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Prospects and Challenges of Water Management Stakeholders in the Rural Communities of the Noun Division, West Region, Cameroon

Dereck Mbeh Petiangma

Department of Geography and Planning, University of Bamenda

P.O. Box 39, Bambili, Cameroon

E-mail: aliciadereck@gmail.com

Kometa Sunday Shende

Department of Geography and Planning, University of Bamenda

P.O. Box 39, Bambili, Cameroon

E-mail: shendek@hotmail.com

Niba Mary Fonteh

Department of Geography and Planning, University of Bamenda

P.O. Box 39, Bambili, Cameroon

E-mail: mariefontehniba3@gmail.com

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Abstract

Seven years after the formulation of the Sustainable Development Goals (SDGs), uncertainty looms on whether the 2030 targets would be achieved. In the Noun Division of Cameroon diverse stakeholders have made substantial efforts to meet the 2030 SDG on the provision of portable water to the rural communities. Despite these laudable efforts, access to portable water remains a topical issue in the Division. The focus of this study was to assess the prospects and challenges of water management stakeholders in the provision of portable water to the rural communities of the Noun Division. In order to meet this objective, a total of

400 questionnaires were randomly administered to household heads in rural councils with the help of traditional authorities. International, national, regional and local stakeholders involved in the management of water resources were interviewed. The “17 in 1” and “iQ. BAC” water test kits were respectively used to analyse the chemical properties of drinking water sources in situ and faecal content within 48 hours. Descriptive and inferential statistical techniques were used to analyse quantitative data while content and narrative analysis were used for qualitative data. Findings revealed that local, national and international portable water management stakeholders prioritised the improvement of portable water sources over other parameters. Whereas the proportion of people who depended on unimproved water sources reduced from 79.92% in 2015 to 57.52% in 2022, that with mean round trip time of over 30 minutes rather increased from 49.62% to 50.38%. Moreover, 50% of the interviewee indicated that portable water is expensive in the area, suggesting why 42.3% of the population still rely on streams today. Five sampled streams analysed with the iQ. BAC test kit tested positive for total coliform while confirmatory laboratory analysis revealed E. coli concentration of 11-100MPN/100ml in Njimom which according to WHO is synonymous to medium risk. The “17 in 1” test kit revealed abnormal concentration of lead (0.03-0.05 ppm) and sulphate (400-800 ppm) mainly in streams and boreholes. PCA identified five main components that account for 72.71**%** variance in the hydrochemistry of drinking water sources. Though, none of the four scenarios developed revealed complete access to improve drinking water in rural areas of the Noun Division by 2030, Njimom and Foumbot showed remarkable progress under the most probable scenario (50% increase in current effort) considered to be the most realistic. Water governance stakeholders should quadruple their current efforts in improving portable water sources and adopt a holistic approach that engulfs water quality improvement if they wish to make significant progress on SDG 6.1.

Keywords: Stakeholders, Management, Portable water, Rural communities, Noun Division, Cameroon

1. Introduction

Water is life (Tanana *et al.*, 2021; Penafiel and Radomsky, 2021), and remains the most precious natural resource (Mazza, 2016), which can be considered as the bloodstream of the biosphere (Trimble and Mazzeo, 2020). It is fundamental to thriving ecosystems, communities and the world economies (Overduin *et al.*, 2019). In 2015, 71% of the global population used a safely managed drinking water service with one in every three living in rural areas (WHO and UNICEF, 2017). SDG target 6.1 has been tracked in multiple works using indicator of “safely managed drinking water sources that is located on premises, available when needed and free from faecal and priority chemical contamination (WHO, 2016).

Water crisis in Sub-Saharan Africa has remained a major challenge even in the 21st Century. Great disparity in progress made to improve water sources has been reported between rural and urban areas in most parts of the continent. Chitonge *et al*. (2020) in a survey observed that despite skewed high access to improved water facilities in urban areas compared to rural milieu, over 80% of communities still focus on improving access in urban rather than rural areas where the situation is precarious. In Ghana, Anjum *et al.* (2020) discovered that approximately 81% of the population lacked access to basic water services with about 6% still relying on surface water to meet their daily needs especially in rural areas.

In Cameroon, the proportion of households with access to drinking water rose from 45.3% in 2007 to 61.0% in 2014 (MINEPAT and UNDP, 2020). The government has vowed to significantly improve access to drinking water by 2030 via decentralisation of public water system and investment on water infrastructures in rural areas. General information published by Howard and Han (2020) also showed that, 17% of Cameroonians have water in their houses, 22% have it in their compound and 60% have it outside their compound. In 2015, 79.92% of the rural communities in the Noun Division of Cameroon did not have access to portable water. Despite the relentless efforts made by stakeholders to improve water sources in rural communities of the Division, access to portable water remains a topical issue. Apart from trekking for several km to fend for drinking water and the presence of long queues at improved water sources, most of the streams that rural dwellers rely on for domestic use have colour and are shared with cattle. This coupled with calls for scenario forecasting and appeal for the use of novel techniques in the assessing progress made by stakeholders to provide safe drinking water motivated us to undertake this study in rural areas of the Noun Division.

2. Study Area and Methods and Materials

The Noun Division is one of the 8 divisions in the West Region of Cameroon. It is located approximately between longitudes 10˚30'E and 11˚ 20' E of the Greenwich Meridian and latitudes 5˚ and 6˚ 30'N of the Equator (Figure 1). The Division has eight rural councils (made up of 148 villages), one urban council and shares boundaries with the Bamboutous, Mifi and Koung Khi Divisions in the west, Nde Division in the south west, Center Region in the south and east, Adamawa Region in the north east and the North West Region in the north west.

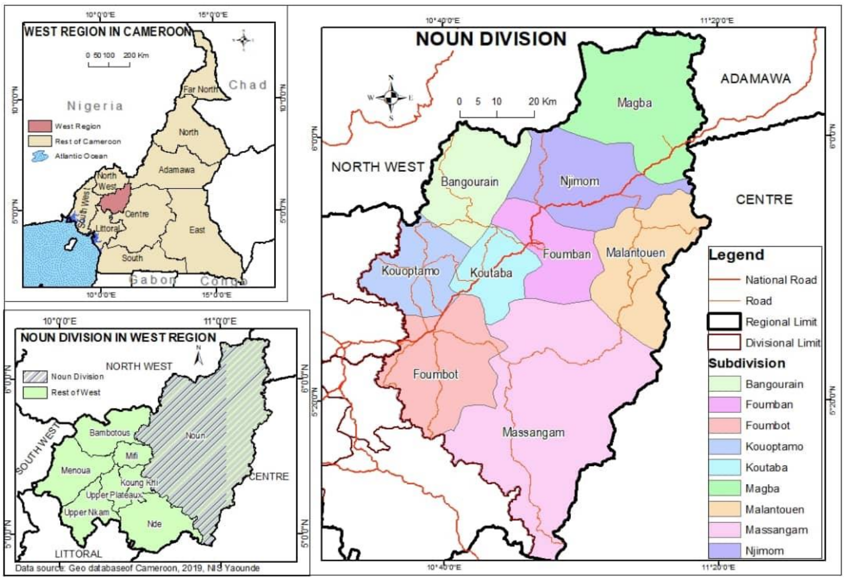

Figure 1. Location of the Noun Division

Source: Geo database of Cameroon

Altitude in the Division ranges from 600m in the south, east and north east to 2400m in Bangourain and Kouoptamo. It is drained mainly by River Noun and Mbam and experiences the Sudano-Guinean climate (Daouda, 1992 cited in Forka, 2009) due to its location within the ecotone of the equatorial and tropical climate. This climate has enabled it to have both forest and Savanna as well as ferruginous soils while its geologic history has made it to have pockets of volcanic soil.

Quantitative and qualitative data were mined concurrently from 400 household heads determined using Taro Yamane's (1967) sample size formula (at 95% confident interval) from a projected population of 539,572 (based on Keenan, 2017 formula) in 2021 and estimated household size of 98,104 (based on average rural household size of 5.5). Two villages were randomly selected from each of the eight rural councils of the Division plus their headquarters for the administration of questionnaires. The semi structured questionnaires carefully phrased to collect data on evolution in access to drinking water (sources/roundtrip time), availability (regularity of flow), affordability (costs), and quality (prevalent water related diseases) between 2015 and 2022 were randomly administered with the help of village chiefs to quarter heads and household heads. Key stakeholders in the water sector such as the secretary general of some municipal councils, officials of the Cameroon Water Utilities Corporation (Camwater), village development associations, vendors and donors were interviewed particularly on their stakes, amount budgeted and spent annually and their vision.

Data on acceptability especially colour were obtained through direct field observation while that on chemical and bacteria content were determined using the "17 in 1" and "iQ. BAC" water test kits respectively. The former permitted on the spot determination of 16 chemical properties of drinking water sources by simply dipping test strips in water sources and comparing the changed colour with that on the colour chart of the container. The latter was used to detect faecal bacteria in drinking water sources after an incubation period of 48 hours. The sensitive kit can detect as little as 1 CFU/ml of E. coli and coliform bacteria within 48 hours. Contaminated water sample changed to orange/pink while uncontaminated water changed to yellow. Secondary data used were articles, reports, and hospital consultation records.

Descriptive, exploratory, inferential and modelling statistical techniques embedded in Microsoft Excel and SPSS were used to analyse and present quantitative data in percentages. Principal component analysis (PCA) was used to determine associations, communalities and probable underlying origin of various chemicals in drinking water. Four "what if" scenario forecasting were designed and run in Microsoft Excel to estimate the proportion of rural communities that would depend on unimproved water sources in rural areas of the Noun Division in 2030. Scenario One was based on current trend detected from historic data. Scenario two (Hypothetical scenario) also based on current trend assumed zero population growth. The third scenario (Most probable scenario) assumed a 50% increase in current trend effort. This assumption was based on government plan to increase the proportion of state budget allocated to councils in Cameroon from 3% to 15% as stipulated by law. The fourth scenario (Unrealistic scenario) assumed 100% increase in current trend effort. It was termed unrealistic because no council officials expressed intentions of doing it. Content and discourse analysis were used to analyse qualitative data.

3. Results

In order to effectively assess the prospects and challenges of water management stakeholders in the rural communities of the Noun Division, the following aspects were examined: stakeholders involved in the provision of safe drinking water and access to improved drinking water sources, affordability, acceptability, availability of improved water and quality.

3.1 Stakeholders involved in the Provision of Safe Drinking Water

From the study carried out, the results revealed that 47.64% of actors that have provided improved water sources to rural dwellers in the Noun Division are international stakeholders, 34.16% are local stakeholders while 18.2% are national/regional stakeholders. International organisations and NGOs are involved mainly in the construction of improved wells and boreholes. They account for approximately 80% of improved wells and boreholes observed, while 20% has been provided by banks and individuals. Key international stakeholders identified in the field include the French Islamic League for Education (LIFE), Islamic Help, Korean Cooperation, the Islamic Development Bank and the African Development Bank. Other stakeholders who are also active include Humanity First Cameroon which works together with Humanity First Canada in the construction of wells, the Malantouen Women Diaspora Association financing the construction of boreholes and GIZ involved both in capacity building and financing of water projects.

National and regional stakeholders are mainly ministerial departments like the Ministry of Water and Energy (MINEE), Ministry of Public Health (MINSANTE), Ministry of Planning and Regional Development (MINEPAT) and the Ministry of Decentralisation and Local Development (MINDEVEL). They work together with Municipal Councils in the construction of wells and boreholes. PNDP and FEICOM have also financed water projects through councils. Camwater provide tap water uniquely within the Foumbot urban space while the Cameroon Red Cross and the army have constructed boreholes in Foumbot and Koutaba respectively. The main stakeholder at the local level is the council. They operate in partnership with most national stakeholders and are often accused of taking the glory even on efforts made by national and international partners. Village development associations, civil society, parliamentarians, traditional authorities and individuals are other local stakeholders. Over 50% of unimproved wells observed in the study area have been constructed by individuals to satisfy their domestic water needs.

3.2 Access to Improved Drinking Water

Improved water sources encompass taps, boreholes, protected wells, protected springs, rainwater and packaged water while unimproved sources are open well, unprotected spring, surface water (rivers, streams, and ponds), and other vendor-provided water in drum (WHO and UNICEF, 2019). Assessment of progress in access to improved water sources was limited to the evolution of water sources and round trip time.

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3.2.1 Sources of Drinking Water

Figures 2 and 3 present perennial sources of drinking water in rural areas of the Noun Division in 2015 and 2022. Each stacked bar in the figure shows the situation in a municipality but with the mean percentage bar showing it for all rural areas in the Division.

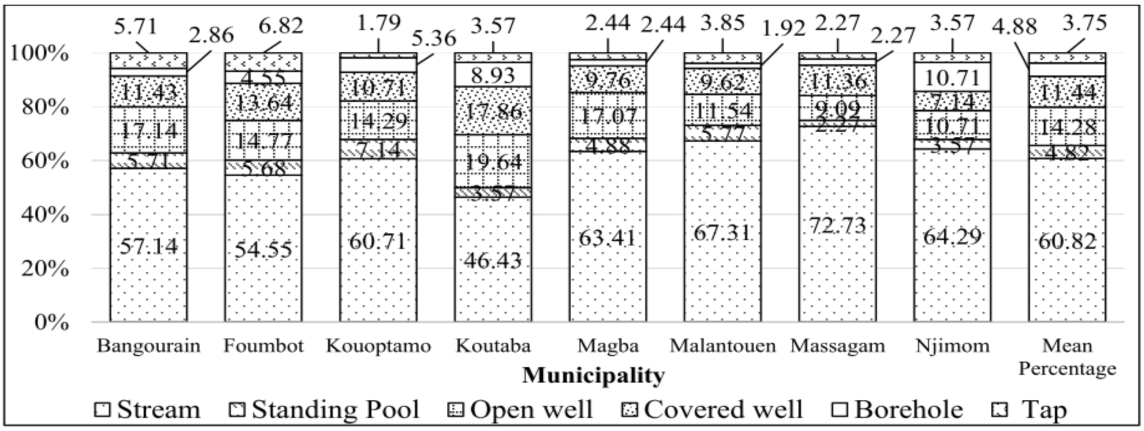

Figure 2. Principal sources of drinking water in 2015

Source: Fieldwork, 2022

Figure 2 indicates that 79.92% of rural households in the Noun Division obtained their drinking water from unimproved sources (60.82% from streams, 14.28% from open wells and 4.82% from pools of standing water) in 2015 while 20.07% obtained it from improved sources (11.44% from covered wells, 4.88% from boreholes and 3.75% from taps). Five rural council areas had a greater proportion of households relying on unimproved sources than the Division average. In Bangourain, 57.14% obtained it from streams, 5.71% obtained it from standing pools, and 17.14% obtained it from open wells. In Kouoptamo, the proportion that obtained it from streams, standing pools and open wells were 60.71%, 7.14% and 14.29% respectively. In Magba, where 85.36% obtained it from unimproved sources, 63.41% relied on streams, 4.88% relied on standing pools and 17.07% depended on open wells. In Malantouen and Massagam where 84.62% and 84.09% respectively obtained the precious resource from unimproved sources, 67.31% and 72.73% relied on streams, 5.77% and 2.27% obtained it from standing pools while 11.54% and 9.09% depended on open wells.

The situation in Foumbot, Koutaba and Njimom that had a relatively smaller proportion of households relying on unimproved water sources was still pathetic. In the Foumbot council area where 75% fetched drinking water from unimproved sources, 54.55% relied on streams whereas 5.68% and 14.77% fetched it from standing pools and open wells. In Koutaba and Njimom, the proportion of people depending on unimproved sources were 69.64% and 79.92% out of which 46.43% and 64.29% relied on streams whereas 3.57% from each of the areas used water from standing pools. The situation in 2022 is slightly different (Figure 3).

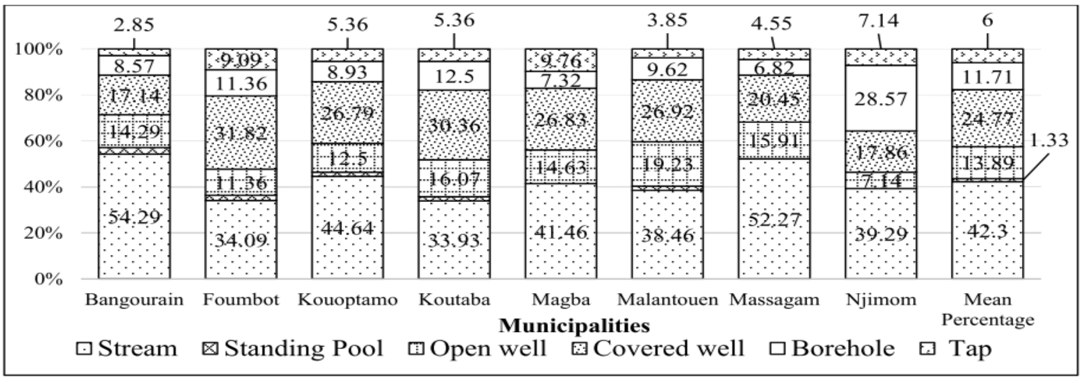

Figure 3. Principal sources of drinking water in 2022

Source: Fieldwork, 2022

Based on figure 3, the proportion of rural households depending on unimproved drinking water sources in the Division in 2022 has dwindled by 22.4% from 79.92% in 2015 to 57.52%. The is due to aggregated decline in the proportion of households depending on streams, open well and pools to 42.3%, 13.89% and 1.33% in the Division in 2022. Though the proportion of people relying on covered well and boreholes doubled to 24.77% and 11.88% in the Division respectively, the proportion depending on improved sources remain largely below average.

Apart from the council areas of Foumbot and Njimom where the progress made has reduced the proportion of people depending on unimproved water sources to less than 50% (47.72% and 46.43% respectively), efforts in the other rural councils have failed to reach this significant landmark. Even remarkable efforts in Magba, Malantouen, and Kouoptamo that shrunk the proportion of people relying on unimproved water sources by 29.27%, 25.01% and 23.21% failed to lover it below 50% as 56.09%, 59.61% and 58.93% of their respective populations still depend on streams, pools and open wells today. In Koutaba, the proportion depending on unimproved water sources reduced by 17.86% from 69.64% in 2015 to 51.78% in 2022 while Massagam and Bangourain registered the lowest progress. In Massagam it reduced slightly from 84.09% to 68.18% whereas in Bangourain the decline was from 79.99% to 71.44%. Decline in the proportion of households depending on streams and pools resulted to disproportionate increase in the proportion with access to improved sources because 6.82% drifted to unprotected wells which is still an unimproved water source. Table 1 shows evolution in the number of households that have subscribed to Camwater network in Foumbot since 2015 and the volume of water produced and used.

Table 1. Evolution in number of Camwater subscribers in Foumbot

Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total users	2076	2506	2552	2619	2670	2724	2772
New subscribers	430	46	67	51	54	48	119
Volume of water produced (m^3)	348899	354386	350162	380285	417135	388915	431243
Volume consumed (m^3)	243203	252427	277578	285849	315491	285940	325559

Source: West Regional Delegation of Camwater, 2022

The table shows great inconsistency in the number of new subscribers. In 2015 there were 430 new subscribers. The number dropped to 46, 67, 51, 54 and 48 in subsequent years until 2021 when 119 new subscribers were connected. This timid progress implies that Camwater network in Foumbot is expanding at an annual rate of 4.17%.

3.2.2 Round Trip Time

The UN Sustainable Development Goal on water stipulates that people without water on their premises must not use over 30 minutes to fetch for it off their premises. Figure 4 shows evolution in the proportion of households in rural communities of the Noun Division between 2015 and 2030 whose round trip time to collect water exceeds 30 minutes. Despite the strides made to improve water sources, figure 4 indicates that the proportion of households with round trip time exceeding 30 minutes increased timidly from 49.62% in 2015 to 50.38% in 2022. This strongly suggest that some inhabitants who used less than 30 minutes in the past to extract water from unimproved sources now spent much longer time to fetch it from improved sources. With the exception of Foumbot, Koutaba, Malantouen and Massagam, roundtrip time has increased in rural council areas including Njimom that registered one of the greatest progresses in the improvement of water sources. Between 2015 and 2022, the proportion of people spending over 30 minutes to fetch drinking water has increased from 22.86% to 34.29% in Bangourain, 28.57% to 39.29% in Kouoptamo, 39.02% to 43.90% in

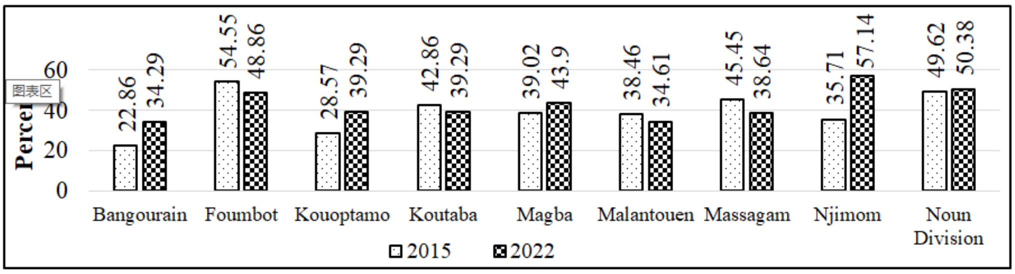

Figure 4. Proportion of households collecting drinking water in over 30 minutes

Source: Fieldwork, 2022

Magba and 35.71% to 57.14% in Njimom. In Malantouen and Massagam, the proportion has reduced rather dwindled from 38.46% and 45.45% to 34.61% and 38.64% respectively.

3.3 Affordability

The assessment of affordability was limited to the households that collect water from piped sources. Pipe water in the area is mainly Camwater network in Foumbot, rehabilitated scan water network managed by the council in Magba, community water projects and boreholes constructed by councils and vendors and distributed via taps. Figures 5 and 6 show the population’s perceptions on the affordability of drinking water and evolution in its costs overtime.

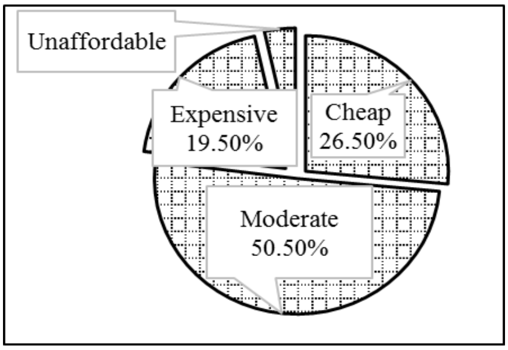

Figure 5. Perceptions on affordability

Source: Fieldwork, 2022

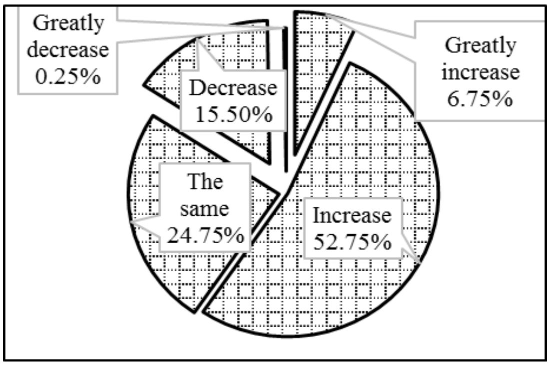

Figure 6. Evolution in costs of water

Source: Fieldwork, 2022

From figure 5, 26.50% of households in the area consider pipe water to be cheap, 50.50% believed it is moderate, 19.50% think it is expensive while 3.50% consider it to be unfordable. Based on figure 6, 52.75% of households indicated that the costs of water has increased, 24.75% considered it to be stagnant, 15.50% believed that it has decreased while 6.75% indicated that it has greatly increased. Though subjective, the fact that over 50% of pipe borne water users indicated that its cost has increased must not be neglected. Table 2 shows the unit price of a cubic meter of water charged by some in some rural councils.

Table 2. Price of a Cubic Meter of Water Charged by Some Vendors

Vendor	Area of operation	Price per m3 (FCFA)
Camwater	Foumbot	293/364
Borehole (Individual)	Koutaba	250/625
AGEPOM(defunct Scan water)	Magba	600
Community Water Project	Koupara (Kouoptamo)	625
Council water	Massagam	600
Community water Project	Kuron (Bangourain)	free
Community water	Ngoundoup	1000 (monthly)

Source: Camwater Foumbot (2022); Koutaba/Magba Councils (2022); Fieldwork (2022)

Though Camwater charges the lowest price per cubic meter of water, its fixed monthly meter rent (930 FCFA) and installation costs increases it costs and discourages consumers. Customers who consume less than 10m^3 a month pay 293 FCFA per m^3 while those who consume above this limit pay 364 FCFA per m^3. All these added to installation fees of 117.245 FCFA (for 20m diameter pipe) and 176.632 FCFA (for 40m diameter pipe) for distances ranging between 0-5m and 192.850 FCFA (20m diameter pipe) and 268.013 FCFA (40 diameter pipe) for households at 50m increases its costs and probably deters consumers. The defunct Scan water project in Magba rejuvenated and managed by the council as well as the council water project in Massagam both charged 600 FCFA/m^3 which to many people in the locality is expensive. Users of the community water project in Koupara (Kouoptamo) pay 25 FCFA for 40litres which is equivalent to 625 FCFA per m^3. It is similar to the pricing policy of vendors in Koutaba who in addition to that charge 250 FCFA per m^3 from customers who have channelled water to their premises. The management unit of the community water project in the village of Ngoundoup (Koutaba) collect a fixed amount of 1000 FCFA monthly from all users for maintenance work.

3.4 Acceptability

Acceptability is a subjective parameter of drinking water which lacks universally acceptable standard. Components of acceptability are appearance, taste and colour. Whereas water from improved sources was observed to be colourless, odourless and tasteless, that from most streams had varied colour. The images in figures 7 show the colour of some streams which are important drinking water sources in rural areas of the Noun Division.

Figure 7A is a popular stream in Mbankouop (Kouoptamo), 7B is at Matta Barrage (Magba), 7C is in the neighbourhood of Njimelua (Massagam) while 7D is a popular drinking water source near the chief's palace in Bangourain. All the streams have varied colours suggesting that they are not safe for drinking. Some users of the stream in Figure 7D said it has no taste and odour and that the dark colour is because it originates from a wetland dominated by raffia Palm. This is crucial because the colour of the stream alone strongly suggest that it is not safe.

Figure 7. Colour of some water sources in the Noun Division

Source: Fieldwork, 2021/2022

3.5 Availability

3.5.1 Frequency of Flow

Assessment here was limited to piped water which is much more prone to interruptions than the other sources. Figure 8 presents findings of the multiple option questionnaire that appealed to those who have taps in their neighbourhood to select the description that best suits their flow pattern.

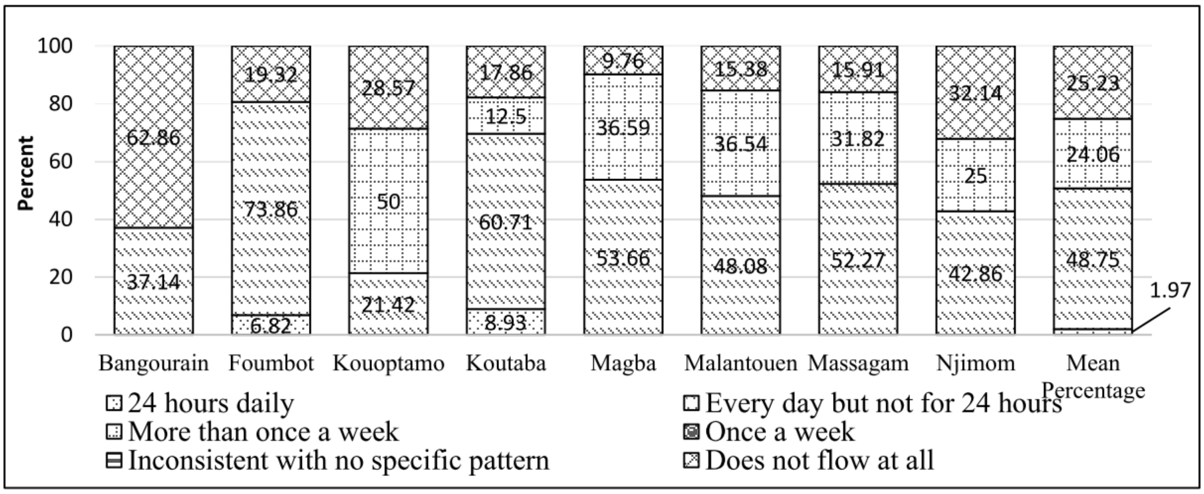

Figure 8. Regularity of flow from taps

Source: Fieldwork, 2022

Only 1.97% of rural inhabitants in the Division have uninterrupted flow for 24 hours every day. 48.75% have water everyday but not for 24 hours whereas 24.06% have it more than once a week and 25.23% have taps that do not flow at all. Bangourain has the highest proportions (62.86%) of taps that does not flow due to the abandonment of defunct scan water taps while Foumbot (73.86%) leads the rest in terms of taps that flow daily but not for 24 hours, followed by Koutaba (60.71%) and then Magba (53.66%). Over 80% of water vendors interviewed explained that frequent electricity failure in the area is the main reason why taps hardly flow for 24 hours. Officials at the Camwater treatment center in Foumbot further explained that low voltage and frequent power failure interrupts the treatment of water. Though emphasis here was on taps, field observation revealed that some wells constructed in the area do not contain water in the dry season. One interviewee in Njimom said they are obliged to ration water from their well by limiting every household to just two gallons (40 litres) daily in the dry season.

3.5.2 Frequency of Breakdown/Repair Time

Taps, boreholes and covered wells were assessed under this dimension. Analysed survey data revealed that 42.7%, 57.3% and 19.6% of tap, covered well and boreholes experienced at least one breakdown annually. The relatively proportion for boreholes is probably because most of them were constructed between 2019 and 2022 and are yet to start experiencing major problems. With regards to repair time, 37.3%, 51.4% and 59.6% of the tap, borehole and covered well users reported that their facilities are repaired rapidly when there is any breakdown.

3.6 Progress in Drinking Water Quality

3.6.1 Bacteriology and Probable Evolution in Water Quality

Water quality analysis with the "iQ. BAC" test kit revealed that the georeferenced streams in Figure 9 (in Bangourain, Kouoptamo, Magba, and Massagam) and Njimom (5.866889˚N and 11.106068˚E) were contaminated with either E. coli or coliform bacteria.

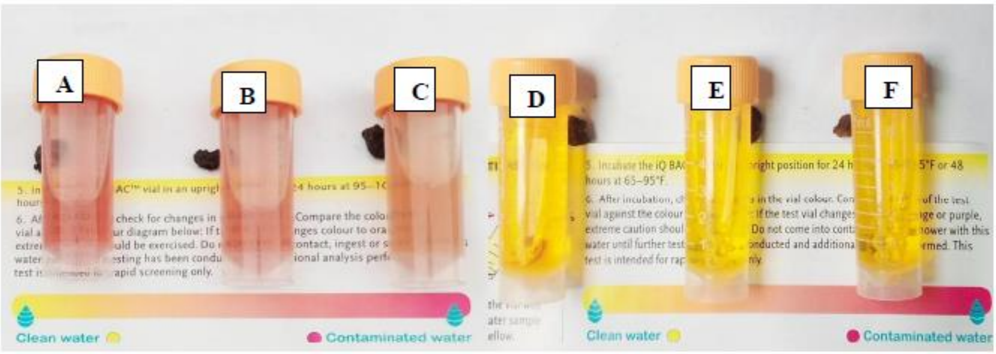

Figure 9. Bacteria test results of some sample streams

Source: Fieldwork, 2022

The vials with contaminated water samples (near orange colour) labelled A, B, and C are test results for the streams in Bangourain, Massagam and Njimom while the vials with uncontaminated samples (yellow colour) lettered D, E, and F are results for streams in Foumbot, Koutaba and Malantouen respectively. This is probably because water samples from the streams that tested positive were collected just after rainfall. Laboratory analysis revealed a positive total coliform result for the stream in Njimom with further analysis confirming E. coli concentration of between 11-100MPN/100ml which according to WHO standard falls within the category of medium risks.

Analysed data from some hospitals showed that diarrhoea and typhoid are very common in the area. Figure 10 shows evolution in the number of patients diagnosed with typhoid and diarrhoea in the municipality of Foumbot, Kouoptamo and Malantouen from 2017 to 2021. That of Foumbot and Malantouen constitutes the lone cases diagnosed at their respective district hospitals while that of Kouoptamo is combined cases for the district hospital and all integrated health centers in the rural council. The figure indicates that the number of typhoid cases diagnosed at the Foumbot district hospital has remained fairly constant from 2017 to 2018, suggesting that the marked progress registered in the provision of improved water sources has not been accompanied by corresponding improvement in water quality. In Malantouen, the number of diagnosed cases at the District hospital increased drastically from

187 in 2018 to 980 in 2020 before slumping slightly to 880 in 2021. Field observation revealed that most of the boreholes and covered wells serving as drinking water sources in Malantouen were constructed between 2019 and 2020, suggesting that much preference was on availability of drinking water rather than quality. In Kouoptamo, diagnosed cases from all integrated health centers and the district hospital increased from 753 in 2018 to 1152 cases in 2019 before dwindling slowly to 880 in 2021. Kouoptamo is the third most popular in the rank of municipalities relying on unimproved water sources.

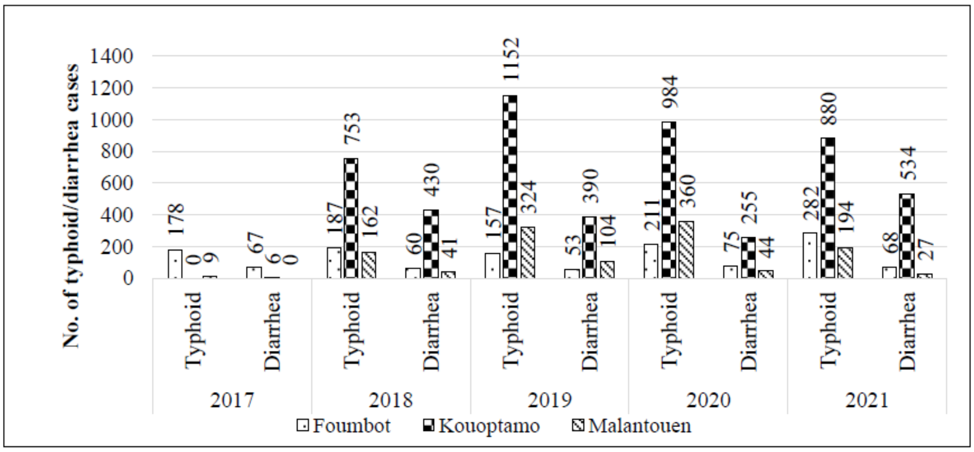

Figure 10. Typhoid cases diagnosed in some municipalities from 2017 to 2021

Source: Foumbot, Kouoptamo and Malantouen District Hospitals

Based on figure 10 again, diarrhoea which feature conspicuously in literature as one of the most preponderant water related hazard, is also one of the major driver of morbidity in the area. The number of diarrhoea cases diagnosed at the Foumbot and Malantouen district hospital between 2017 and 2021 has remained fairly constant despite the positive strides registered in the improvement of water sources. This further suggests that effort to improve water sources has not been accompanied by meaningful actions to improve water quality. The situation in Kouoptamo is disturbing because the timid decline in diagnosed diarrhoea cases from 2018 to 2020 was upset by an upsurge in cases in 2021. This again mirrors the little attention given to water quality improvement by stakeholders in the study area.

3.6.2 Hydrochemical Properties of Drinking Water Sources in Rural Areas of the Noun

Water samples were collected from eight streams, eight wells, and eight boreholes, in different rural councils and analysed on the spot using the “17 in 1” test kit to determine their chemical characteristics and compare it with the standards stipulated by the Environmental Protection Agency (EPA). Figure 11 shows the absolute locations of the wells, stream sources and wells that were sampled.

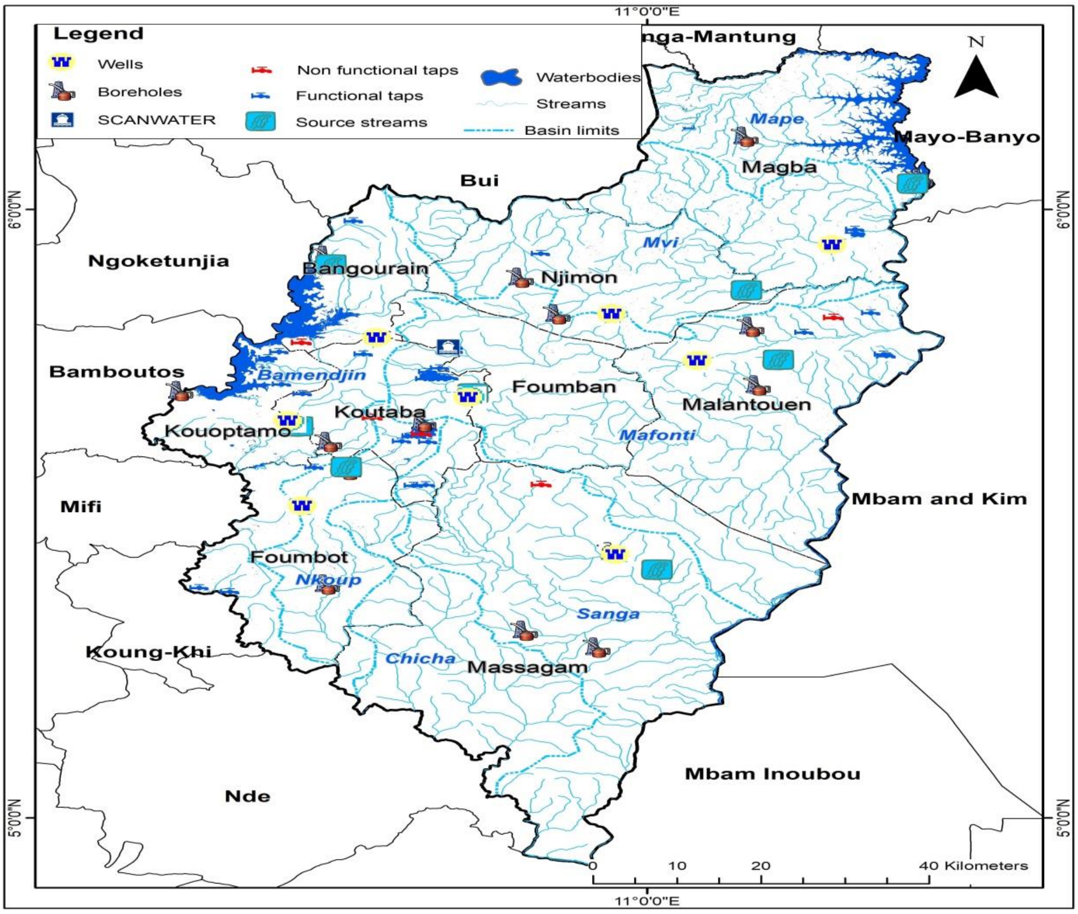

Figure 11. Location of water sources sampled for chemical/bacteria analysis

Source: Fieldwork, 2022

Table 3 shows the chemical properties of the streams sources in Figure 10 alongside the EPA standards Figures in read are abnormal composition that exceed EPA stipulated standards.

Table 3. Detail Chemical Properties of Sampled Streams Tested

Parameter	**EPA standard (in ppm)**	**Bangourain** *5.909275°N 10.661315°E*	**Foumbot** *5.57631°N 10.677909°E*	**Kouoptamo** *5.643455°N 10.625895°E*	**Koutaba** *5.697387°N 10.813194°E*	**Magba** *6.042305°N 11.283796°E*	**Malantouen** *5.752651°N 11.140248°E*	**Massagam** *5.407941°N 11.010576°E*	**Njimom** *5.86688°N 11.106083*
pH	6.5 - 8.5	6.0	6.5	6.0	6.5	6.5	6.5	6.0	6.0
Hd	-	100	50	100	25	250	100	50	100
H_2SO_3	0	0.5	0	0	0	0.75	0	0	0.5
Fe	0 - 0.3	0.3	0.15	0.3	0.1	0	0	0.3	0.3
Cu	0 - 1	0.1	0.1	0	0	0.1	0.1	0.1	0.1
Pb	0–0.015	0.03	0.015	0.03	0.03	0.015	0.015	0.03	0.03
Mn	0 – 0.1	0	0	0	0	0	0	0	0
Tc	0 – 3	0	0	0	0	0	0.25	0	0
Hg	0–0.002	0	0	0	0	0	0	0	0
NO_3	0 – 10	0	5	0	0	0	5	10	0
NO_2	0 – 1	0	0.5	0	0	0	0.5	1	0
SO_4	0 – 200	400	200	0	100	400	400	0	400
Zn	0 – 5	5	2.5	2.5	0	10	0	0	5
F-	0 – 4	0	2	2	0	4	4	0	0
NaCl	0 – 250	250	250	100	50	100	100	250	250
Ta	40 - 180	0	0	40	0	0	0	40	0

Source: Fieldwork, 2022

Based on table 3, the streams in Bangourain, Kouoptamo, Massagam and Njimom are slightly acidic (pH < 6.5), have abnormal lead and sulphate concentration of 0.03 ppm and 400 ppm than their respective recommended ranges of 0-0.015ppm and 0-200 ppm. Similar lead concentration was detected in the stream in Koutaba. The recommended hydrogen sulphide concentration of 0 ppm was exceeded in Bangourain and Njimom (0.5 ppm) as well as in Magba (0.75 ppm). Apart from Kouoptamo and Massagam, total alkalinity in the other streams was zero (0 ppm) far below the recommended range of 40-180 ppm. This implies that the streams under that condition cannot buffer or neutralise acids rapidly to stabilise pH. this is crucial because 42.3% of households depend on streams for drinking water in rural areas of the Noun Division in 2022.

Similar problems exhibited by table 3 were also detected in covered wells that were tested in the different rural councils of the Noun Division (Table 4). Water from the covered well in Foumbot, Kouoptamo, Massagam and Njimom were found to be slightly acidic (pH < 6.5) with that in Kouoptamo having abnormal hydrogen sulphide concentration (0.5 ppm) and the one in Njimom having excess sulphate (400 ppm) above their recommended standards of 0 ppm and 200 ppm respectively. Worse still, total alkalinity for the slightly acidic streams in Foumbot, Massagam and Njimom was zero indicating that they are more likely to remain acidic if nothing is done to neutralise their condition. This again is crucial because 24.48% of the people who have access to improved water sources in the communities depend on covered wells. More disturbing information was unravelled from similar analysis of borehole which is the second most dominant improved water source used by the population (Table 5).

Table 4. Detail Chemical Properties of Sampled Covered Wells Tested

Parameter	EPA standard (in ppm)	**Bangourain** *5.788535°N 10.711272°E*	**Foumbot** *5.51194°N 10.63167°E*	**Kouoptamo** *5.652019°N 10.616409°E*	**Koutaba** *5.690427°N 10.809091°E*	**Magba** *5.940991°N 11.198905°E*	**Malantouen** *5.750525°N 11.054514°E*	**Massagam** *5.431905°N 10.967127°E*	**Njimom** *5.827709°N 10.962823°E*
Ph.	6.5 - 8.5	6.5	6.0	6.0	6.5	6.5	6.5	6.0	6.0
Hd	Nill	100	250	25	100	50	50	50	50
H_2SO_3	0	0	0	0.5	0	0	0	0	0
Fe	0 - 0.3	0	0	0.3	0.3	0.15	0	0	0
Cu	0 – 0.1	0.1	0.1	0.1	0.1	0.1	0	0	0.1
Pb	0 – 0.015	0.015	0.015	0.015	0.015	0.015	0.005	0.015	0.015
Mn	0 – 0.1	0	0	0	0	0	0	0	0
Tc	0 – 3	0	0	0	0	1.5	0	0	0
Hg	0 – 0.002	0	0.002	0	0	0	0	0	0
NO_3	0 – 10	4	10	10	10	5	5	0	10
NO_2	0 – 1	0.4	1	0	0.5	0.5	0.5	0	0
SO_4	0 – 200	200	0	0	0	200	200	200	400
Zn	0 – 5	5	5	0	0	2.5	0	0	0
F-	0 – 4	0	4	0	4	0	0	0	4
NaCl	0 – 250	0	100	0	100	100	0	50	100
Ta	40 - 180	0	0	120	40	0	40	0	0

Source: Fieldwork, 2022

Table 5. Detail Chemical Properties of Sampled Boreholes Tested

Parameter	EPA standard (in ppm)	**Bangourain** *5.92393°N 10.656533°E*	**Foumbot** *5.571887°N 10.680277°E*	**Kouoptamo** *5.701365°N 10.500088°E*	**Koutaba** *5.651304°N 10.760317°E*	**Magba** *6.050241°N 11.292246°E*	**Malantouen** ***5.710694**°N 11.11829°E*	**Massagam** *5.427686°N 11.012659°E*	**Njimom** ***5.561763**°N 10.65941°E*
Ph	6.5 - 8.5	6.0	6.0	6.0	6.5	6.25	6.0	6.0	6.0
Hd	-	100	250	100	100	100	50	100	50
H_2SO_3	0	0.5	0	0.5	0	0	0.5	0	0
Fe	0 - 0.3	0	0.15	0.3	0.15	0.3	0	0.3	0.3
Cu	0 - 1	0	0.1	0.1	0	0.1	0	0	0.015
Pb	0 – 0.015	0.005	0.03	0.015	0.015	0.015	0.03	0.015	0
Mn	0 – 0.1	0	0	0	0	0	0	0	0
Tc	0 – 3	0	0	0	0	0	0	0	0
Hg	0 – 0.002	0	0	0	0	0	0	0	0
NO_3	0 – 10	0	5	0	5	25	0	0	0
NO_2	0 – 1	0	0.5	0	0	0.5	1	0	0
SO_4	0 – 200	800	0	0	10	800	200	400	200
Zn	0 – 5	0	0	0	2.5	5	0	0	0
F-	0 – 4	0	0	0	0	4	0	0	0
NaCl	0 – 250	0	100	250	100	250	100	0	0
Ta	40 - 180	120	0	0	0	0	80	0	0

Source: Fieldwork, 2022

Table 5 shows that the boreholes in Bangourain, Foumbot, Kouoptamo, Magba and Njimom had pH values of less than 6.5 which is within the recommended range. That in Magba, had nitrate concentration of 25 ppm which is far above the acceptable maximum limit of 10 ppm and sulphate content of 800 ppm which is four times the maximum limit of 200 ppm. The sulphate content of the boreholes in Bangourain was also 800 ppm while that in Massagam was 400 ppm which is twice the maximum limit. Lead concentration of 0.03 ppm which is twice the recommended maximum amount (0.015 ppm) was detected in the boreholes in Foumbot and Malantouen. Total alkalinity of the boreholes in Foumbot, Kouoptamo, Koutaba, Magba, and Njimom was zero (0 ppm), implying that those with lower pH are likely remain as such while those with normal pH risks becoming acidic if nothing is done.

Similar analysis on some few taps and open wells revealed that the former were generally within the recommended standards though pH in Magba and total alkalinity in Koutaba were below the recommended ranges. The open wells analysed in Kouoptamo and Malantouen had lower pH of 6.0, abnormal lead content of 0.03 ppm and 0.05 ppm respectively, and total alkalinity of zero.

3.6.3 Synergy/Variance in Chemical Properties of Drinking Water Samples

The Pearson correlation matrix (Table 6) indicates the degree of association between the different chemical components of drinking water sources based on the mean of the hydrochemical properties in Tables 3, 5, and 5.

Table 6. Pearson Correlation Matrix for Chemical Properties of Drinking Water **S**ources

	pH	**Hd**	**H_2SO_3**	**Fe**	**Cu**	**Pb**	**Tc**	**NO_3**	**NO_2**	**SO_4**	**Zn**	**F-**	**NaCl**	**Ta**
pH	1													
Hd	-0.1	1												
H_2SO_3	-0.1	0.2	1											
Fe	**-0.3**	-0.2	0.0	1										
Cu	-0.0	0.2	0.0	**0.3**	1									
Pb	-0.2	0.1	0.1	0.2	-0.2	1								
Tc	**0.3**	**0.5**	**0.5**	-0.2	0.1	-0.1	1							
NO_3	0.1	0.0	**-0.4**	0.2	**0.3**	-0.1	-0.2	1						
NO_2	0.1	0.1	**-0.3**	**-0.3**	0.0	0.2	-0.2	**0.4**	1					
SO_4	-0.0	-0.0	**0.3**	-0.2	-0.0	**-0.3**	0.2	0.2	-0.2	1				
Zn	0.2	**0.5**	**0.4**	-0.1	0.2	0.1	**0.6**	0.1	-0.1	**0.3**	1			
F-	**0.3**	**0.4**	-0.1	-0.2	**0.3**	-0.1	**0.3**	**0.5**	0.2	0.2	**0.4**	1		
NaCl	-0.1	0.1	0.2	**0.4**	**0.3**	**0.5**	-0.0	**0.3**	0.2	0.1	**0.3**	0.2	1	
Ta	**-0.3**	**-0.3**	**0.4**	-0.0	**-0.3**	-0.1	-0.1	0.0	0.0	0.1	**-0.4**	-0.2	**-0.3**	1

Hd = Hardness, Tc = Total chlorine

Table 6 shows moderate positive correlations between total chlorine (Tc) and zinc (r = 0.6) and similar correlations between hardness (Hd) and Tc and Zn (r = 0.5). This together with the weak positive correlation between hardness and F-, (r = 0.4) indicates that these properties are the greatest contributors to water hardness amongst the properties correlated in the matrix. Also, moderate and weak positive correlations between H_2SO_3 and Tc, Zn, SO_4, and total alkalinity suggest that their interaction with hydrogen sulphite contributes to their enrichment dwindling of nitrates and nitrite which rather have weak negative correlations with it. Positive correlations between NaCl and metals (Fe, Cu and Pb and Zn) implies that sodium chloride contribute enormously to the enrichment of these metals in drinking water. the generally negative association between total alkalinity and strongly suggest interaction amongst these properties contribute its generally low value in drinking water sources in the study area.

Principal component analysis revealed more insightful information on the analysis. The analysis was limited to the 14 variables in table 6 rather than the 16 in the preceding tables because the value of manganese in all the samples was zero while only a single value was observed for mercury. Rotated factor loading (based on varimax normalisation) revealed five principal component (PC1, PC2, PC3, PC4 and PC5) (with eigenvalues greater than 1) that explain 72.71% of total variability in the chemical properties (quality) of drinking water. Table 7 shows the components and their associated variable loading, eigenvalues and variance.

Table 7. Component loading, eigenvalues, and variances for drinking water chemistry data in the Noun Division

	Component				
Variable	PC1	PC2	PC3	PC4	PC5
Total chlorine	**.854**	-.117	-.167	-.027	.176
Zinc	**.850**	.217	.014	-.101	.051
Hardness	**.737**	-.029	.163	-.074	-.164
Iron	-.280	**.799**	-.195	.142	-.113
Sodium chloride	.228	**.702**	.237	.115	-.354
Copper	.163	**.650**	.167	-.195	.206
Nitrate	-.091	.317	**.812**	-.053	.250
Nitrite	-.061	-.232	**.767**	-.026	-.397
Fluoride	**.448**	.112	**.604**	-.211	.293
Total alkalinity	-.269	-.354	.052	**.752**	.177
Hydrogen sulphite	**.511**	.053	-.370	**.681**	.078
pH	.186	-.239	.080	**-.651**	.202
Lead	.128	.193	-.006	.231	**-.817**
Sulphate	.233	.065	.084	.303	**.632**
Eigenvalue	**2.997**	**2.289**	**2.113**	**1.475**	**1.306**
Variability (%)	**21.408**	**16.350**	**15.091**	**10.535**	**9.327**
Cumulative (%)	**21.408**	**37.756**	**52.849**	**63.384**	**72.711**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 9 iterations.

The first principal components (PC1) which account for 21.41% of total variance has strong positive loadings total chlorine (0.85), zinc (0.85) and hardness (0.74) confirms the synergy revealed among the components by the Pearson Correlation matrix (table 6). This gain implies that they are factors responsible for the generally high hardness observed in drinking water samples in the study area. Similar positive correlations have been reported water hardness and between zinc (Sengupta, 2013), fluoride (Karthikeyan *et al.*, 2000) and hydrogen sulphite.

The second principal component (PC2) which account for 16.35% of total variability (with eigenvalue of 2.289) has high positive loadings for iron, sodium chloride, and copper which in table 6 are all positively correlated. Iron and copper are both metals that are likely to becomes more corrosive when sodium chloride concentration increases. It would not therefore be totally wrong if the component is considered as factors responsible for the enrichment of metals in drinking water sources. You *et al.* (2019) found a positive association between sodium chloride and the corrosion of iron cast which has been ubiquitously used to protect wells and some boreholes in the area in most parts of the Noun Division.

The third principal component (PC3) with an eigenvalue of 2.113 is responsible for 15.85% in total variability. Revelations of strong positive loadings for nitrate (0.81), nitrite (0.77) and moderate association with fluorine (0.60) suggest that the component is underlain by factors encouraging the enrichment of these anions in drinking water sources. Though not out of proportion, the conspicuous presence of nitrate and nitrate in all drinking water sources in Foumbot which is the most intensive agricultural area in the Noun Division suggest anthropogenic origin while conspicuous presence in almost all wells suggest seepage from septic tanks might have contributed (Environmental Health Investigations Branch, 2000). The positive association of the properties with fluoride under this principal component is not a novelty. Chakrabarty and Sarma (2011) reported similar trend in India.

The fourth principal component (PC4) with an eigenvalue of 1.475 is responsible for 10.54% of total variability. Total alkalinity and hydrogen sulphite both have strong positive loading under the component while pH has moderate negative loading. While high concentration of hydrogen sulphite is normally expected to lower pH, high total alkalinity is supposed to be accompanied by high pH. This abnormality unveiled by this principal component needs to be investigated further for clarity. The last principal component (PC5) which account for just 9.33% of total variability has strong negative loading for lead (-0.82) and moderate positive loading for sulphate (0.63). The negative loading for lead is an indication that a certain characteristic is lacking in the characteristic of the latent variable associated with the principal component.

3.7 Scenario Forecasting of Access to Improved Water Sources in 2030

Findings for the four scenarios (current trend, hypothetical, probable and pessimistic) articulated in the methodology all revealed bleak impending state of rural water facility in the Division and all her rural councils (Figure 11) in 2030. Under current trend scenario, 31.92% of households will depend on unimproved water sources in 2030 in all rural councils of the Division. Under the hypothetical scenario which assumed static population growth under current trend efforts, 11.12% of the inhabitants will still lack access to improved water sources in 2030. The most probable scenario (Fifty Percent Scenario) which assumed that increase in the proportion of state budget allocated to councils from 3% to 15% (as stipulated by the law) would permit councils and other stakeholders to increase current trend effort by 50% indicates that 19.12% of rural communities will still depend on unimproved water sources in 2030 if it is effectively done. Even a 100% increase in efforts (pessimistic scenario) to provide improved sources of drinking water will still leave 6.32% of rural communities extracting water from unimproved sources. This general situation shields spatial disparity in historic and probable within the 8 rural councils in the Division is displayed in figure 10. The charts in figure 10 lettered A, B, C, and D shows the proportion of households that would still depend on unimproved water sources in each municipality under the different scenarios. Only the data for 2022 and 2030 have been displayed on the charts because that of the intermediary years makes the details too congested and invisible.

Figure 12A which presents current trend scenario forecast shows that none of the eight rural municipalities will have complete access to improved water by 2030. In Njimom with the most rapid annual progress rate, 8.19% of households would still depend on unimproved water sources in 2030. The situation in Bangourain and Massagam will be more pathetic as 61.18% and 50.03% of their respective population would still depend on doubtful water sources. Under the hypothetical scenario (Figure 12B), only Foumbot and Njimom would have complete access to improved drinking water sources. In Magba, 1.85% of the people will still depend on unimproved sources whereas Bangourain, Kouoptamo, Koutaba, Malantouen and Massagam would have 51.92%, 5.81%, 10.98%, 2.49% and 31.86% of the households still extracting drinking water from unimproved sources in 2030. This scenario is unrealistic because population growth cannot be static as assumed. Under the most probable scenario (Figure 12C), only Njimom is more likely to have complete access to improve water sources in 2030. Foumbot would have 0.92% of her population depending on unsafe water sources whereas Bangourain and Massagam would still have 56.8% and 40.9% of their population extracting drinking water from unimproved sources. In Kouoptamo and Malantouen the proportion would be less than 20% whereas in Magba it would be less than 6%. This is disturbing given that it is the most probable path that municipalities in the area are likely to take if the planned increase in the proportion of state budget to councils from 3% to 15% is effectively implemented. However, such an increase would only translate to the progress envisaged here if other stakeholders that do not depend on the government equally increase their efforts. The pessimistic scenario illustrated by Figure 12D is the most robust. Under it, Njimom, Foumbot and Magba would provide improved drinking water sources to all households even before 2030. Kouoptamo and Malantouen would have just 5.81% and 2.49% of their population depending on unimproved water sources while Koutaba will still have 10.98%. Bangourain and Massagam which have the lowest progress rate would still have 51.92% and 31.86% of their population in 2030 deriving drinking water from unimproved sources under the scenario.

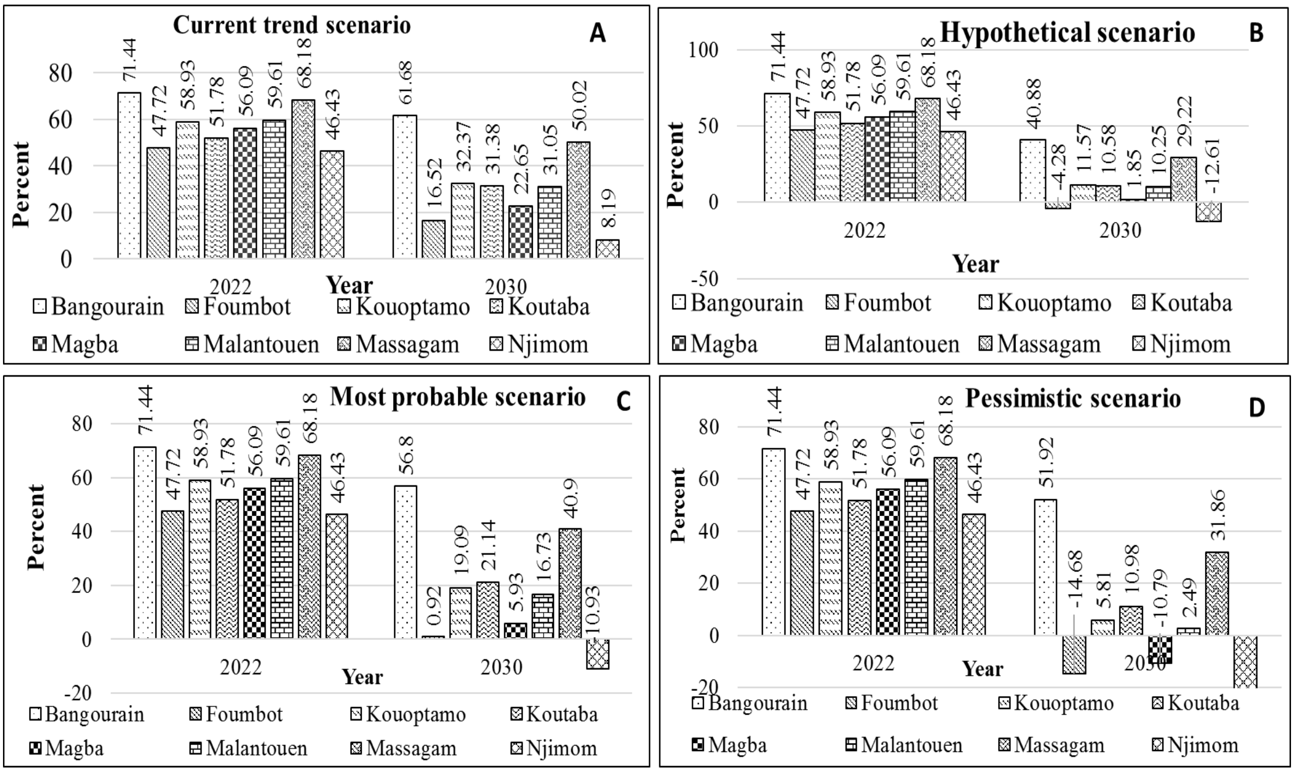

Figure 12. Scenario forecast for improved water sources by 2030 for municipalities

Source: Fieldwork, 2022

4. Discussion

In most rural areas of the world, dependence on unimproved water sources has trapped many people within the vicious cycle of poverty. This study was undertaken to assess the progress made by water governance stakeholders to provide safe drinking water to the rural communities of the Noun Division from 2015 when the SDGs were formulated. Analysis of quantitative and qualitative data generally revealed that limited progress has been made in the provision of improved water sources to rural communities in the study area. The findings revealed that the proportion of people depending on unimproved water sources in rural communities of the Noun Division shrunk from 79.92% in 2015 to 57.52% in 2022 and that 42.3% of the population still collect drinking water from streams in 2022. The proportion collecting water from standing pools dwindled thrice from 4.82% in 2015 to 1.33% in 2022 while that relying on open wells reduced timidly from 14.28% to 13.89%. Bangourain and Massagam emerged as the municipal council areas where over 50% of their population still rely on unimproved water sources in 2022 while Koutaba and Foumbot with 33.93% and 34.09% had the least. This result deviates greatly from WHO and UNICEF report of 2017 which stipulates that one (1) out of three (3) people in the rural areas used safely managed water source in 2015. It is also antithetical to the Cameroon’s Ministry of Water and Energy estimate that 61% of rural communities had access to improved water sources in 2015 and JMP household survey of 51% access in 2008 and estimated access of 75% in 2015 based on an annual progress rate of 2.1% in 2009. Though the explanation to this could be probable variance in scale of the study area (national survey and hence lose sampling) as well as probable slump in progress rate over time, it equally strongly suggests that finer studies at smaller scales (municipalities, villages levels) can produce results that deviate enormously from national data (used by JMP) as noticed by Bressler and Hennessy (2018) in Greenland and Finland.

Another intriguing findings of the study is the revelation of meagre increase in round trip time albeit the improvement in drinking water sources. The proportion of households fetching drinking water in less than 30 minutes increased from 49.62% in 2015 to 50.38% in 2022 mainly because the provision of improved sources in some localities has forced some people to abandon nearby unimproved sources that they have been depending on. Equally disturbing is the fact that Koutaba and Foumbot which registered the greatest progress in cutting down reliance on unimproved sources of water still have over 40% fetching water in over 30 minutes. One of the prime objective of the SDG 6.1 whose progress is monitored by WHO, UNICEF, and the Joint Monitoring Program is to ensure that people who do not have safely managed drinking water sources on their premises spend less than 30 minutes (round trip) to collect water off their premises. Increase in round trip time is therefore a strong indication that improved water sources in the area are few and are located in particular localities. Such localised and unplanned actions are more likely to amplify inequality in access even at the municipal and village levels.

Moreover, the abnormality detected in the chemical and bacteria content of drinking water sources must not be overlooked. Abnormal lead concentration such as that detected in water sources in Bangourain, Kouoptamo, Koutaba, Massagam and Njimom can damage the human brain, kidney, nervous system and the white blood cells (WHO, 2016). Though its principal origin is the corrosion of portable water pipes, lead is also found in the soil, and rocks and can enter drinking water especially when pH is low. Sulphate concentration beyond the recommended range detected in Bangourain, Magba, and Malantouen has been associated with diarrhoea and dehydration especially in infants. Sulphur in drinking water originates from the bed rocks. The probable health impacts of hydrogen sulphite (detected in streams in Bangourain, Magba and Malantouen) include nausea, vomiting and epigastric pain. Apart from methamoglobinemia in infants, an association has been reported between nitrite/nitrate and gastric cancer (Picetti *et al.*, 2022) as well as thyroid diseases (Ward *et al.*, 2018). Nitrate and nitrite come mainly from fertilizer washed into water bodies by overland flow. This is crucial given that agriculture in the area is very intense especially in the municipality of Foumbot, Koutaba and Kouoptamo. In addition, the positive bacteria test for streams in Bangourain, Kouoptamo, Magba, Massagam, and Njimom suggest even more dangerous health implications. Dinka (2018) warned that drinking water must be free from bacteria, protozoa, helminth and virus. Despite the fact that the results of the findings were obtained using simple water test kits, the findings here must not be neglected. Reliability test of the “17 in 1” test kit used for chemical analysis at the Camwater treatment center in Foumbot showed over 95% accuracy level while that of the “iQ. BAC” done with samples of uncontaminated water and water sample mixed with animal faeces also provided reliable findings.

The results from scenario forecasting were generally in consonance with other modelling studies in literature. It agreed with Moyer and Hedden (2020) pessimism that complete access to safe drinking water in 2030 would be hard to achieve unless there are major shifts in current policy priorities. Oxfam (2020), equally claimed that numerous evidence attest that complete access to improve sources of drinking water would not be met. Under current trend scenario, 31.92% of rural communities in the Noun will still depend on unimproved water sources in 2030. Under the most probable scenario which assumed a 50% increase in current trend effort by water governance stakeholders and pessimistic scenario which assumes a 100% increase, 19.12% and 6.32% of rural dwellers would still lack access to improved water sources. Even the hypothetical scenario which assumed current trend efforts but with an unrealistic assumption of holding population constant still revealed that the target would not be achieved in 2030. This confirms the hypothesis of the study which states that water governance stakeholders are less likely to provide safe drinking water to rural dwellers in the Noun Division by 2030.

This study apart from situating the state of drinking water in the rural communities of the Noun Division relative to national and global contexts, it equally gives a pointer to stakeholders in the sector on alert on the task to be done if they dream of achieving agenda 2030. What must be noted here is that chemical and bacteria analysis were performed using the "17 in 1" water test kit and the iQ BAC coli test kit respectively. Both are rapid test kit designed to facilitate rapid testing of drinking water sources. They are therefore cost effective reliable instruments that can be used to overcome the barricade (high costs) that have often act as a barrier to water quality related study especially to young researchers. Water sources detected with problems can then be subjected to more comprehensive and conventional laboratory test for confirmation. The study partially responds to Moyer and Hedden (2020) call for consideration of uncertainty in scenario analysis on water and sanitation in sub-Sahara Africa, though the shared socio-economic pathways (SSP) they specifically recommended was not used. Scenario forecasting was done at a confident interval of 95%.

5. Conclusion

The main objective of this study was to examine the progress made by stakeholders in the provision of safe drinking water to rural dwellers of the Noun Division from 2015 and to forecast the state of portable water in 2030. Analysed data revealed that there is minimal progress in accessibility, availability, affordability and faecal content of drinking water sources. The average round trip time slightly increased while a significant proportion of the population indicated that drinking water has become very expensive. Chemical and bacteria analysis also revealed that there are significant problems with various drinking water sources, notably the abnormal concentration of lead, hydrogen sulphite, nitrite, nitrate and sulphate which have been reported to have serious health implications in similar studies. Five streams also had positive bacteria test which is equally another danger. Scenario analysis using four probable paths showed that complete access to safe drinking water in the study area in 2030 will not be tenable unless extraordinary effort is taken by the stakeholders.

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