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Climate Variability and Power Outages in the West Region of Cameroon

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Abstract

In West Cameroon, however, by referring to the natural intra and interannual variation of the climate which is climate variability, while climate change means a change in the climate attributed directly or indirectly to human activities that alter the composition of the climate global atmosphere. In other words, climate change designates a significant modification of this average: if repeated meteorological variations are sufficient to modify the average over thirty years, then it is considered that they no longer correspond to normal interannual variations but to a variation of the climate itself. Working on climate variability and electrical load shedding, we exploited and analyzed the database of meteorological data collected at the Edea hydroelectric dam, the main supplier of electricity in this part of the country. For 06 months, we collected data from randomly selected households in different cities in the West of the country, interviews with local elected officials and with The Energy of Cameroon (Enéo) staff and finally, our field observations on the impact of power cuts on the socio-economic activities of the population in the West of the country.

Our results show that the main impacts of climate variability on the hydroelectric power production of the dam result from the evolution of the water resource with regard to climatic conditions, and from the increase in economic actors through the population concerned by this resource: energy, household, service, trade... Thus, the results show that the city of Bafoussam in a humid and dry tropical climate is located at an altitude of 1432m and records an average of 1500 mm of annual rainfall with a annual average temperature of 20.9 °C against 4473 mm, 19. 7 °C recorded in the city of Dschang (1340m) and Foumban (1187m altitude) with an average of 22. 7 °C over the year and precipitation average is 1727 mm. The evolution of flows and the multiplication of drought episodes recorded in West Cameroon impact hydraulic production by reducing the water reserve of the Bamendjine dams. This decrease has an impact of a possible increase in the frequency of load shedding already recorded around 09 days 29 minutes without light in the study area and its impact on socio-economic activities including services, trade and households. The torrential rains impact the electrical infrastructure, in particular the poles and electrical wires, which leave the population in the dark. The energy supply made by Eneo is very insufficient due to the growing demand of the population of the West (+7%). Awareness of the reality of climate change is necessary. The politician must turn to renewable energy to build a solar power plant and wind energy to boost demand. It will also be necessary to build new energy infrastructures adapted to climate change (concrete poles, buried wires underground, the best transformers).

Keywords: Electrical load shedding; West-Cameroon; Service disruption; Climate variability; Electrical load sheddin

Introduction

Electricity generation has a connection with climate variability and change. According to Koch et al., (2015), the generation of electricity depends directly on climate/weather parameters like wind (wind power generation) and temperature for thermal plants. For hydro power generation, river discharge is the main factor and it is influenced by precipictation and temperatures. Hydroelectric power (HP), being one of the most used source of energy produced in the world, the Hydroelectric power production is by the used of gravitational force of the running water or flow water as well as waterfalls driven turbine to generate electricity [1].

Apart from disrupting power generation, climate variability and change equally hit the entire electric system. The electric power system is the electric infrastructures that consist of the generation, transmission, and distribution of the electric energy to the end users or customers [2]. The electrical supply system is made up of the three major parts in which we have generation unit, transmission unit and distribution unit and each of these units contain transformers to regulate the voltage (Salahuddin, 2017; Kamia, et al., 2019). All these units of electrical power supply system are exposed to the climatic variations. They reduce production but equally impacts transmission and use in households and institutions [3].

In Cameroon, electricity generation by hydro power plants has a share in the entire enegy sector as almost 90% of the economy depends on it. Although production has increased in the last few years with the construction of many new dams, electricity supply to households is still very insufficient. More than 30% of the total power produced is lost along the transmission line. This is partly because the transmission infractructure are vulnerable to weather changes. In Cameroon, only a few studies analyze the impacts of climate variability on electricity production and the few studies have focalized on effects at the level of production. Works by Handayani et al. [4-6].

indicate that severe weather events often cause disruptions in electricity supply and power outages due to failure in distribution netweorks. Transmission networks have been shown to be susceptible to lightning strikes, which are main cause of climate related power outages (Handayani et al., 2019).

In this paper, the effects of climatic variability on hydro electric power transmission and supply to users are analyzed. It is hypothesized that the constant power outges are caused by fluctuations in climatic paraters, notably, winds and rainfall. The power supply system in the West region of Cameroon is vulnerable to climatic changes. The frequent power outages registered during rainfall and heavy storms prompted us to investigate the relationship existing between weather aberrations and power outages as well as the impacts on the entire electricity supply system [6-10].

Electricity Supply in the West Region of Cameroon

According to the statistic of the electric utility (ENEO), West region has 182 543 subscribers to the Low Tension (LT) and 92 subscribers to the Medium Tension (MT) supply system. These number of subscribers vary across the various towns of the region (Table 1). The transport network is coming right from the South Interconnected Network starting for the Songloulou to Nkongsamba and extent to the West and the North West region of Cameroon. The extension of all these transport networks are exposed to the weather. The west region transport network is at the head quarter of the region where all departure lines take place. All the electric lines are space electric lines which are exposed to climate variability such as violent winds and rainfall storms.

Table 1: Number of ENEO Subscribers on MT and LT supply systems.

Commercials unites	Subscribers on LT	Subscribers on MT
Commercial Division West 1- BAFOUSSAM	63 840	49
Commercial Division West 1- NOUN	30 620	13
Commercial Division West 2-MENUA_ MBAMBOUTOS	51 617	15
Commercial Division West 2-NHT_NKAM	36 466	15
TOTAL	182 543	92

Source: MINEE regional Delegation (2020).

Materials and Methods

The Study Area

The West Region of Cameroon is located on the western Highlands and contains many urban centers that depend solely on electricity supply from the Songloulou dam in Edea. The regional head quarter is Baffoussam, a big business center and a central point for the redistribution of electricity supply lines to other towns of the West and to the neighbouring Northwest Region. SONATREL, the body in charge of the electric transportation in the Region is facing the problems of inaccessibility to transport electric energy to the distribution units called ENEO to distribute to households. The electricity supply line is extended from the South interconnected grid passing through Nkonssamba line to the West and to the North West region of the country. The main urban centers of the region are Bafoussam, Foumban, Dschang, Mbouda and Nde. They all depend on the same supply line (Figure 1) and have little or no alternative energy sources.

Figure 1 shows that the electricity supply network is dense in urban centers while the rural areas are still less connected. Baffoussam has the highest density. The main transmission line of 90kv which extends from the South West region to the West and to the North west region (151km) is the line of Medium tension while the distribution lines of 30kv are found all over the towns of the West region covering a distance of 830km. The rate of electricity coverage of the region was estimated at 52% in 2015 and the rate of accessibility was 45, 8% for the same period (MINEE regional delegation, 2020). Since then, the situation has not witnessed any remarkable change.

Data Collection and Analysis

A mixed research approach was used to collect both quantitative andqualitative data for this study. A total of 155 questionnaires were administered to households within the five selected urban centers of the West region: Bafoussam, Foumban, Dschang, Mbouda and Bangangte. Field observation and 3 focus group discussions were organized. Also, 24 interviews were conducted with experience resource persons working with electricity supplycompany and in the Delegation of energy and water supply. Field observations permitted us to get the state of infrastures. Participants in focus group discussions were energy users and local authorities. The climatic data was collected from the year 1988 to when 2017 anddata on the frequency of power outages collected from the five urban centers for six months.

Microsoft Excel, Statistical Package for Social Science (SPSS) version 21.0 were used to analyse data. The cumulative differences and the cumulative percentile difference were calculated to establish wind, temperature and rainfall anomalies. To determine the trends on the climatic elements such as rainfall, wind and temperature, the regression lines were fitted to the data in order to obtain the trend of any lines. The R-Square (R^2) was recorded for each graphs or analysis for the determination of the significant of the trend. Interviews and data from Focus group was transcript and treated using content and thematic analysis.

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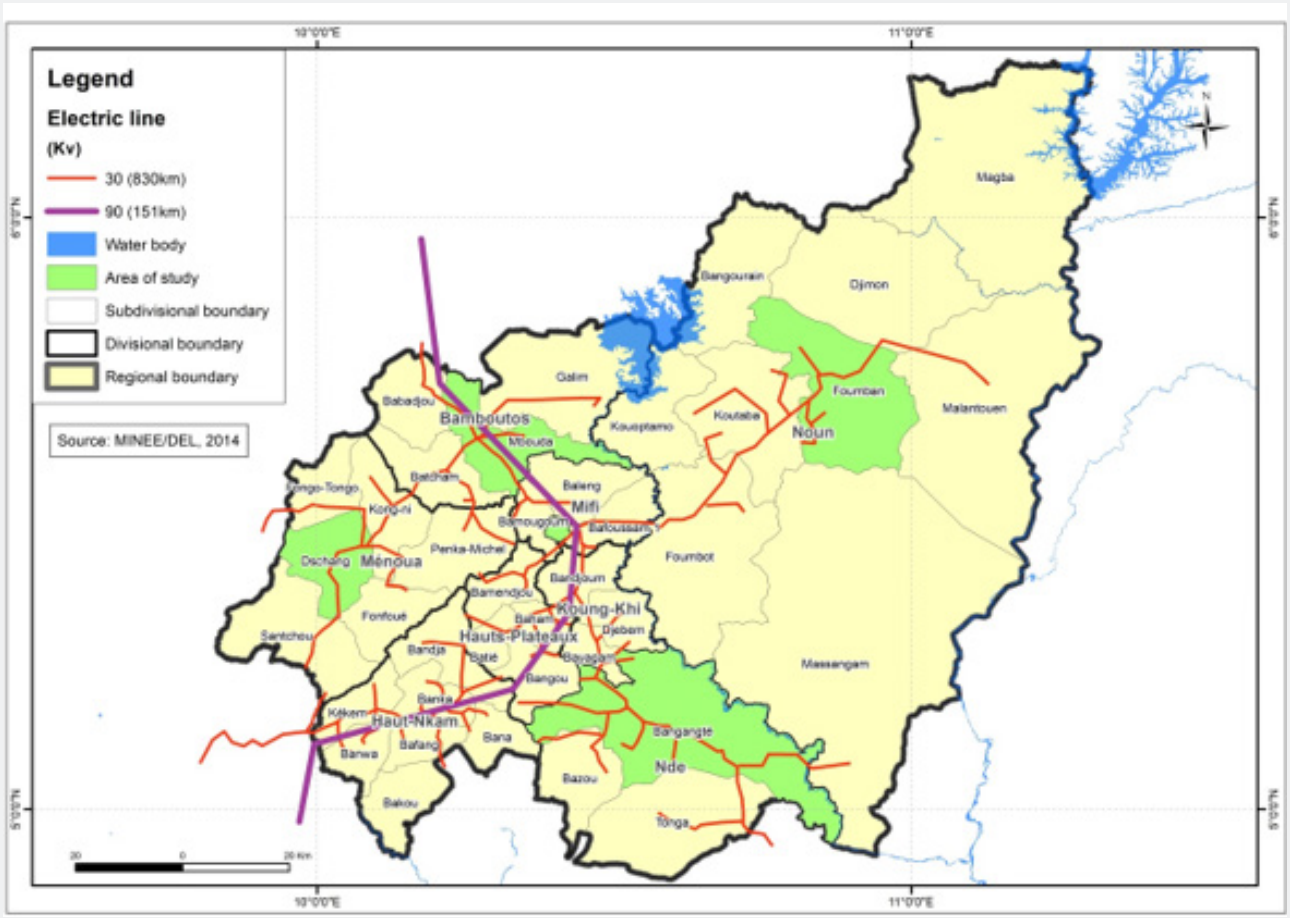

Figure 1: The hydro power transmission lines in the West region.

Results and Discusion

Indicators of Climate variability susceptible to influence electric power supply in the West Region of Cameroon

The indicators of climate variability that disrupts electric supply systems are rainfall variations, temperature and wind fluctuations. Extreme rainfall events have disastrous effects on the electric transmission lines. Such anomalous events have been occurring in the region over the past years Figures 2 indicates a fluctuation between the years with positives anomalies and years with negative anomalies. These are periods during which rainfall is either below or above the normal. In most cases, such rainfall events are associated with thunder storms, lighthening and thunder that destroys the electricity transmission lines. Years such as 1988, 1989, 1994, 1996 and 2012 recorded positive anomalies characterized with violent rainfall events.

The region have two seasons that is rainy and dry season. The rainy season is longer and extends from mid-March to mid-November while the dry season is shorter from mid-November to mid-march with little amount of rainfall. This implies that the negative effects of violent rainfall events on electricity supply infrastructure are pronounced in the rainy season. Results from focus group discussions and interviews revealed that many localities experience frequent outages during the rainy season than in the dry season. This seasonality of outages strongly correlates with rainfall anomalies.

Violent winds are another indicator of climate variability that affects power outages in the region. The wind speed in this region varies in to 10meters per Second (10m/s) and 50meters per second (50m/s). The variation in wind speed is equally associated with rainfall events. In most cases, violent winds are more destructive when ccomapanied by rainfall. Violent winds do not only pull down electric poles but equally destroy trees, roofs and other infrastructures that falls on the electricity transmission lines. Temperatures have been fluctuating with an increasing trend. The rising temperatures have effect on electric wires, transformers and other exposed infrastructure.

Climate variability and power outages in the West region of Cameroon

The questionnaire survey shows that the population of the west region are aware of the relationship existing between cli-

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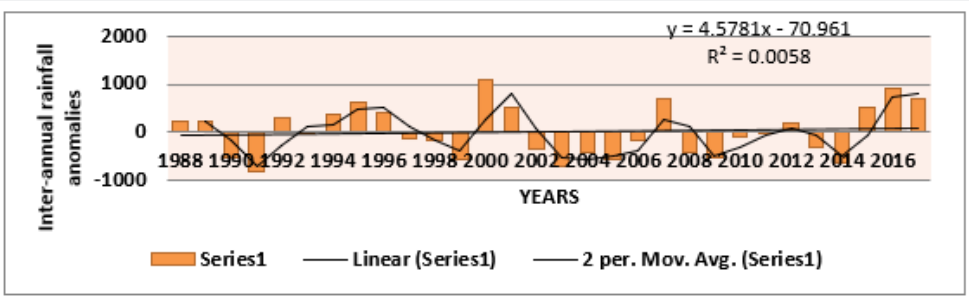
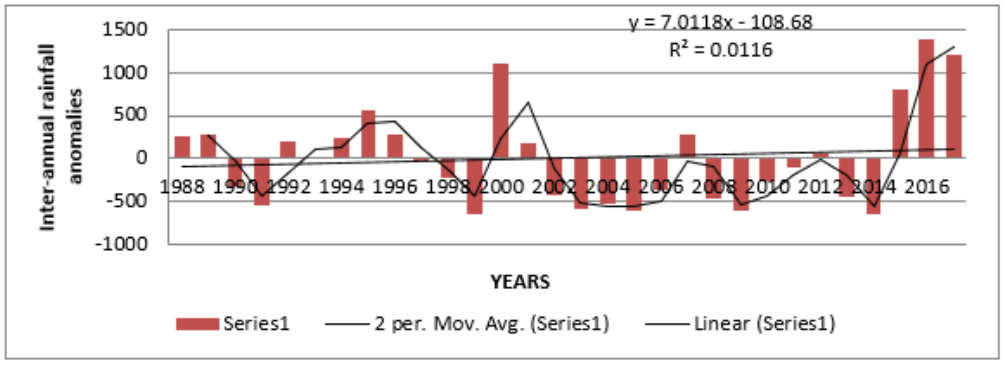
mate variability and power outages in the region (Figure 3). Responding to the question, what climatic element is responsible for power outages ?, majority of the respondents(61.8%) said extreme rainfall event, violent winds and thunder storms (26.8%) and very high temperatures (5.7%). Most of the respondents said rainfall is accompanied by lightning strikes which causes power outages. Findings equally revealed that the frequency of power outages have increased over the past years. 51% said the power outages occur more frequent, 33,8% of the respondents said they power outages occurs frequent and 14% of the respondents said the power outages occurs less frequently (Figure 4). Given that climatic changes are usually unpredictable, 51% of electric cuts are not notified and only less than 15,3% are notified. The notified cases could be due to technical works, which in most cases are repairs on transmission lines. During an interview conducted with the chief of services in the regional delegation of energy and water resources on March 2021, the following excerpt was capture.



Inter- annual rainfall anomalies for Bafoussam (1988-2017).



Inter- annual rainfall anomalies for Mbouda (1988-2017).

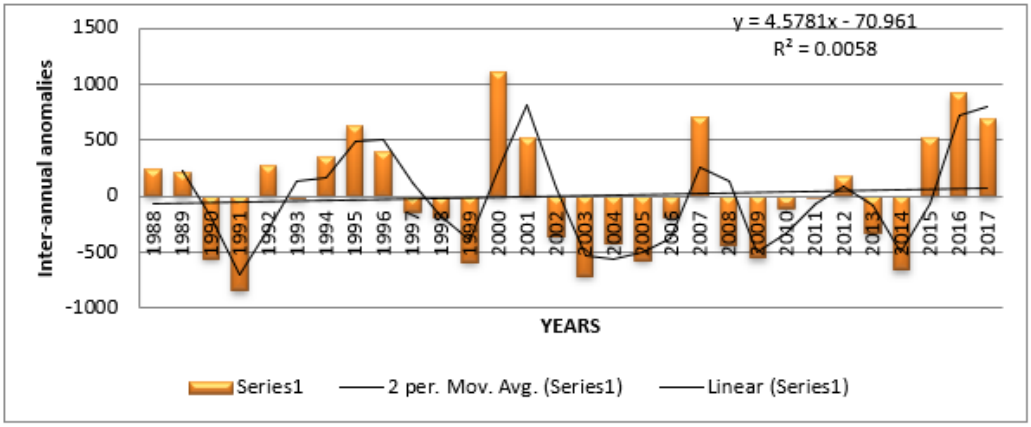


Figure 2: Inter -annual rainfall anomalies for Dschang, Mbouda and Bafoussam (1988-2017).

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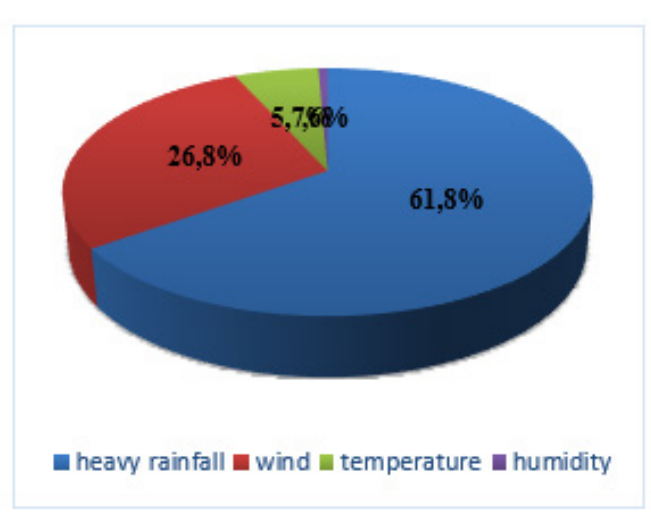

Figure 3: Population perceptions.

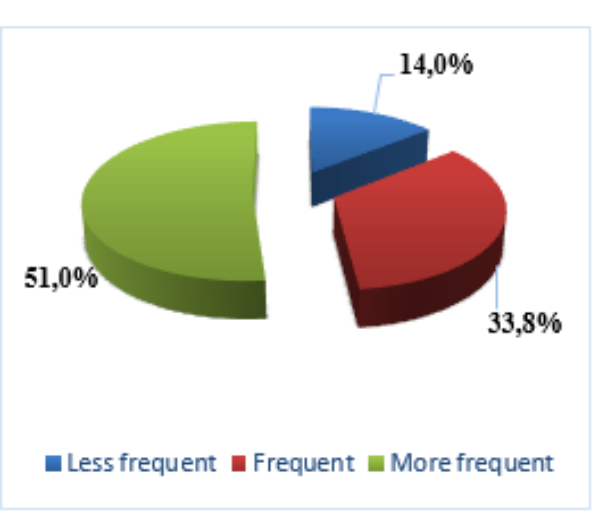

Figure 4: Frequency of power outges.

"..... violent winds associated with heavy downpour have created a negative impact on the infrastructural network. The falling of the branches of trees on the transmission network as well as the falling of electric poles usually cause disruption and power outages ....."

In thesame light, the manager of ENEOFoumbanon March2021 reitirated the relationship existing between climatic fluctuations aand power outages. He had this to say ;

« ... Lightning strikes cause power outages or electric failure. It usually brings sudden change in the voltage transmission lines. When the voltage is high, itwill affect most of the household devices and damage transmission lines equipment's... ».

These perceptions and expert views demonstrated the gravity of the situation. The rising frequency of climatic of perturbations there means the future is uncertain as far as electricity supply is concerned. Findings revealed that the following infrastructure lines have been reported to have suffered from damages due to climatic aberrations and thunder storms in the past five years:

i. The thermal center of Bafoussam with the installed power of 14MW in which 2,5MW is operational and the two isolated thermal plants center in Mape with the installed power of 2,149MW in which 0,644MW is available

ii. 3km lines of the MT relies on the thermal center 14MW of Bafoussam source post in Bafoussam 90/30KV (villages of Tchouong and Djunang in the Bafoussam 3 Subdivision);

iii. 7km Lines MT in the division of Mifi (Departure D11 of the post of BAFOUSSAM);

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iv. 16km lines MT in the division of Mifi (D12 from the post of Bafoussam);

v. 18km lines MT in the division of Mifi (D13 from the post of Bafoussam);

vi. 375km lines MT in the division of Moungo in the Littoral and Haut-Nkam (departure D32 Bafang from the post of 90/30KV);

vii. 585km lines MT in the division of Mifi and Noun (D32 Foumbot from the post of Bafoussam);

viii. 1 145km lines of the MT in the division of Mifi to Koung-Khi, The Hauts-Plateaux, Haut Nkam and Ndé (Departure D33 Bangangte from the Bafoussam post);

ix. 7km lines of MT in the Division of Noun coming from the thermal center of Mape 1,03MW.

Periodicity of Power Outages

The temporal scale of climatic variability reflects the periodicity in outages. On the seasonal perception, respondents 25% of respondents said it occurs in both in the dry and rainy season, 51% of the respondents said is occurs in the rainy season and 23% of the respondents said is occurs but in the dry season. The rainy reason registered the highest number of outages due to rainfall anomalies, associated with lightenning and thunder. For the duration of outages, 41% of respondents said power outages usually last days, 21% said they last for hours while 30% said the duration is not determined. The long duration occurs when ever major destruction occurs and when transformers are burnt. Electricity supply Infrastructures in the West are highly exposed to the effects of drastic weather changes. Plate 1 shows an overcharged electric pole and a transmission center. The transmissions lines are the installation that permit the extension of electric energy with the tension superior at 33KV from the site of the production to the distribution network with the frequency of 50Hz. The entire transmission electric systems are exposed to the climatic variation like any other infrastructure of the electrical system [11-15].

Plate 1: Exposed electricity transmission infrastructure.

Climate variability and electricity production in the west region

More than 90% of electricity energy consumed in the West region comes from the production unit in Edea. So, the impacts of climatic fluctuation in the West region are experienced during transportation rather than during production. Nevertheless, a number of micro hydroelectricity projects have been put in place for the production of electricity in the west region (Table 2). These micro projects have been hit by changes in climatic elements and extreme weather events. The fall in water volumes due to dry spells and floods have been reported to have infleunce supplies negatively.

The power produced in these areas satisfy the needs of the rural population. The construction of hydroelectric dams such as the one in Bamendjing and the Mape do not produce electricity directly, but help supply water to the main station in Songloulou during periods of water shortages. Nevertheless, changes in rainfall patterns have affected water supply to these dams and have reduced their electricity production capacities.

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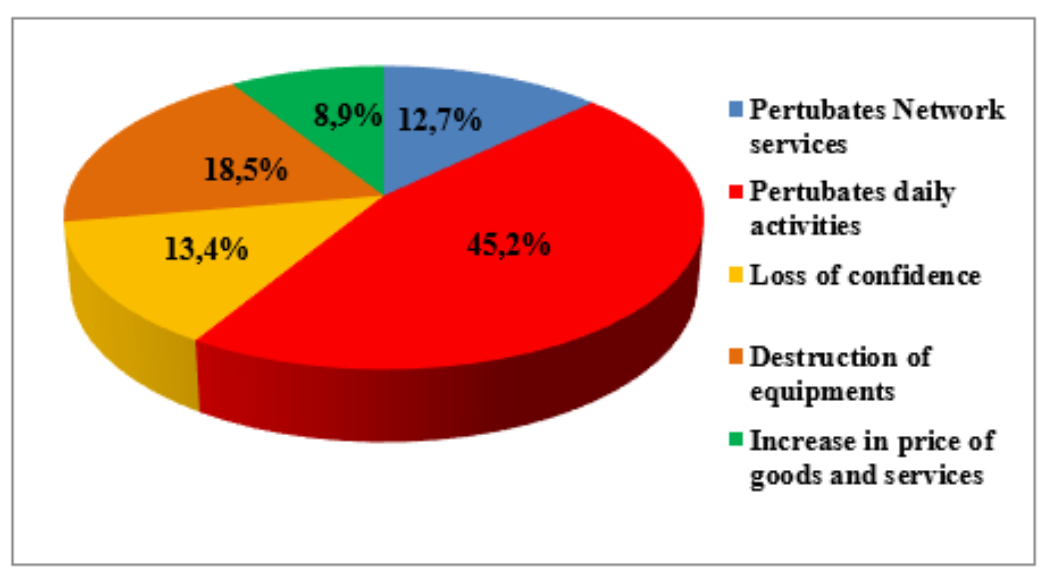
Table 2: Micro hydroelectricity projects in the West region.

Places	Power installed KW	Years
Mamamram	7.5	2004
Tongou	5	2006
Nefolem	6.5	2006
Tchouandeng	20	2010

Source: ADEID(2010).

Impacts of the power outages on human activities

Findings reveled that frequent power outages have negative impacts on the economy of the west region. A wide range of challeges have been identified (Figure 5). The questionnaire survey revealed that power outages completely pertubates the everyday activities of the population (55.25%), disrupt network services and internet communication(12.7%), destroy household equipments (18.5%) and increses the prices of good and services in the maeket (8.9%). This is because hydroelectric power supply is their main source of energy that supports close to 97% of economicactivities in the region. Businesses such as banks, secretarial works or cyber cafe works and students suffer alof from this problem. During an interview conducted inFoumban town on March 2021, the following excerpt was captured to buttress the impacts of power outges on the population.



Source: Field work March 2021.
Figure 5: impacts of power outages.

"..... Without electricity our company cannot function well because once there is power outage there is perturbation of network. We work entirely with electricity, and once there is power outage most of the functions will be totally interrupted. It is a serious problem for all the sectors as many activities are done online nowadays....."

« ..... Constant power outges have increased my expenditures and made reduced my gains. I have a cold store and each time current goes off, i use a generator which is very costly to run.... »

« .....i will never forget the incident. Lights were on and off due to heavy rainfall and thunder storm. This destroyed all our electrical appliances as no one was home to disconnect them..... »

These excepts adds to the uestionnaire survey to show the impacts of power outages on households and petit businesses are enormous. Many victims have accused the electricity supply authorities for these problems without knowing that some are caused by weather abberrations. Faced with this, the population have been adopting other measures to cope with the constant power outages.

Measures Used by the Population to Cope with Power Outages

The measure used by the populations to adapt to the power outages depend on the social class, income level of the household and the activity type involved. At the household level, the primary use of electricity is for lighting. With unstable supply, alternative

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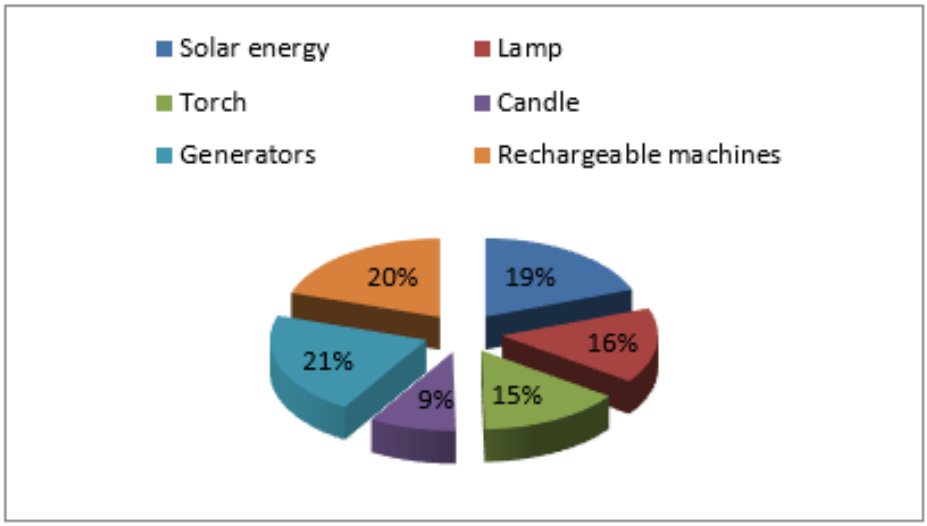
lighting sources have been employed. Figure 6 shows that 19% of the popultion use solar energy, 21% use rechargeable facilities, 20% use kerosen lamps, 9% use generators while others use battery touches and candles during power outages. The use of generators to cope with the power outages is done mostly by business men and some of offices. Most of the services like hospitals, CONGELCAM, fuel station and other services are using the automatic generators (Plate 2).



Source: Field work March 2021.
Figure 6: Strategies by the population to copes power outages.

Plate 2: Alternative power facilities and lighting sources during power outages.

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The use of the solar energy is all over the towns of the West Region of Cameroon. Most of the instruments on plate 2 are charged using direct solar energy. The affordable prices of some of these gadgets have favored their usage. Some of the business men and households are using different rechargeable machines to copes out their daily activities or for home adaptability. For instance, barbers are using the rechargeable machines, households are using rechargeable bulbs.

The uses of the lamps, torches and candles are the ancient method of lighting that are common mostly in rural areas that are not connected to the electricity transmission lines. Nevertheless, these old methods are resurfacing in the urban melieux and used by all social classes to cope with power outages. However, the general observed trend is rising for those using solar energy as most of the modern facilities are rechargeable using solar enegy. Given the tropical climatic conditions in this region with abundant sunshine, solar energy seems to be the future of renewable energy in Cameroon. A number of centres have been constructted for the production of solar energy in the West region of Cameroon (Table 3).

Table 3: The solar centres of the West Region by Huawei frame project.

Numbers	Name of site	Power	Region	Department	Subdivision	Latitutde	Longitude
1	Makoutam-Plateau	54KW	West	Noun	Malantouen	57,416	110,489
2	Makpa 1	97,2KW	West	Noun	Malantouen	55,474	110,436
3	Batoula-Bamenghui	54KW	West	Bamboutos	Malantouen	56,261	101,525
4	Njigbachouh	54KW	West	Noun	Massangam	55,602	110,511
5	Mbakop	54KW	West	Noun	Massangam	50,572	111,572
6	Mayoh (Njitoukwet)	81KW	West	Noun	Malantouen	58,253	110,804
7	Belekwet Chefferie	26,1KW	West	Menoua	Nkong-Ni	55,181	101,626
8	Bamboue 2	54KW	West	Bamboutos	Batcham	55,906	101,439
9	Mankang-Mayong	54KW	West	Menoua	Santchou	55,296	100,652
10	Mangourain (Nkouombi)	54KW	West	Noun	Massangam	54,431	110,683
11	Njinga-Ndoutain	97,2KW	West	Noun	Malantouen	56,765	111,196
12	Baboutcheu-Ngaleu	21,6KW	West	Haut-Nkam	Bafang	50,978	10,198
13	Tsah-Bamendou	54KW	West	Menoua	Penka-Michel	54,687	102,054
14	Bamela	32,4KW	West	Bamboutos	Batcham	55,932	101,492
14	Feuguimbou (Nfenguembou)	183,6KW	West	Noun	Malantouen	55,292	110,932
16	Fotemo	54KW	West	Menoua	Nkong-Ni	56,437	100,934
17	Fondjomekwet	81KW	West	Haut-Nkam	Bandja	55,823	101,619

Source: MINEE Regional delegation of Bafoussam (2021).

The actors of the renewable energy sector in Cameroon and in the west region in particular are creating the different sources of energy to copes with the shortages inhydroelectricity supply especially in the periods of low water. These solar centers constructed within the framework of Huawei project have boast production and reduced over dependence on hydroelectric power, which has been proven to be highly vulnerable to the vagaries of weather.

Discussion

Vulnerability of electricity supply system to climatic fluctuations

This work set out to explain the relationship between climatic variabilities and power outages in the West region of Cameroon. Findings revealed that 80% of the population attributes more

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than 60% of power outages to climatic fluctuations. As they put it "..... whenever there is a violent storm, currents goes off.....". This perception corroborates with empirical findings revealed in this study. Studying the same thematic, Dumas, (2019), showed that climate hazards or elements are affecting all the components of the electric grid system from the energy production to the end use. The impacts at the level of production high been highly studied Alyson (2014)but this work demonstrates that transmissions lines are highly vulnerable to climatic fluctuations. In the same line, Kamia (2019) revealed that heavy precipitation increases flood in low-lying delta areas, making coastal thermal power plants and transmission substations vulnerable to flooding. He also mentioned that flooding generally results in acute situations, using the example of severe flood that occurred on the northern coast of Jakarta in 2013 that forced a 909-megawatt natural gas power plant to shut down for 12days. Also, between 2014 and 2015, heavy precipitation caused 1048 events of power outage in the java-Bali distributions network (Anderson, 2013; Kamia, 2019). According to Alemazkoor et al., (2020) nine in ten (9/10) major outages in the United State are mostly caused by hurricanes. Most of the long-term outages risk is as a result of climate change triggered shifts in hurricanes frequency and intensity. This work equally revealed that the impacts of power outages on the population are a call for concern. Production is not suffcient and constant outages are making a bad situation worse (Rupel et al. 2017, Nsangou et al. 2020). Strategies to cope are limited and households, businesses and institutions are affected nagetively. The use of solar energy is becoming an alternative but activities that require alot of power can not be driven by solar energy. As such, much energy is produced in Cmeroon but very little reaches the population as alot is lost during transmission. Climatic fluctuations contribute greatly to this lost along transmission lines [16-20].

Conclusion

This work had as objective to assess the impacts of climate variability on hydroelectric power supplyin the west region of Cameroon. Given the impacts on electricity production widely demonstrated in lirature, the guiding premise of this work was to establish the impacts at the level of transmission. Using a mixed research method, findings show that the West region is higly depended on hydroelectric power whose transmission lines are highly vulnerable to climatic fluctuations. Extreme weather events such as heavy downpours, violent storms, lighthening and thunder and floods have been reported to damage transmission lines and electric poles. 70% of the population is unanimous that electric cuts occur each time extreme conditions occur. The frequency of suchcuts have been rising in the past few years. The impacts of power outages on the economy are alarming and alternative sources of energy are being employed. Given that the severity and trend of climatic aberrations are rising, the electric management body needs to pay attention to supply infrastructure. Concret poles could be used and the climatic dimension taken into consideration when setting up electricity transmission facilities.

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