncil.org/limbe>
22. Che VB, Kervyn M, Ernst GGJ, Trefois P, Ayonghe S, Jacobs P et al. Systematic documentation of landslide events in Limbe. *Journal of the International Society for the Prevention and Mitigation of Natural Hazards*, 2012;59(1):47-74.
23. Buh J. Relief classifications and features along with the Mount Cameroon Region; 2009. Accessed: June 2015
24. Folifac F, Lifongo L, Nkeng G, Gaskin, S. Municipal drinking water source protection in low-income countries; 2009.
25. Administrative units of Cameroon. Administrative map of Cameroon and their headquarters; 2017. Accessed: June 2019.
26. Nana C. Research methods and applied statistics. Buea, South West Region, Cameroon: GOOAHEAD; 2012.
27. Ndue PN. Research methodology: Theory and practice: A guide for successful development and production of academic research. Baraka Publishing; 2007.
28. WHO/UNICEF. Progress on sanitation and drinking-water–2010 Update. Geneva and New York: WHO/UNICEF JMP; 2010.
29. UNPD. A Compact amongst nations to end human poverty. New York: Oxford University Press; 2000.
30. UN-Habitat. Expert Group meeting on urban indicators secure tenure, slums & a global sample of cities. REVISED DRAFT REPORT Urban Secretariat & Shelter branch in Close Collaboration with the United Nations Statistic Division and the Cities Alliances; 2004.
31. Manual of water supply and treatment in India: Center for Planning & Housing Development (CPHEEO) New Delhi; 1999.
32. Achoachere RA, Egbe SE, Yaya OO, Mbua RL. Characterization of groundwater in the basaltic fractured rock aquiferous formation of the Limbe Coastal Region of Mount Cameroon, SWR, Cameroon. *Environmental Science Current Research: S1002*. Herald; 2019.
33. Fombe LF, Molombe Jeff M. Hydro-geomorphological implications of uncontrolled settlements in Limbe, Cameroon. *International Review of Social Sciences*. Accessed: February 2019.
34. Molombe JM. Unpublished PhD. Thesis on urbanization and housing development in the Buea and Limbe Municipalities, University of Buea, Cameroon; 2016.
35. National Institute for Statistics. Population and housing census statistics in Cameroon; 2019. Accessed: June 2019.
36. LCC. Limbe Echoes. A quarterly magazine of the LCC. No. 011, May-July 2015; 2020.
37. Maluh NB, Balgah SN, Kimingsi JN. Housing situation in the Bamenda Urban Space, challenges and way forward. *Journal of Geography, Environment and Earth Science International*. 2019;23(4).
38. Thomas D. Health and socio-economic status: Isolating causal pathways. In ABCDE World Bank Conference, Cape Town, South Africa; 2008.
39. Gardner Outlaw, Engleman TR. Sustaining water easing scarcity. A second update 1997, Washington DC, Population action international (PAI) population and environment program; 1997.
40. Tambe AEM, Ahfembombi LL, Gordin A, Tume JP. Urbanization and the vulnerability of wetlands in the Bamenda urban space, North West Region of Cameroon. *International Journal of Resources and Environmental Management*. 2019;4(3).

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