Research Article

Impact of Climate Change on Domestic Water Accessibility in Bamenda III Sub-Division, North West Region, Cameroon

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Abstract

The effects of climate change are felt most at the household level, when taps and springs run dry for several weeks or months, forcing people to access potable water from doubtful sources. There has been an increase in the population of Bamenda III without a proportionate increase in the water supply capacity. This has resulted in severe water crises, even though Bamenda III municipality has water supplies from the Council, Community, CAMWATER, natural springs and streams, wells and boreholes. Household data on water accessibility against a backdrop of a changing climate was collected using 269 questionnaires to assess perceptions on the state of water resources and climate. Rainfall data were collected from 1963-2019 and results revealed that mean annual rainfall is at 182.52 mm, with a standard deviation of 29.16 and a Coefficient of Variation of 15.69%, while the mean Standardized Precipitation Index is -0.07 (mild dryness), and rainfall has reduced by -2.07 mm from 1963-2019. The population attributed problems of water accessibility to climate change, urbanization and poor water governance. It is recommended that sustainable water management through Nature-based Solutions and Ecosystem-based Adaptation should be implemented from the watershed to the community level.

Keywords: adaptation, precipitation, scarcity, water security, vulnerability

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Résumé

Les effets du changement climatique se font surtout sentir au niveau des ménages, lorsque les robinets et les sources s'assèchent pendant plusieurs semaines ou mois, obligeant les gens à accéder à de l'eau potable provenant de sources douteuses. Il y a eu une augmentation de la population de Bamenda III sans augmentation proportionnelle de la capacité d'approvisionnement en eau. Cela a entraîné de graves crises d'eau, même si la municipalité de Bamenda III est alimentée en eau par le Conseil, la Communauté, CAMWATER, des sources naturelles et des ruisseaux, des puits et des forages. Les données des ménages sur l'accessibilité à l'eau dans un contexte de changement climatique ont été recueillies à l'aide de 269 questionnaires pour évaluer les perceptions sur l'état des ressources en eau et le climat. Les données sur les précipitations ont été collectées de 1963 à 2019 et les résultats ont révélé que les précipitations annuelles moyennes sont de 182,52 mm, avec un écart type de 29,16 et un coefficient de variation de 15,69 %, tandis que l'indice de précipitation standardisé moyen est de -0,07 (sécheresse légère), et les précipitations ont diminué de -2,07 mm de 1963 à 2019. La population a attribué les problèmes d'accessibilité à l'eau au changement climatique, à l'urbanisation et à la mauvaise gouvernance de l'eau. Il est recommandé que la gestion durable de l'eau par le biais de solutions basées sur la nature et d'adaptation basée sur les écosystèmes soit mise en œuvre du bassin versant au niveau communautaire.

Mots clés: adaptation, précipitations, rareté, sécurité de l'eau, vulnérabilité

Introduction

Water accessibility is the proportion of the population with reliable improved drinking water. Such improved sources include piped water into a residence, public standpipe in a neighbourhood, borehole, protected well, protected spring and rainwater harvesting. Climate change affects these water sources in multiple ways, with complex spatio-temporal patterns, feedback and interactions between physical and human processes (Bates *et al*., 2008). These effects are already adding challenges to sustainable water resources management, which are already under severe pressure in many regions of the world and subject to high climate variability and extreme weather events (Stewart *et al.,* 2020). The main effects of climate change on water resources include accessibility, availability, quality and quantity of water for basic human needs (water security), threatening the effective enjoyment of the human rights to water and sanitation. Although the effects can be highly individual at the local scale (Intergovernmental Panel on Climate Change-IPCC, 2019), current trends and future projections indicate major shifts in climate, and more extreme weather events in many parts of the world (IPCC, 2014). It is therefore paramount that water resources managers consider the potential impacts of a changing climate when planning for water resources development.

This paper bridges some methodological gaps in previous studies like Zotem and Nfor (2020) who analyzed rainfall variability and quantity of water supply in Bamenda I. These authors used a household questionnaire, Standardized Precipitation Index (SPI) and Seasonality Index (SI), but did not assess water accessibility through springs, streams, the spatial distribution of public taps as well as basics such as distances covered by households to the nearest water points. Although they used major climatic indices such as SPI and SI, they failed to show detailed decadal variations and consequences on water supply. In other studies, Tume (2019, 2021) used SPI and SI respectively to assess the vulnerability of water resources to climate variability on the Bui Plateau but failed to assess the state of other water sources which households rely on springs, streams, wells and boreholes. Chiaga *et al.,* (2019) examined watershed management and the sustainability of urban water supply in Bamenda. The authors revealed that the Bamendankwe Highland is the main watershed of the Mezam Division of the North West Region of Cameroon. These researchers, however, did not consider the role of climate change in water resources dynamics in the city of Bamenda. Furthermore, Wirba *et al.,* (2020) explored water management practices and sustainability implications in the Bamenda metropolis. Although the study covered the entire city of Bamenda, only two neighbourhoods were selected in the Bamenda III Council Area, that is, Mile IV and Mile VI, where 40 questionnaires were administered. Given that Bamenda III is the second most populated municipality in the metropolis, with 55 neighbourhoods and a population of over 230,000 inhabitants, a sample of 40 was not representative enough. This paper, therefore, attempts to blend the role of climate change on water accessibility in Bamenda III, using a household questionnaire and a detailed analysis of climatic data.

Materials and Methods

Bamenda III is found in the Mezam Division of the Northwest Region of Cameroon, located between Longitude 10°10'0"and 10°14'0" East of the Greenwich Meridian and Latitude 5°56'0" and 6°0'0" North of the Equator (Figure 1). Bamenda III has boundaries with four sub-divisions: Bafut to the North, Tubah to the West, Bamenda II to the East and Bamenda I to the South. There are two main villages, Nkwen with 46 neighbourhoods and Ndzah with 9 neighbourhoods (Bamenda III Council, 2012).

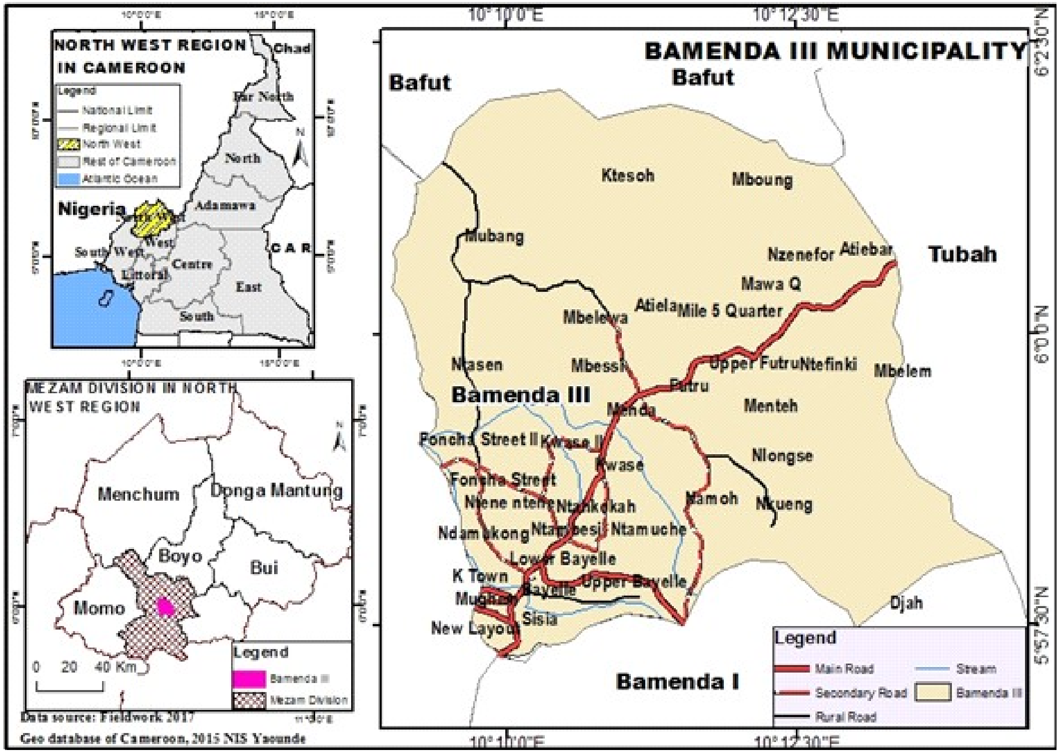

Figure 1: Location of Bamenda III Sub-Division

Primary data was in the form of a household questionnaire, which was administered in 10 neighbourhoods in Nkwen and two neighbourhoods in Ndzah. A total of 269 questionnaires were administered (Table 1). The choice of these neighbourhoods is because the 12 neighbourhoods in both villages represent 20% of the surface area of the study and 10% of the total population. Secondary data (rainfall) was collected from the North West Regional Meteorological Service for a period of 56 years (1963-2019). Some current literature on climate and water resources was also appreciated from UN-Water Development Reports and journals. The household questionnaire was treated in the Statistical Package for Social Sciences (SPSS) Version 20. A cross-tabulation of various variables under treatment were established and exported into Microsoft Excel 2016. This entailed calculation of percentages and the establishment of tables and charts. The climatic data were treated in Microsoft Excel 2016, where monthly and inter-annual graphs were generated. Rainfall data were further analyzed using the Standardized Precipitation Index (SPI), a tool that was developed primarily for defining and monitoring drought. Conceptually, SPI is the number of standard deviations by which the precipitation values recorded for a location would differ from the mean over certain periods. In statistical terms, the SPI is equivalent to the Z-score.

$Z - score = x - \frac{\mu}{\delta}$ .... (McKee *et al.*, 1993)

Where:

Z-score expresses the x score's distance from the mean (μ) in standard deviation δ units.

Statistically, the SPI is based on the cumulative probability of a given rainfall event occurring at a geographic location (Table 2). SPI was used to assess the occurrence of drought incidents. All anomaly graphs generated from the data were fitted with trend lines and linear equations. The trend lines indicate an increase or decrease in the elements under study. Other measures of central tendencies for rainfall included Standard Deviation (ó) and Coefficient of Variation (CV). CV is calculated thus:

$$\sigma = \frac{\sqrt{\Sigma(\mathrm{Y} - \bar{\mathrm{Y}})}^2}{\mathrm{N}},\ CV = \sigma * \frac{100}{\bar{\mathrm{Y}}},\ \text{Where: } \bar{\mathrm{Y}} = \text{mean, N} = \text{sample size}$$

Table 1: Distribution of questionnaires

Village	Neighbourhood	Questionnaires administered
Nkwen	Atielah-Mbelewa	24
	Atiesu-Mbessi	15
	Bayelle I	22
	Bunjong-Mambu	19
	Futru I	31
	Lower Menteh	9
	Manka-Mambu	34
	Nchang-Ntambang	44
	Sisia I	11
	Mubang	20
Ndzah	Mokop	13
	Terrekoh	27
Total		269

Table 2: Standardized Precipitation Index Classification

SPI Value	Category	Probability (%)	Severity of event
>2.00	Extreme wet	2.3	1 in 1 year
1.5 to 1.99	Severely wet	4.4	1 in 1.1 years
1.00 to 1.49	Moderately wet	9.2	1 in 1.3 years
0 to 0.99	Mildly Wet	34.1	1 in 1.5 years
-0.1 to -0.99	Mild dryness	34.1	1 in 3 years
-1.00 to -1.49	Moderate dryness	9.2	1 in 10 years
-1.50 to -1.99	Severe dryness	4.4	1 in 20 years
<-2	Extreme dryness	2.3	1 in 50 years

Results

Climate Variability and Change

Climate change is the statistical variations in the properties of the climate system such as changes in temperatures, precipitation, and other climatic elements due to natural or human drivers over a long period. Climate change could drastically alter the distribution and quality of natural resources, thereby adversely affecting the livelihood security of the people (IPCC, 2019). The population of Bamenda III perceive that the magnitude of climate variability is high. Field data revealed that 54.4% of the population perceived a high magnitude, while 24.9% perceived a low magnitude and 22.7% perceived that the magnitude is moderate. Sources of climate information are diverse. Most of the people receive climate-related information from television (45%), followed by seminars (23%), radio (21%), government agencies (6%) and the internet 5%). This proves that the population of Bamenda are well informed about changing climatic conditions as none of the field responses did not indicate that they do not receive any climate-related information.

Rainfall in Bamenda increases from the onset of the wet season to a peak in July to September and gradually drops as the dry season sets in (Figure 2). The lowest rainfall is recorded from December to March. To assess how much rainfall has changed, the data were grouped into 3-month segments (Table 3).

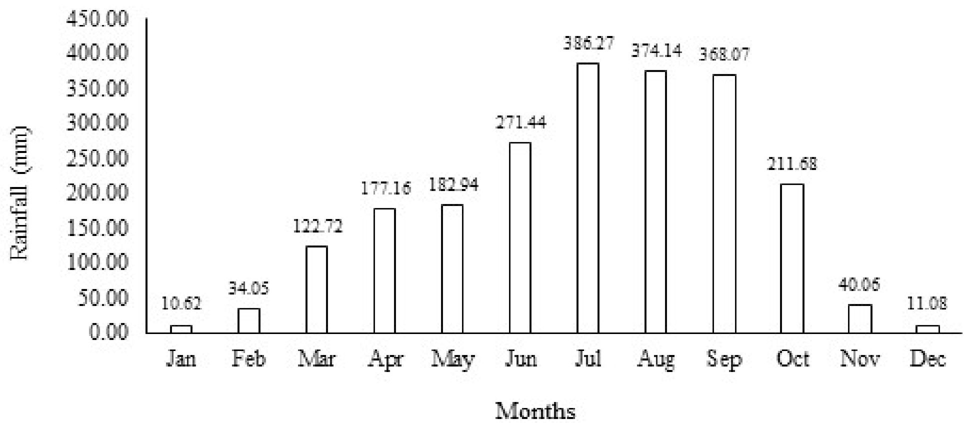

Figure 2: Mean monthly rainfall for Bamenda

Table 3: Rainfall change over Bamenda (1963-2019)

	Decadal mean rainfall (mm)					
Months	1963-1972	1973-1982	1983-1992	1993-2002	2003-2012	2013-2019
DJF	25.07	19.85	16.5	9.7	17.71	24.5
MAM	184.17	161.78	158.82	149.1	138.9	178.01
JJA	387.6	361.9	364.2	356.4	325.9	235.06
SON	238.81	240.9	202.5	210.9	195.97	126.5
Mean	208.91	196.11	185.51	181.53	169.62	141.02
Change	26.39	13.59	2.98	-1.00	-12.90	-41.50

From 1963-1972, rainfall had an excess of 26.39 mm and has been declining over time. Between 1973-1982, the rainfall had dropped by 13.59 mm and 2.98 mm from 1983-1992. Since 1993, Bamenda has witnessed rainfall deficits (-1 mm from 1993-2002, -12.9 mm from 2003-2012 and -41.5 mm from 2013-2019). The average rainfall declined from 1963-2019 is **-2.07 mm**. This proves that the climate is changing and is affirmed by the declining inter-annual rainfall trend (Figure 3).

The mean annual rainfall for Bamenda is 182.52 mm, with a Standard Deviation (SD) of 29.16 and a Coefficient of Variation (CV) of 15.96% (reliable). The climatic index used in assessing climate variability and change for this study is SPI. The SPI inter-annual pattern is the same as the inter-annual rainfall, with the same Coefficient of Determination (R^2) of 0.4548 (45.48%) (Figure 4).

Further insights into rainfall change over Bamenda are better presented through decadal SPI trends. From 1963-1972, the SPI trend decreased above the average (Figure 5).

The SPI episodes were 1963 (1.57-moderately wet), 1964 (1.12-moderately wet), 1965 (0.73-mildly wet), 1966 (1.09-moderately wet), 1967 (0.96-mildly wet), 1968 (1.21 (moderately wet), 1969 (2.02-extreme wet), 1970 (1.09-moderately wet), 1971 (-0.6-mild dryness) and 1972 (-0.13-mild dryness). Eight out of the ten years of this decade were wet years, except 1971 and 1972. The dry years continued till 1973. The decade 1973-1982 experienced an increasing SPI trend, with nine wet years out of the ten (Figure 6).

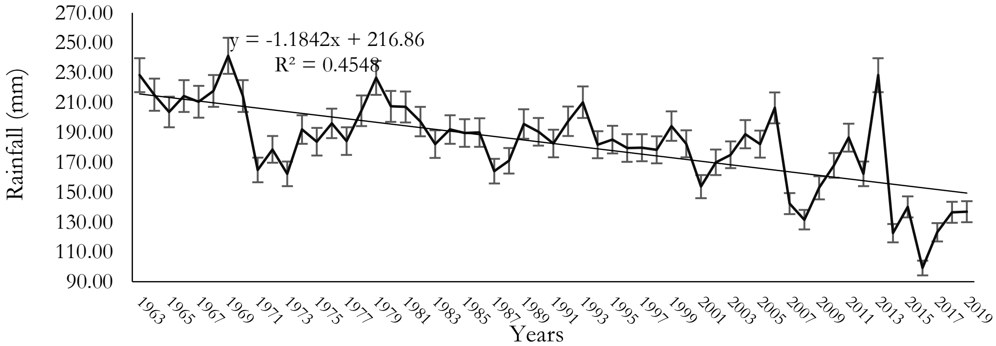

Figure 3: Inter-annual rainfall for Bamenda (1963-2019)

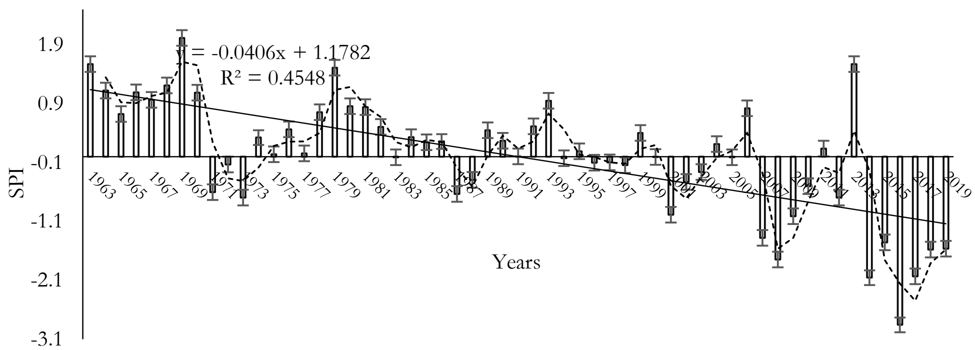

Figure 4: Inter-annual Standardized Precipitation Index for Bamenda (1963-2019)

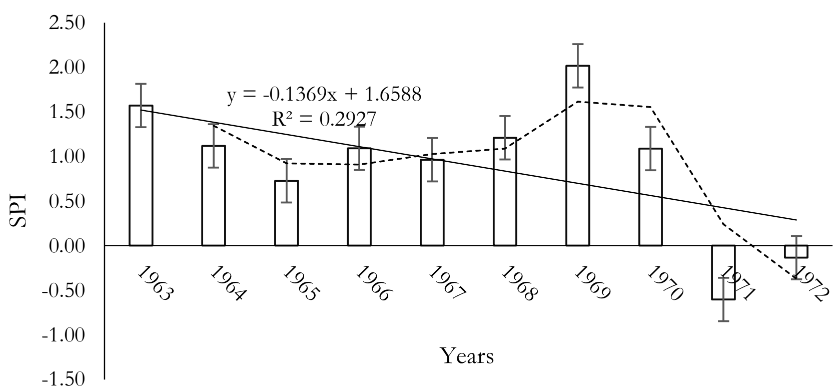

Figure 5: Standardized Precipitation Index for Bamenda (1963-1972)

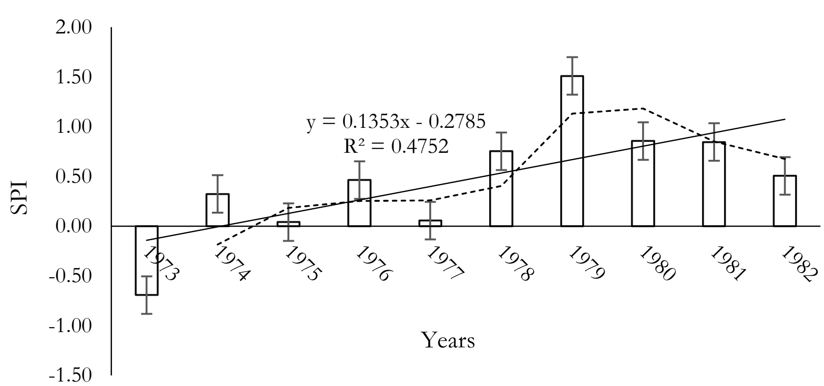

Figure 6: Standardized Precipitation Index for Bamenda (1973-1982)

SPI episodes were, 1973 (-0.69-mild dryness), 1974 (0.32-mildly wet), 1975 (0.04-mildy wet), 1976 (0.46-mildly wet), 1977 (0.06-mildly wet), 1978 (0.75-mildly wet), 1979 (1.51-moderately wet), 1980 (0.86-mildly wet), 1981 (0.84-mildly wet) and 1982 (0.51-mildly wet). The SPI trend increased above the average from 1983 to 1992 (Figure 7).

In 1983, the SPI value was (-0.01-mild dryness), 1984 (0.33-mildly wet), 1985 (0.24-mildly wet), 1986 (0.26-mildly wet), 1987 (-0.63-mild dryness), 1988 (-0.39-mild dryness), 1989 (0.45-mildly wet), 1990 (0.27-mildly wet), 1991 (0-mildly wet) and 1992 (0.51-mildly wet). The 1993 to 2002 period can be seen as a dry decade, with a decreasing SPI trend and seven years of negative SPI (Figure 8).

The SPI episodes were 0.95 (mildly wet) in 1993, 1994 (-0.03-mild dryness), 1995 (0.09-mildly wet), 1996 (-0.10-mild dryness), 1997 (-0.10-mild dryness), 1998 (-0.14-mild dryness), 1999 (0.4-mildly wet), 2000 (-0.01-mild dryness), 2001 (-0.99-mild dryness) and 2002 (-0.43-mild dryness). The 2003 to 2012 period was also another dry decade, with a decreasing SPI below the average (Figure 9).

The SPI values were, 2003 (-0.26-mild dryness), 2004 (0.21-mildly dry), 2005 (-0.01-mild dryness), 2006 (0.82-mildly wet), 2007 (-1.38-moderate dryness), 2008 (-1.75-severe dryness), 2009 (-1.01-moderate dryness), 2010 (-0.50-mild dryness), 2011 (0.14-mild dryness and 2012 (-0.69-mild dryness). From 2013 to 2019, the SPI continued to decline below the average (Figure 10). It is also another dry decade.

The SPI incidents were, 2013 (1.57-severely wet), 2014 (-2.06-extreme dryness), 2015 (-1.46-moderate dryness), 2016 (-2.86-extreme dryness), 2017 (-2.03-extreme dryness), 2018 (-1.58-severe dryness) and 2019 (-1.56-severe dryness). Rainfall and SPI characteristics for Bamenda can be summarized (Table 4).

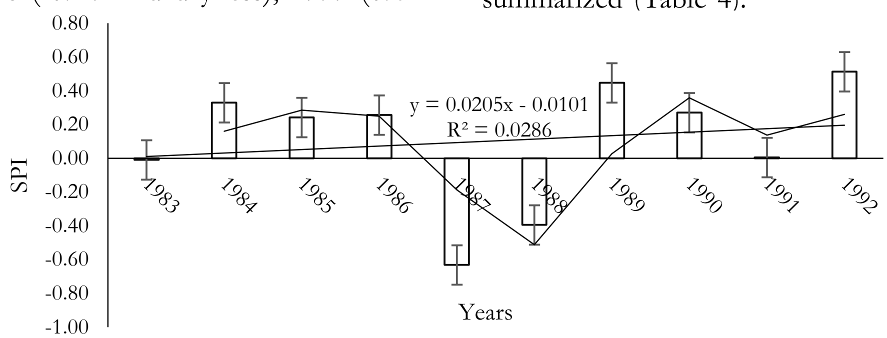

Figure 7: Standardized Precipitation Index for Bamenda (1983-1992)

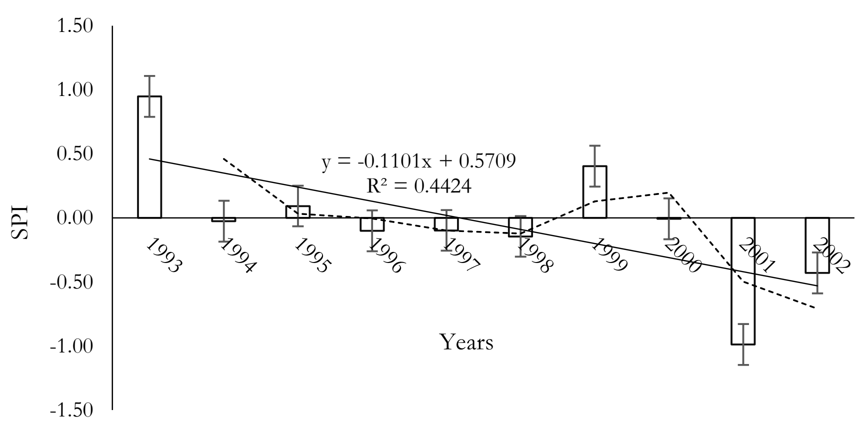

Figure 8: Standardized Precipitation Index for Bamenda (1993-2002)

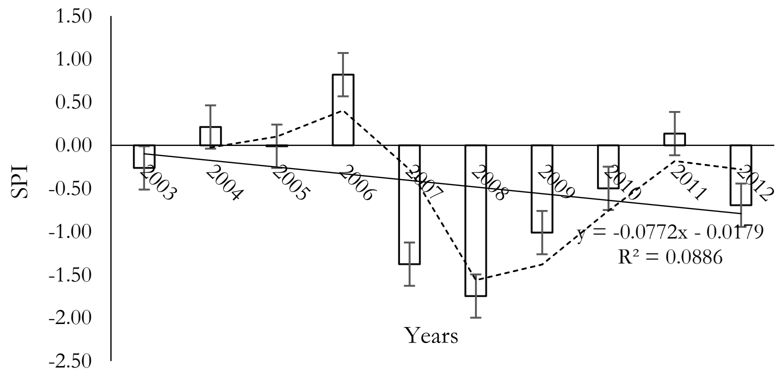

Figure 9: Standardized Precipitation Index for Bamenda (2003-2012)

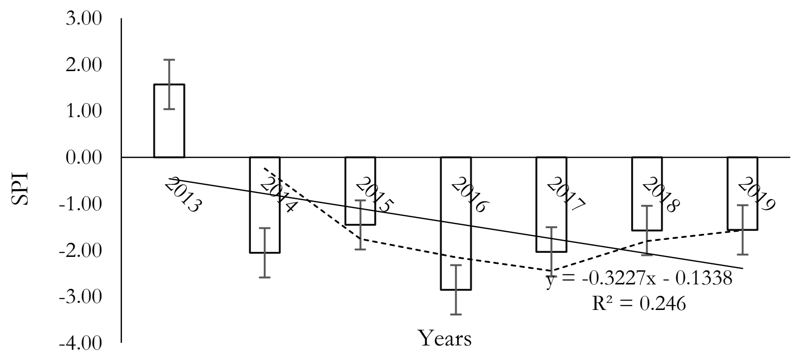

Figure 10: Standardized Precipitation Index for Bamenda (2013-2019)

Table 4: Summary of rainfall characteristics and SPI

Period	MAR (mm)	SD	CV (%)	Mean SPI	SPI class	Trend	Reliability
1963-1972	208.92	22.34	10.69	0.91	Mildly wet	Decreasing	Reliable
1973-1982	196.1	17.33	8.84	0.47	Mildly wet	Increasing	Reliable
1983-1992	185.52	10.73	5.78	0.1	Mildly wet	Increasing	Reliable
1993-2002	181.51	14.61	8.05	-0.03	Mild dryness	Decreasing below average	Reliable
2003-2012	169.62	22.89	13.49	-0.44	Mild dryness	Decreasing below average	Reliable
2013-2019	141	40.95	29.04	-1.42	Severe dryness	Decreasing below average	Unreliable
Mean	180.445	21.50	12.65	-0.07	Mild dryness	Decreasing	Reliable

MAR: mean annual rainfall, SD: Standard Deviation, CV: Coefficient of Variation, R^2: Coefficient of Determination

Water Accessibility

Sources of water in Bamenda III are public taps, streams, private taps, boreholes, protected springs, protected wells and unprotected springs (Table 5). The sampled neighbourhoods have at least one of the water sources, meaning that water is relatively accessible.

The most accessible water sources are public taps, streams, private taps in homes and unprotected springs (at watersheds). The population gets water through head portage, wheelbarrow, cars and private water lines in households (Table 6).

Water accessibility in terms of distance to the nearest water point is related to water security. *Water security is the sustainable access, on a watershed scale, to adequate quantities of water of acceptable quality, to ensure human and ecosystems health (Norman et al., 2010).* It is a multi-dimensional concept that recognizes that sufficient good quality water is needed for social, economic and cultural uses while, at the same time, adequate water is required to sustain and enhance important ecosystem functions. In another perspective, water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2018). In Bamenda III, the majority of the people cover distances of less than 50 m water points (Table 7).

Water insecurity sets in when people cover a distance of more than 200 m to carry drinking water and water for other domestic chores. In Bamenda III, 17.1% of the population covers more than 200 m to get water. The basic domestic uses of water in Bamenda III like elsewhere are shower, laundry, toilet sanitation, house cleaning, doing dishes, cooking and drinking (Table 8).

Table 5: Sources of domestic water in Bamenda III

Neighbourhoods	Public tap		Stream		Private tap		Borehole		Protected spring		Protected well		Unprotected spring	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Atielah-Mbelewa	6	12.50	5	10.87	6	6.12	2	10.00	3	16.67	1	5.88	1	4.55
Atiesu-Mbessi	1	2.08	2	4.35	5	5.10	3	15.00	1	5.56	2	11.76	1	4.55
Bayelle	4	8.33	3	6.52	8	8.16	1	5.00	1	5.56	1	5.88	4	18.18
Bunjong-Mambu	6	12.50	1	2.17	8	8.16	1	5.00	1	5.56	1	5.88	1	4.55
Futru I	5	10.42	9	19.57	12	12.24	1	5.00	1	5.56	2	11.76	1	4.55
Lower Menteh	1	2.08	2	4.35	2	2.04	1	5.00	1	5.56	1	5.88	1	4.55
Manka-Mambu	10	20.83	3	6.52	14	14.29	3	15.00	1	5.56	2	11.76	1	4.55
Nchang-Ntambang	8	16.67	6	13.04	22	22.45	2	10.00	2	11.11	2	11.76	2	9.09
Sisia I	1	2.08	2	4.35	1	1.02	1	5.00	1	5.56	1	5.88	4	18.18
Mubang	3	6.25	8	17.39	5	5.10	1	5.00	1	5.56	1	5.88	1	4.55
Mokop	1	2.08	2	4.35	4	4.08	2	10.00	1	5.56	1	5.88	2	9.09
Terrekoh	2	4.17	3	6.52	11	11.22	2	10.00	4	22.22	2	11.76	3	13.64
Total	48	100	46	100	98	100	20	100	18	100	17	100	22	100.00

Table 6: Means of getting water in Bamenda III

Neighbourhoods	Head		Wheelbarrow		Car		Private water line	
	F	%	F	%	F	%	F	%
Atielah-Mbelewa	10	6.54	4	21.05	3	7.89	7	11.86
Atiesu-Mbessi	11	7.19	0	0.00	1	2.63	3	5.08
Bayelle	13	8.50	1	5.26	2	5.26	6	10.17
Bunjong-Mambu	9	5.88	2	10.53	4	10.53	4	6.78
Futru I	25	16.34	0	0.00	5	13.16	1	1.69
Lower Menteh	0	0.00	1	5.26	1	2.63	7	11.86
Manka-Mambu	24	15.69	1	5.26	2	5.26	7	11.86
Nchang-Ntambang	25	16.34	4	21.05	8	21.05	7	11.86
Sisia I	5	3.27	3	15.79	2	5.26	1	1.69
Mubang	16	10.46	0	0.00	4	10.53	0	0.00
Mokop	1	0.65	2	10.53	1	2.63	9	15.25
Terrekoh	14	9.15	1	5.26	5	13.16	7	11.86
Total	153	100	19	100	38	100	59	100

Table 7: Approximate distances to the nearest water points

Neighbourhoods	<50 m		51-100 m		101-200 m		200 m+	
	F	%	F	%	F	%	F	%
Atielah-Mbelewa	8	5.84	6	13.64	5	11.90	5	10.87
Atiesu-Mbessi	9	6.57	3	6.82	0	0.00	3	6.52
Bayelle	12	8.76	6	13.64	1	2.38	3	6.52
Bunjong-Mambu	6	4.38	6	13.64	2	4.76	5	10.87
Futru I	18	13.14	0	0.00	10	23.81	3	6.52
Lower Menteh	4	2.92	2	4.55	1	2.38	2	4.35
Manka-Mambu	20	14.60	9	20.45	1	2.38	4	8.70
Nchang-Ntambang	21	15.33	6	13.64	8	19.05	9	19.57
Sisia I	3	2.19	4	9.09	2	4.76	2	4.35
Mubang	10	7.30	0	0.00	8	19.05	2	4.35
Mokop	7	5.11	1	2.27	0	0.00	5	10.87
Terrekoh	19	13.87	1	2.27	4	9.52	3	6.52
Total	137	100	44	100	42	100	46	100

Table 8: Domestic water chores

Chores	<5 L		6-10 L		11-15 L		16-20 L		21 L+	
	F	%	F	%	F	%	F	%	F	%
Shower	0	0.0	143	53.2	72	26.8	25	9.3	29	10.8
Laundry	0	0.0	28	10.4	34	12.6	75	26.4	132	49.1
Toilet flush/cleaning	106	39.4	79	29.4	64	23.8	8	3.0	12	4.5
House cleaning	59	21.9	58	21.6	42	15.6	75	27.9	35	13.0
Cleaning dishes	60	22.3	54	20.1	50	18.6	75	27.9	30	11.2
Cooking	23	8.6	79	29.4	60	22.3	75	27.9	32	11.9
Drinking	269	100.0	0	0	0	0	0	0	0	0
Average		27.5		23.4		17.1		17.5		14.3

On the average, majority of the people use about 6 to10 litres every day, which falls below international standards, implying there is water scarcity to meet domestic needs. Water scarcity is caused by several factors, and climate change is one of the leading drivers (Figure 11).

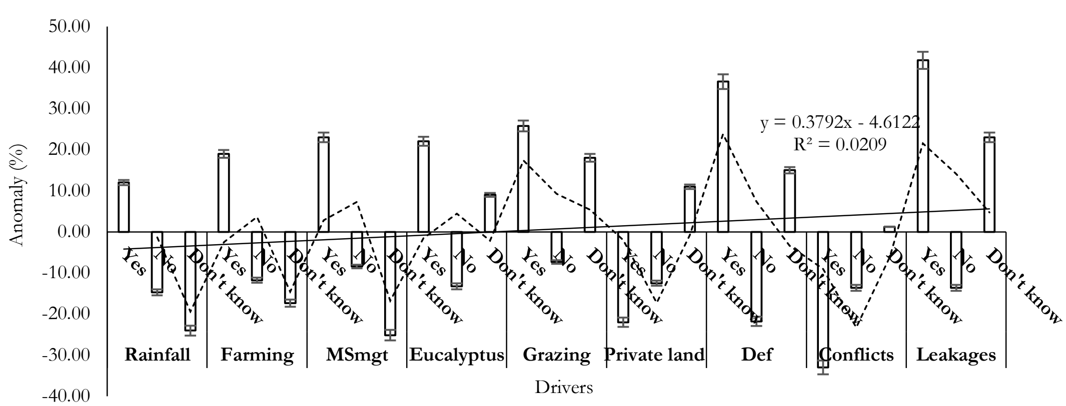

Figure 11: Trend in drivers of water scarcity in Bamenda III

The trend of water scarcity is increasing. The population perceived that unreliable rainfall contributes to 72.1% of the scarcity. This is affirmed by the rainfall data which proved that rainfall is becoming unreliable in Bamenda with an average CV of 29.04% for the period 2013 to 2019, and recurrent incidents of dryness through negative values of SPI for the same period. Other contributors of water scarcity are farming and grazing at watersheds, mismanagement of water projects, eucalyptus plantations around watersheds, private land ownership at watersheds, deforestation, conflicting water uses and irregular repairs of pipeline leakages. The peak periods of water scarcity is during the dry season when the water table is lowest (Figure 12).

The population's perception of low water availability from November to March coincides accurately with the dry season. Moderate water supply sets in April to May when people begin to collect rainwater to meet some of the domestic chores. Water availability is generally high from June to October when rainfall is relatively high. The perceived annual fluctuation and reliability of domestic water supply has the same patterns of mean monthly rainfall. The population of Bamenda III indicated that water scarcity is manifested through chronic water shortages, drying streams, periodic floods and rising temperatures. All the sampled neighbourhoods have experienced all these manifestations, though in different intensities. In the face of these problems, the population has resorted to adaptation by water storage, rationing, restoration of watersheds, good governance, no farming and grazing at watersheds, rainwater collection, planting of environmentally friendly trees, parks and gardens (Town Green) water reserves and inculcating water resources management into the local development agenda. These adaptation strategies are not very effective. Water governance, farming and grazing at watersheds, rain harvesting, parks and gardens, water reserves and factoring in water into the local development agenda are not effective. Some of this ineffectiveness in adaptation strategies are climate-related like prolonged dry seasons, unprotected watersheds, mismanagement of funds, low representation of women in water governance, amongst others. Again, population increase against a backdrop of little or no efforts to improve water sources has been one of the key drivers of water scarcity in Bamenda III. Bamenda III has urban and semi-urban characteristics, with an influx of population in the search for better opportunities through commercial ventures and education. Since 2016, the population has also increased by internally displaced people from hotspots of the crisis in the Northwest Region.

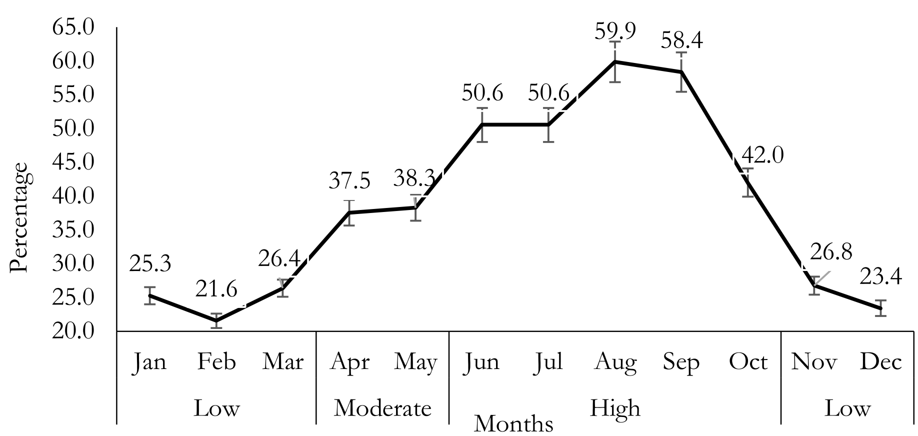

Figure 12: Annual fluctuation and reliability of domestic water supply in Bamenda III

Discussion

In the phase of so many problems plaguing water accessibility in Bamenda III, so much needs to be done in terms of water governance, restoring water sources (watersheds) and many other strategies in the face of climate change. Water governance is the decision-making process through which water is managed *(Norman et al., 2010)*. Good governance involves adhering to principles of human rights, including effectiveness, responsiveness and accountability; openness and transparency; participation in the performance of key governance functions relating to policy and institutional arrangements; planning and coordination and regulation and licensing. For the integration of substance, integrated water resources management (IWRM) involves stakeholders across society, the economy and the environment. Greater public participation to manage climate risk is suggested as a way to build adaptive capacities at multiple levels, avoid institutional traps and prioritize risk reduction for socially vulnerable groups. At the same time, scientific information and data also need to be made available at the local level and included as information into local multi-stakeholder decision processes (Stewart *et al.,* 2020).

The 2021-2030 period has been declared as a decade of ecosystem restoration by the international community. At the local level of Bamenda III, much can be done from lowland wetlands to watersheds. Restoring wetlands and riverine areas can improve water quality by capturing pollutants and sediment from land degradation. In catchment areas, restoration can improve the flows and availability of water. Restoration of forests and other ecosystems has the potential to save an estimated USD 890 million each year in water treatment costs in the world's largest cities (United Nations Environment Programme-UNEP, 2021). To avoid catastrophic climate change, 2030 should mark two milestones: the end of the UN Decade on Ecosystem Restoration and the achievement of emissions reduction targets in line with the Paris Agreement goal to limit global warming to below 2°C. Delaying this will push humanity to pass a tipping point, beyond which solutions will be less effective and some damage, irreversible (IPCC, 2019). Improved land stewardship, including restoration, is one effective strategy to limit global warming (Strassburg et al., 2020). Restoration is only part of the solution. Successfully achieving net-zero emissions will also rely on rapid emission reductions across all sectors worldwide. Without this multi-pronged effort, the benefits gained through restoration efforts may be only temporary.

Nature-based Solutions (NbS) can potentially contribute over one-third of the total climate change mitigation needed by 2030 to keep global warming to just below 2°C. NbS is inspired and supported by nature and use, or imitate natural processes to contribute to the improved management of water (UN-Water, 2018). NbS can involve conserving or rehabilitating natural ecosystems and/or the enhancement or creation of natural processes in modified or artificial ecosystems like watersheds. Within nature-based solutions, the restoration of watersheds is a key element. This could involve action to better manage some 2.5 billion hectares of forest, crop and grazing land (restoration and avoided degradation), and restoring over 230 million hectares of natural cover (Griscom et al., 2019). An important sub-set of NbS is Ecosystem-based Adaptation (EbA), which helps people adapt to climate change. EbA is a nature-based approach that uses biodiversity and ecosystem services to help people adapt to the adverse effects of climate change (International Institute for Environment and Development-IIED, 2019). It involves activities such as water catchment restoration by tree planting, slope stabilization by tree planting to prevent landslides, applying integrated water resource management to address water shortages and managing forests sustainably to prevent erosion and regulate water flow. EbA rests on combining local knowledge with evolving information on climate change and has been applied to address the local challenges of climate change impacts.

Conclusion

Climate variability and change is already a reality in Bamenda III. Water catchments and sources are not properly harnessed. Water governance institutions are weak and inactive. There is a limited supply of pipe-borne water in communities and water-borne diseases are inevitable. Both climate and water management require mechanisms for oversight and coordination. Sectoral fragmentation and bureaucratic competition may pose serious challenges for the integration across scales. This calls for greater public participation to discuss and manage climate risk; building adaptive capacities at multiple levels; and prioritizing risk reduction for socially vulnerable groups. Upscaling NBS and EbA are central to achieving the 2030 Agenda for Sustainable Development. Sustainable water security will not be achieved through business-as-usual approaches. NBS work with nature instead of against it, and thereby provide an essential means to move beyond business-as-usual to escalate social, economic and hydrological efficiency gains in water resources management. NBS show particular promise in achieving progress towards sustainable food production, improved human settlements, access to water supply and sanitation services, and water-related disaster risk reduction. They can also help to respond to the impacts of climate change on water resources.

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