ISSN 2354-9114 (online), ISSN 0024-9521 (print)
Indonesian Journal of Geography Vol.53 , No. 3, 2021 (318–327)
DOI: http://dx.doi.org/10.22146/ijg.66716 website: https://jurnal.ugm.ac.id/ijg
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INDONESIAN JOURNAL OF GEOGRAPHY

RESEARCH ARTICLE

Geospatial Analysis of Hydrometeorological Dynamics for Managing Socio-economic and COVID-19 Threats in the Ossiomo Watershed, Nigeria

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Received: 2020-12-12
Accepted: 2021-06-08

Keywords:
Catchment discharge;
COVID-19;
Dam;
Hydroelectric power, Precipitation;
Watershed.

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Abstract. The geographical occurrence and diffusion of the current COVID-19 pandemic is partly a function of the awareness, socio-economic dynamics, mobility, and health management practices in place. In Nigeria, the first confirmed case of the COVID-19 pandemic was proclaimed on February 27, 2020, in which an Italian citizen was tested positive for the virus in Lagos. Ossiomo watershed in Edo State, Nigeria, is mainly a rural region with limited healthcare access and abundant rains and surface water flowing in different drainage networks. The highly contagious and pathogenic COVID-19 disease, requires effective management of available water resources for sustainable health development. This is because one of the recommendations for preventing COVID-19 is washing hands with soap using running water. In most rural Africa, including Ossiomo, healthcare facilities are inadequate and no sustainable pipe-borne water except rain harvesting for survival. Using Inverse Distance Weighted (IDW) Geographic Information System (GIS) interpolation technique, the rainfall map produced (derived from a 31-year collated geo-coded hydrometeorological data - rainfall and discharge, covering the Ossiomo watershed) shows that rainfall decreases northward with minimum monthly precipitation of 18.8mm in January and to the south with a mean maximum rainfall of 339.0mm in July. NCDC records on Covid-19 were used to create Choropleth maps that revealed very low confirmed cases and relatively moderate-high deaths, though considered relatively low when compared to global statistics. The Pearson Product Moment Correlation Coefficient (PPMCC) further indicates a strong correlation between rainfall and drainage discharge with r=0.717. With sustainable socio-economic activities and adequate water supply, coupled with effective COVID-19 management practices, the pandemic may not linger in the study area.

1.Introduction

Besides massive unemployment, the dearth of food remains a challenge in developing countries, especially in rural regions (Egwue *et al.,* 2020; Carreras *et al.,* 2020). This is because, home confinement or reduced mobility and transportation in many African countries, have altered domestic food production (Francesconi *et al.,* 2021). In rural Africa, like the Ossiomo watershed in Edo State, Nigeria, access to government pipe-borne water is a luxury; hence, the continued reliance on rain harvesting and available stream waters by the rural poor. Since one of the management practices for COVID-19 is the washing of hands with water: viz-a-viz keeping to non-pharmaceutical protocols, it became very expedient to study the hydrometeorological water sources in Ossiomo watershed in order to ascertain the potentials in rain harvesting and surface drainage discharge as panaceas for managing COVID-19 in a typical rural Africa geographic area.

Previously, a comparative assessment of freshwater resources by the World Meteorological Organization (WMO, 1997) reckoned that about 2/3 of the world's population would be inhabiting in water-distressed countries by 2025 (Babatolu and Akinnubi, 2014). As observed by Cecchini (2020), 47% of the global population will encounter water paucity by 2030. Corona virus disease (COVID-19) suggests that yearnings for rapid development should not destroy our planet. Literature further reveals that COVID-19 is a highly communicable and infective viral ethological process caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), that emanated from Wuhan in China, and which then spread round the globe (Shereen, Khan, Kazmi, Bashir, and Siddique, 2020). Without adequate water provisions in quality and quantity, the disease may linger as a major pandemic globally because, as noted by World Health Organization (WHO, 2020), 20 seconds of washing of hands in running water, social distancing, wearing a surgical mask, among others, as some of the ways to prevent and possibly slow the spread of the disease. Implicitly, the availability of water is germane and central to the containment of COVID-19. However, it has also been observed that most persons infected with COVID-19 virus often have mild-to-moderate respiratory malady and get well without receiving special treatment, while older population in addition to those with underlying medical ailments such as diabetes, respiratory disorder, degenerative cardiovascular disease, and cancer are susceptible to severe illness (WHO, 2020). As noted by the Nigerian Centre for Disease Control (NCDC, 2020), Nigeria recorded its first instance of Covid-19 in Lagos State, Nigeria on February 27, 2020. Francesconi *et al.,* (2021) noted that (except for South Africa) regardless of whether or not the statistics of COVID-19 infections recorded from Africa is relatively lower, concerns are on the increase with respect to how the pandemic will impact the fragile food systems already experienced in the continent. Thus, the need to examine available hydrometeorological water resources (rainfall and river discharge) for human uses becomes inevitable for sustainable health development (SHD), especially in sub-Saharan rural Africa.

Aziegbe (2006) has previously opined that a quick perusal of a world Atlas shows that most major areas of human settlements are adjacent to rivers, lakes, springs, oases, or ocean and, by no coincidence, demonstrates the utter dependence of civilization on adequate water supplies. Studies show that climate variability affects river discharge within the Hydrologic cycle in one way or another, especially in land use decisions (Chang, 2003). The application of distributed hydrological theory for the modeling of a typical hydrological process has become a potent way to comprehend and resolve water challenges (Lai *et al.*, 2016). This is because, the model accounts for the geospatial dynamics of inherent surface characteristics and hydrometeorological factors by splitting the watershed (drainage basin or water catchment) into smaller and relatively homogenous units mapped and studied as drainage morphometry (Graham and Butts, 2005; Bello, Azandeh and Rilwani, 2014).

Implicitly, weather deals with the state of the atmosphere at a given point in time at a given location, while climate is the synthesis of weather at a given area within a period of between 30 and 35 years (Ayoade, 1993). The fundamental elements examined in weather or climate impact include precipitation, temperature, sunshine, wind, and pressure (Fryirs and Brierley, 2013). Also, of the different forms of precipitation (i.e., rain, hail, snow, etc.), only rainfall is extensively measured with any degree of certainty (Ward and Robinson, 2011). Rainfall and temperature play significant roles in watershed management (Odjugo, 2011). Ward and Robinson (2011) have reiterated that most of the precipitation that gets to the ground is engrossed by the surface layer of soils. Once any depression storage has been filled, the remainder will flow over the surface as overland flow, reaching the stream channels quite quickly and may accelerate erosion, sediment transportation, and eventual deposition in a given ecological environment (Faniran and Ojo, 1980).

As a key component of the ecosystem derivable from the convoluted and interrelated ecosystem of our planet, the watersheds are necessary to the growth and sustainance of the global ecosystem (Heal, 2000). The resurgence of COVID -19 in Wuhan, China, and its attendant spread globally has changed daily lives so much that the impacts are already seen from above through aerospace remote sensing, indicating that change is assertable and results are concrete in the ecosystem (Cecchini, 2020). The recording of the initial case of Corona virus in Nigeria, the largest country in sub-Saharan Africa in terms of population, led to the commencement of the Nigeria's National Coronavirus Emergency Operation Centre (NCPOC) (Adepoju, 2020). It has been observed that the human-to-human circulation of the COVID-19 occurs as a result of closeness to an infected person exposed to sneezing, respiratory defects, coughing, aerosol or droplets (Shereen, Khan, Kazmi, Bashir, and Siddique, 2020). Therefore, managing temporal rainfall within the immediate watershed and drainage discharges for sustainable health development (SHD), and environmental safety are noteworthy (Bello *et al.*, 2014). This is because, for instance, good water quality for drinking has been studied as a sure way to eliminate diseases such as Diarrhoea (Edobor, Ufuah, Rilwani and Bello, 2019).

Conceptual Issues and Literature Review

Nigeria has been identified as being part of the countries experiencing food insufficiency. For instance, Nigeria been ranked 40th among 79 food lacking nations in 2011 going by the Global Hunger Index (GHI) is unacceptable (Egwue *et al.*, 2020). This is particularly worrisome in view of the fact that she was also ranked 40th again in 2012, 39th in 2013, and 38th in 2014. Water is at the heart of agricultural food production. Water (stream) discharge in a given watershed is defined as the volume of water flowing per unit time with a unit of L^3/T (Manning, 1987). This is measured, for example, in *cubic meters per second* expressed as m^3/s or in *cubic feet per second*, also expressed as ft^3/s. Water Current instruments may be used to measure stream flow velocity and water discharge. One of such instruments is the “Price Current Meter”. The cup on the meter is turned by the flowing water, with the speed of rotation proportional to velocity, while the calibration information provided with the meter permits the number of revolutions to be converted over some interval of time to velocity. Resulting from the record of water discharge, a typical rating curve is generated by measuring stream discharges and stages or water level during various flow conditions (Kennedy, 1984; Schwartz and Zhang, 2003). According to Avery (1977), this process requires the organization and storage of what is known and provisions for rapid information retrieval in forms acceptable to various users, hence adopting Geospatial technologies such as integrated Geoinformatics technique in modern research becomes inevitable.

Consequent upon the above discourse, recent global COVID-19 pandemic has added to more public orientation and awareness of hunger-induced problems, thus, resulting to new international attempts to invest in agriculture of developing countries (Egwu *et al.*, 2020). Literature indicates that understanding the non-uniformity of climate dynamics and its impacts on seasonal and annual crop yield caused by discharge as well as the difference between extreme and median flows in different climatic regions have been identified to be of great importance to best water management and, by extension, food production (Xu and Luo, 2015). For instance, Egwu *et al.* (2020) study on food deficiency during the Covid-19 pandemic in southeast Nigeria recommends that rural households be educated on the nutritional implication of various food items such as soybean, egg, fish and milk, especially for children in order to increase their protein intake and at the same time boost their immune system against Corona virus. Unfortunately, without adequate socio-economic water in quality and quantity, realizing the above recommendations in rural areas, like Ossiomo, may not be feasible, hence examining rainfall and water discharge status in the study area remains inevitable.

The above became relevant in view of previous studies carried out by some scholars. For instance, Rood *et al.* (2005) examined the annual stream discharge of 31 rivers between 1910 and 2002 in the Central Rock Mountains in North America specifically close to Canada and USA border. Their findings indicate a decreasing trend of 0.1% for the record of 21 out of the 31 rivers analyzed. Similar study in the area also showed a decline in annual stream flow between 1948 and

2006 (Lace and Holden, 2009). It is trite to note that previously, McCabe Jr and Wolock (1997) studied the statistical possibility of sleuthing trends in annual run-off in the contiguous United States of America, while Shiklomanor *et al.* (2007) noticed that drift in the maximum discharge of the small-to-medium-sized rivers were mostly agreeable with mass records found for the downstream gauges of the 6 largest rivers in Russian.

Climatologically, climatic changes in Africa is widely noticeable and this include warming of 0.7 ^{0}C over the 20th Century, 0.05^{0}C per decade warming, and increased precipitation for East Africa (Mango, Melesse, McClain, Gann, and Setegn, 2011). Furthermore, in examining the role of soil and climate in water discharge as it affects land-use and landcover change in general, Mango *et al.* (2011) examined the consequences of the head-water hydrology of the Mara River in the region of East Africa to events of continued land-use change using the Soil Water Assessment Tool (SWAT). They then projected climate change using satellite-based projected rainfall data. The study showed that further change of forests to grassland and agriculture in the catchment headwaters will probably reduce dry season and peak flows increase thus, leading to greater water paucity at essential periods of the year and aggravating erosive effects on hill slopes. No doubt, a shortage in water availability will adversely affect irrigated agriculture and public health, especially in coping with Covid-19 impacts. For instance, Kundu and Olang (2011) examined the impact of landuse dynamics on run-off and peak flood flow for the Nyando River, Lake Victoria drainage catchment in Kenya. The study showed that the catchment witnessed significant increases in peak discharges especially in the upstream region where higher deforestation rates were observed. Still within the period under review, the peak flow increased by 16 % in the entire 14 sub-catchments, and simulated flood volumes in the catchment did increased by 10% as well. In a developing region like Ossiomo watershed, a situation where government can not effectively provided palliatives means that the people are left to take care of themselves in terms of food and water provisions. The saving grace will be to surrender to nature.

Evaluating the impacts of shifting cultivation farming system on drainage channel size in headwater catchments of South-western Nigeria, Odemhero (1984) observed that the disturbance of the basin ecosystem might further result in alteration which is not just the stream size but also the entire hydraulic geometry of the watershed. Without water, our lifespan on earth will just be about 14 days without water intake, the same period for COVID-19 to manifest (Cecchini, 2020). Monitoring climate variability brings about balance in ecosystem dynamics in a sustainable manner. All over, announcement and advertorials spurring hand-washing using soap and water for a minimum of 20 seconds to prevent the spread of the COVID-19 abound (Chattopadhyay, 2020), whereas, in rural areas where pipe-borne water is lacking, many will have to depend on rainfall harvesting and available surface water (streams and ponds inclusive). In addition, the poor in urban or rural areas are disproportionately impacted because they are more attuned to harvest rainwater or patronize other sources outside their immediate abode and may rely on shared facilities too (Chattopadhyay, 2020). Unfortunately, polluted surface water (even from COVID-19) could lead to rapid morbidity and mortality; hence, proper water management is key. For example, in examining agricultural cooperatives and COVID -19 in Southeast Africa, the role of capital management for rural resilience was carried out by Francesconi, Wouterse, and Namuyiga (2021). The study shows that the Corona virus pandemic and the attendant socio-economic impact constitute a systemic stupefaction that cannot be alleviated simply by resorting to unwise risk-coping strategies. The study also remarked that social distancing preventive strategies imposed to control the spread of the virus had made mostly rural smallholders unable to effectively patronize markets and has subsequently eliminated their income-generating capability and independence. Sequel to the above literature, in this current study, emphasis is laid on hydrometeorological data (rainfall and water discharge) and their impact on the socio-economic activities and COVID-19 health of the people in the Ossiomo river basin as a way out to cope with the debilitating challenges of the pandemic.

Technologically, the integration of geospatial technologies and decision support system (DSS) for the location of suitable areas for artificial recharge in Meimeh Basin, Isfahan, Iran by Ghayoumian, *et al.,* (2005) clearly demonstrated the capabilities of Geoinformatics technique (Geospatial technology) in modeling and quantitatively analyzing time-variant water discharge locations. Geoinformatics is an integrated geospatial technology super structure used for the acquisition of relevant geospatial dataset, their storage and retrieval, manipulation and analysis, their visualization and statistical presentation of derived georeferenced information in both hard and soft media (web inclusive) (Bello *et al.,* 2014). Thus, from a planning standpoint, the watershed is seen as the ideal geographic unit or spatial closure or universe of discourse to analyze and manage natural resources for which rain water and underlying Hydrologic spatial layers are vital .

The above reviewed studies further confirmed that proper management of the hydrometeorological parameter with respect to their influences on the overall well-being of the local inhabitants as far as food security, socio-economic gains, and health are concerned is inevitable hence, this study.

2. Methods

The study area

Ossiomo water catchment is located in Edo State, Nigeria. It lies within Longitudes 5^{0}35'38" E and 6^{0}15'56" E, and Latitudes 6^{0}07'22" N and 6^{0}43'56" N, respectively (Figures 1). The drainage basin is part of the lowlands of Benin, which is part of the vast coastal plains which form the southern half of the Niger Delta region (Udo, 1978). The study area is bounded in the North by a narrow but distinctive west-east clay vale, separating the Afenmai hill region in the North from the Ishan plateau in the south. In the south, the region is bordered by the Niger Delta, while the Lower Niger valleys form the eastern limit near Agbor. Ossiomo watershed is a sub-river basin under the auspices of the Benin-Owena River Basin Development Authority (BORBDA), is one of the ten set up in 1976 by an Act no. 25 on the basis of drainage basin boundaries (Ikhile and Oyebande, 2007). Ossiomo Watershed (Fig.1) straddles nine (9) Local Government Areas (LGAs) in Edo State, Nigeria. The Nine LGAs within Ossiomo Watershed include the central and southern part of Esan West, the southern part of Esan Central; the western part of Igueben; almost the entire Uhumhode; the North and south-western part of Orhiomhon; north-eastern part of Ovia North-East, North and south-eastern part of Ikpoba-Okha, the north-eastern part of Oredo and the north-eastern part of Egor respectively. Ossiomo watershed shares a remarkable border with Ika South in Delta State. The peculiarity of the catchment area within the low coastal land of Benin makes it important for study as a proof of concept on examining alternative source for hydroelectric power generation and possible Fadama agriculture for sustainable food security and Sustainable Health Development (SHD), especially with the threat posed by COVID-19 pandemic in sub-Saharan Africa.

Methodology

A 31-year (1984 – 2014) rainfall dataset was collated into yearly and monthly averages to analyze the hydrometeorological parameters. The rainfall data used was obtained from the Nigerian Meteorological Agency, Lagos, Nigeria. Catchment discharge records obtained from Benin-Owena River Basin and Rural Development Authority (BORBRDA), Federal Ministry of Water Resource (FMWR)

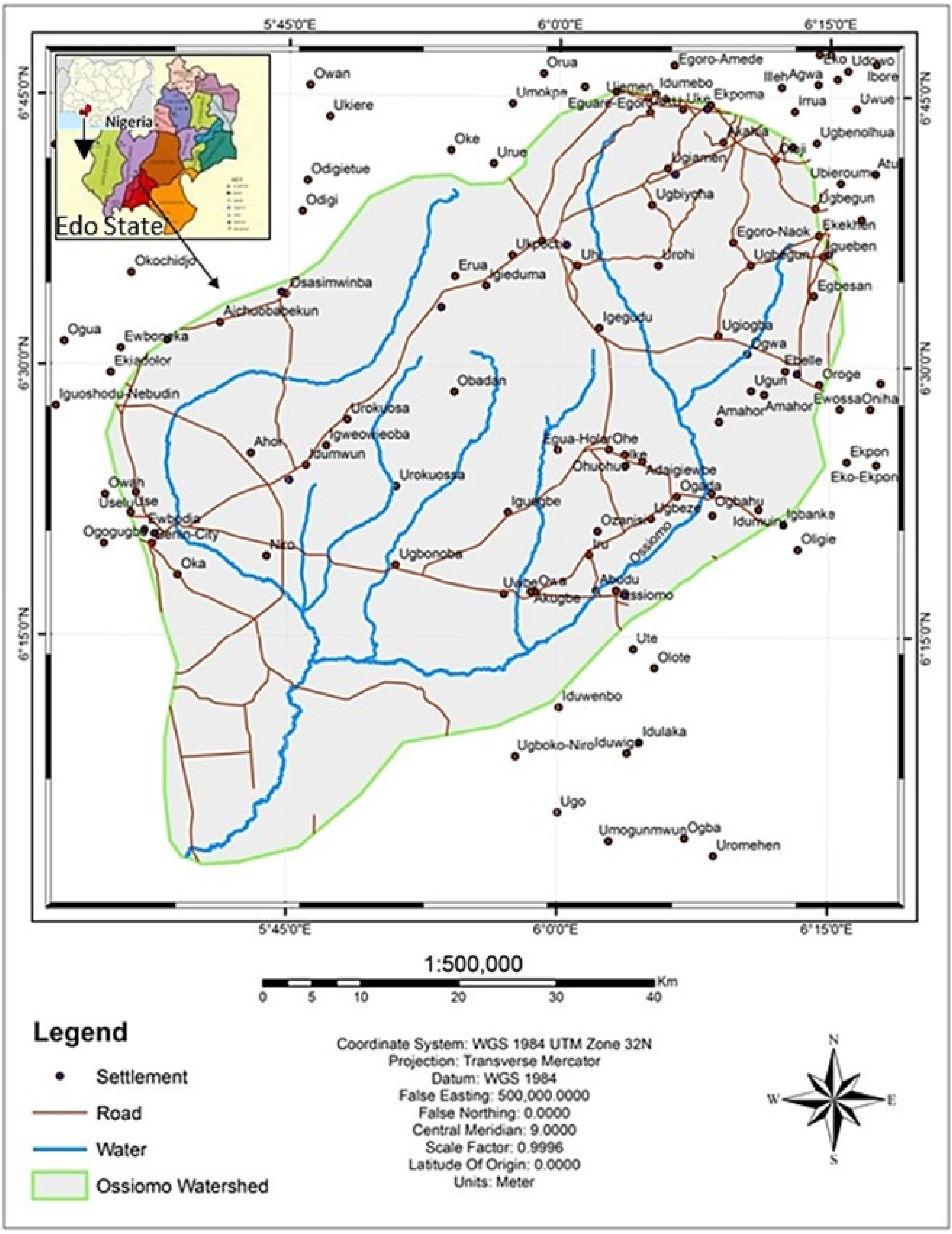


Figure 1. Ossiomo Watershed, Edo State, Nigeria

at Obayantor, near Benin City were also collated based on yearly and monthly means. The characteristics of the four examined gauging stations are tabulated in Table 1. Methodologically, it is pertinent to reiterate that the most applied approach for recording and calculating drainage discharge is hinged on a simple form of the continuity equation. The equation implies that for any incomprehensible fluid (water), the discharge (Q) is equal to the product of its mean velocity ($\bar{V}$) and the stream's cross-sectional area (A).

It is further reiterated that the total discharge of a stream in cubic meter per second *(cumec i.e., m^3/s)* is the sum of discharge through all the segments measured from respective cross-sections. The volume largely depends on the relationship between precipitation and storage factors, and rain contributes to precipitation totals (Ikhile, 2016). The average velocity in each vertical section is determined by averaging values at depths of two-tenths depth, and the vertical sections are selected so that no more than 10% of the flow comes through each (Schuwartz and Zhang, 2003). Therefore, catchment discharge equals precipitation (rainfall in this case) minus evapotranspiration plus or minus changes in storage. The mean values for all the variables collated were summarized and tabulated using tables. In

Table 1. Characteristics of Hydrological gauging stations within Ossiomo watershed, Edo State

Location of Gauging Station	Latitude (N)	Longitude (E)	Staff Gauge Zero (m)	Installation
Benin stream at Benin City	6^{0} 21’ 00”	5^{0} 39’ 00”	95.37	S.G & A.R
Ukhunwan stream at Ugonoba	6^{0} 19’ 00”	5^{0} 51’ 00”	95.66	S.G & A.R
Ossiomo stream at Abudu	6^{0} 18’ 00”	6^{0} 2’ 00”	92.28	S.G & A.R
Ossiomo River at Ologbo	6^{0} 3' 00"	5^{0} 40' 00"	93.94	S.G & A.R
Total Drainage Area				

Source: BORBRDA Hydrological Year Book, FMWR, (2000).

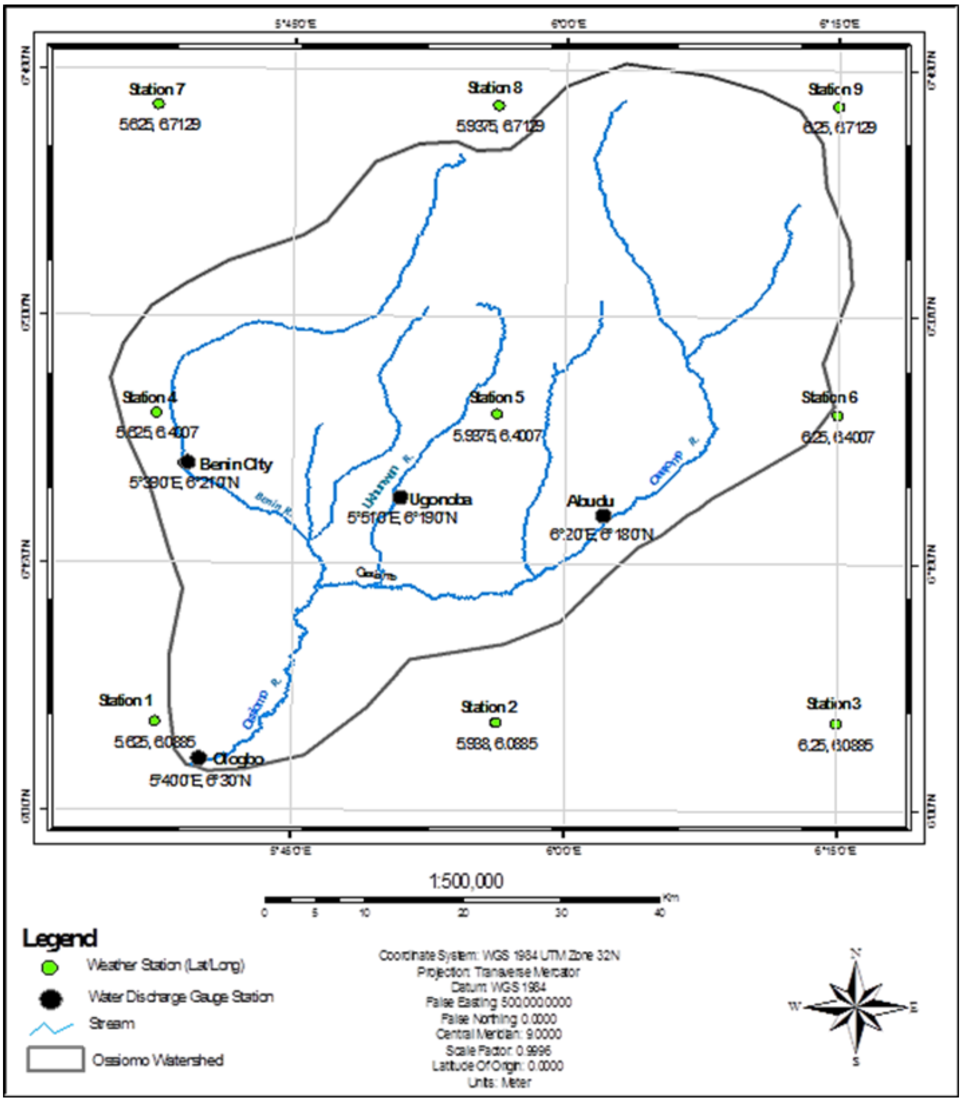


Figure 2. Spatial distribution of gauge stations within Ossiomo watershed
Source Data: Benin-Owena River Basin Authority Hydrological Year Book (2002).

addition, Geoinformatics (GIS)-based Inverse Distance Weighted (IDW) interpolation, graphs, and statistical tests (correlation) were used to show and examine the relationships between rainfall and water discharge. Empirically, regression statistical analysis was used to evaluate the relationship between rainfall and drainage discharge within the Ossiomo watershed in addition to 'testing a hypothesis of no significant correlation' using the Pearson Product Moment Correlation Coefficient (PPMCC) and t-test statistical analysis for the level of significance. From the results obtained, inferences were drawn concerning the socio-economic and health impact it will have on the people as far as managing socio-economic dynamics and Covid-19 threats are concerned.

3. Results and Discussions

Figure 2 shows the location map of the four (4) examined catchment discharge gauge stations. Before discussing further, it is important to reiterate that monitoring a drainage discharge at a given point and the integration of the rainfall-runoff process within a large area provides a sensible comprehension of the time variations in the available water (Babatolu and Akinnubi, 2014). The World Health Organization (WHO) according to Nguyen and Somayajula (2020) has emphasised this, remarking that the supply of safe drinking water, hygienic conditions and sanitation are essential to protecting health during the COVID-19 outbreak. In other words, The findings examined below in this study shows that the Ossiomo River and its immediate Ologbo environs in Edo State, and Nigeria by extension, are no exemptions to this observation.

Rainfall Variability and Water Discharge: Implications for Socio-economic and COVID-19 Managements

Hydrometeorological Assessment of Ossiomo Watershed

As shown in figures 3a and b, the mean collated rainfall for thirty-one years (1984 to 2014) shows that rainfall is not uniform throughout the year in the study area, a characteristic that epitomizes the tropical rainforest (Udo, 1978). Similarly, within the thirty-one-year period under review, the year 2011 had the highest mean rainfall of 267.6 mm, closely followed by the year 2007 with a mean rainfall of 252.7mm and 1995 with 222.4mm. The result of the high rainfall in 2011 may have contributed to the flood disaster recorded in 2012 (Ojigi, 2012). As corroborated in a similar study by Ogunkoya (2013), with increasing rainfall on steep slopes, there is the possibility of experiencing intermittent accelerated drainage discharge.

Specifically, on the average, as illustrated in Figure 3b, rainfall decreases northward with minimum monthly precipitation of 18.8mm in January and to the south with a mean maximum precipitation of 339.0mm in July. This is closely followed by September with mean monthly rainfall of 332.7mm and August with receding mean monthly rainfall of 311.3mm. Usually, in August, the region experiences a short-dry spell where rainfall reduces in intensity hence the relatively low record observed in the study area.

The trend in rainfall clearly shows that it starts in early February in the study area. Increasing rainfall is a veritable chance to harvest water for domestic, agricultural, and industrial uses, especially when government pipe-borne water sources are lacking. Unfortunately, what may be in contention is the quality or fitness-for-use of the rainfall water for safe drinking. A different study is required for this this identified gap.

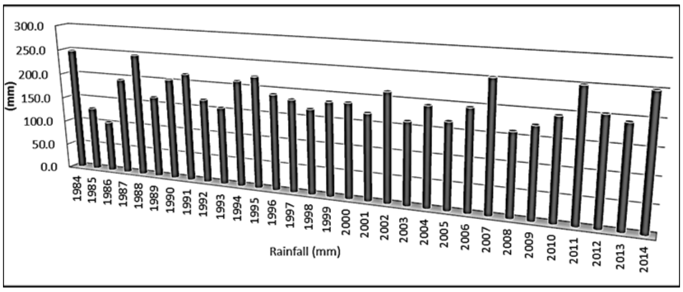


Figure 3a. Rainfall distribution in Ossiomo watershed (1984 – 2014)
Source data: Nigerian Meteorological Agency, Lagos (2016)

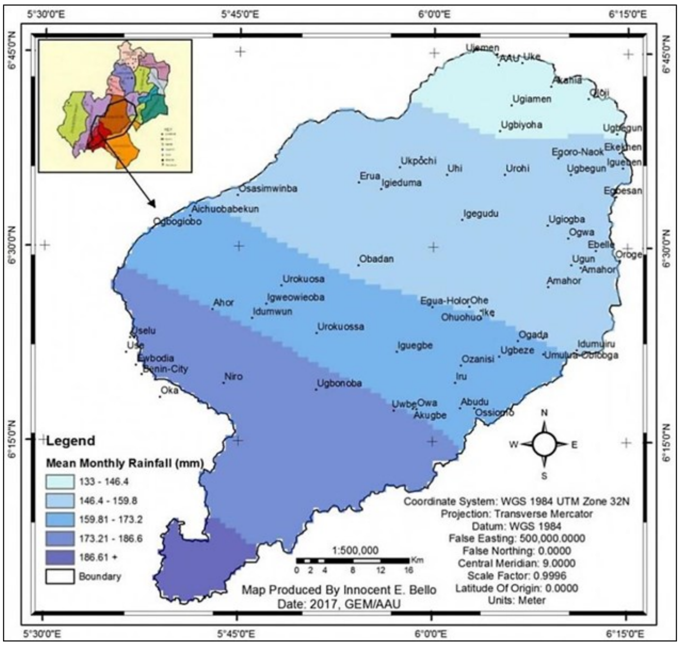


Figure 3b. Mean monthly rainfall distribution map of Ossiomo watershed
Source data: Modified after Balogun (2012)

Status of Covid-19 in the study area, Ossiomo, Edo State

Although there is no specific number tied to Ossiomo community for the sake of stigmatization, however, from the available record from NCDC (NCDC, 2021), Edo State where Ossiomo is located have about 4,905 confirmed cases, 4,715 discharged and 185 death. Figure 4 reveals that, on the average, compared with other parts of the country, the study area cumulative cases of Covid-19 are moderate, while the number of deaths so far is considered medium-to-high. However, the confirmed death cases remain relatively low when compared to global scale (Francesconi *et al.*, 2021).

Correlation between Hydrometeorological parameters and Covid-19

As illustrated in Figures 5 and 6, the variation in catchment discharge is a function of surface water collection resulting from both rainfall and streamflow from other smaller stream orders. This study also further reveals that in increasing order, the three highest mean discharges were recorded in the months of August (49.8 m^3/S), September (50.6 m^3/S), and October (49.1 m^3/S), respectively.

A critical review of COVID-19 cases in the study area and

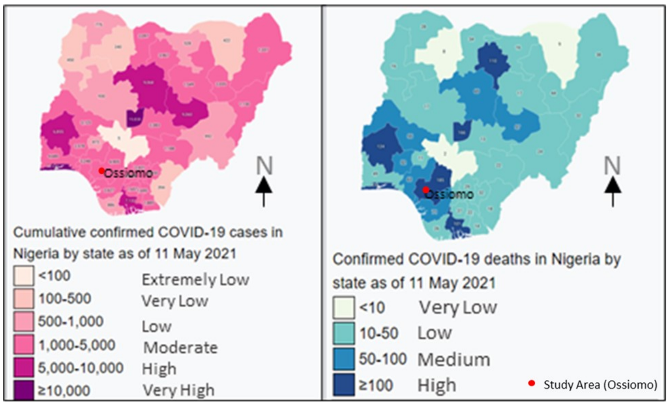
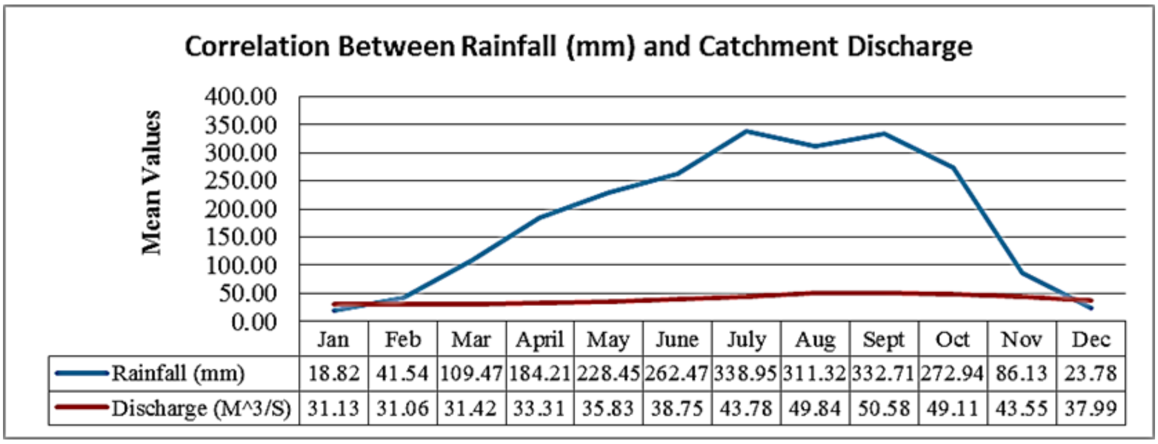


Figure 4. COVID-19 Distribution Pattern in Nigeria
Web Source: (NCDC, 2021)

environs (Edo State) aptly coincide with rainfall season. However, restrictions on movements and the possibility of rural poor still finding their way to water sources such as streams become inevitable. While reported cases of COVID-19 are on the increase (NCDC, 2020), as shown in figure 3b, the burden of water collection from rainfall is increased and availability assured. Implicitly, this is a plus for effective COVID-19 management, especially in communities where pipe-borne water is not available for hand-washing and other anthropogenic or socio-economic uses.

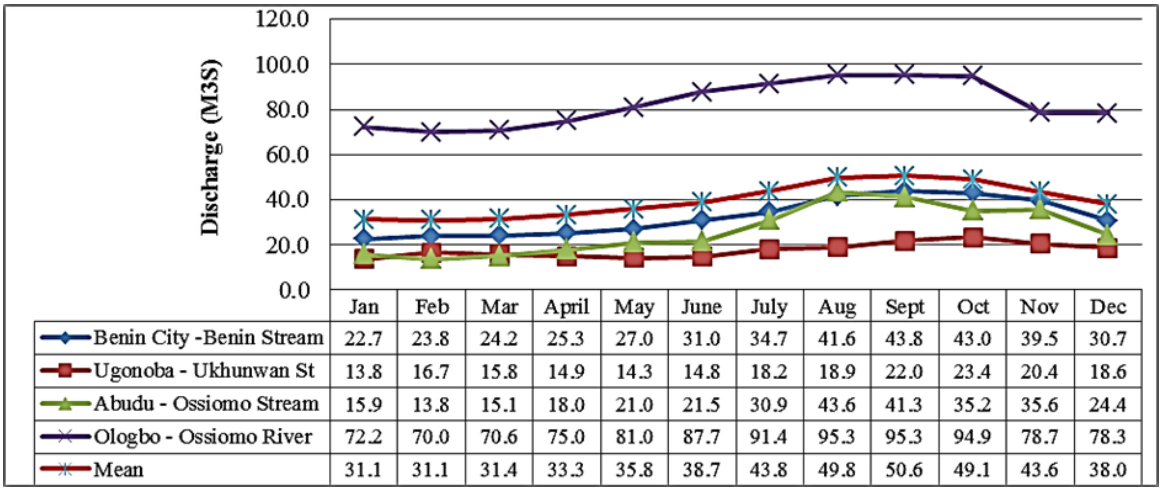
Figure 6 further indicates that there is a significant disparity in catchment drainage discharge within the study area. Ossiomo River at Ologbo, which recorded more than half of the total discharge, 82.5 m³/S (52.2% of total discharge) within the period under review, is a recipient of all the smaller stream flows or discharges from the three other sub-drainage networks, including Benin stream with 32.3m³/S (20.2% of total discharge), Ossiomo stream at Abudu with 26.4 m³/S (16.6% of total discharge), and Okhumwan stream at Ugonoba with 17.6 m³/S (11.2%) respectively.

The above findings imply that all the streams flowing into Ossiomo River at Olobo village from Benin stream at Benin City, Okhunmwan stream at Ugonoba, and Ossiomo Stream at Abudu contribute less than half (48%) of the total catchment discharge, and each also contributes less than the mean (39.7m³/S) of the entire catchment discharge. Implicitly, Ossiomo River's main channel discharge at Ologbo is capable of supporting irrigation agriculture (Fadama), domestic supply, and micro-hydro electricity generation. During the current COVID-19 pandemic, constant electricity supply is required for the overall healthcare services and, in particular, to keep ventilators functional when and where necessary. Thus, based on the above findings, the possibility of contribution to large-scale fish and irrigation farming, domestic use, and hydro-electricity generation is guaranteed in Ossiomo Village. Furthermore, the watershed can be harnessed in line with the above potentials for the area's sustainable health as well as environmental developments. However, according to Nguyen and Somayajula (2020), with the increasing threat from



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Rainfall (mm)	18.82	41.54	109.47	184.21	228.45	262.47	338.95	311.32	332.71	272.94	86.13	23.78
Discharge (M^3/S)	31.13	31.06	31.42	33.31	35.83	38.75	43.78	49.84	50.58	49.11	43.55	37.99

Figure 5. Line graph representation of rainfall intensity versus catchment discharge.
Source: Authors' Lab Analysis



	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Benin City -Benin Stream	22.7	23.8	24.2	25.3	27.0	31.0	34.7	41.6	43.8	43.0	39.5	30.7
Ugonoba - Ukhunwan St	13.8	16.7	15.8	14.9	14.3	14.8	18.2	18.9	22.0	23.4	20.4	18.6
Abudu - Ossiomo Stream	15.9	13.8	15.1	18.0	21.0	21.5	30.9	43.6	41.3	35.2	35.6	24.4
Ologbo - Ossiomo River	72.2	70.0	70.6	75.0	81.0	87.7	91.4	95.3	95.3	94.9	78.7	78.3
Mean	31.1	31.1	31.4	33.3	35.8	38.7	43.8	49.8	50.6	49.1	43.6	38.0

Figure 6. Mean monthly catchment discharge in the four gauges in the Ossiomo watershed.
Source Data: Collated from Benin-Owena River Basin Authority Hydrological Year Books (1989 – 1994)

COVID-19 despite the series of vaccines in the world, the need to keep to clean and healthy safe rules by washing of hands is considered very essential to preserving public health on the one hand and responding to the virus, on the other hand. Thus, unpolluted streams of water like those from the Ossiomo river can be of vital use in this regard.

Test of Hypothesis: "No correlation between rainfall and catchment discharge."

Figures 5 and 7 respectively show the graphical relationship (correlation) and positive scatterplot (and regression line) of catchment discharge. The Product Moment Correlation Coefficient (PMCC), denoted as r and calculated as shown in Table 2, indicates an r-value of 0.717, and figure 7 indicates a coefficient of determination (r^2) of 0.516. The above were calculated as shown below:

Note: Using the computed table (Table 2), r value is calculated as:

$r = \Sigma((X - My)(Y - Mx)) / \sqrt{((SSx)(SSy))}$…………………..(1)

We then input the values as:

$r = 7279.513 / \sqrt{((166783.067)(618.069))} = 0.717$ (a positive correlation which confirms the observation made on the scatter plot).

The significance of r-value obtained is tested using t test.

t-test is iven as: $t = r\sqrt{N-2}/\sqrt{1-r^2}$……………………….(2)

Thus, When N = 12; Degree of freedom is N-2 = 12 – 2 = 10,

r^2 (coefficient of determination) = 0.516,

Therefore, t-test $=0.717\sqrt{10}/\sqrt{1-0.516}=2.2674/0.6957$

The computed t value is = 3.26."

Expectedly, in the event that r is closer to 1, it implies a very strong positive correlation or relationship, while a value of 0 implies that there is no correlation or relationship, whatsoever. Thus, a correlation (r) statistical test value of 0.717, according to Rilwani (2005) and Evans (1996), implies a strong positive correlation; in this case, between precipitation and catchment discharge.

Using t-test to test for significance at 10 degrees of freedom (i.e. 12 – 2) and at 0.05 (*t* 0.95) level of significance, the table value is 1.81; the computed t value of 3.26 lies in the rejection region. With a P-Value of 0.008681, the result is acclaimed to be significant at $p < 0.05$. Thus, the hypothetical assumption earlier stated that "*there is no significant correlation between rainfall and water discharge"* is rejected while the alternative is accepted, instead. This means that there are disposition for high precipitation (X) variable scores to tally with high catchment discharge (Y) variable scores (and vice versa) in the Ossiomo watershed. Therefore, it can be deductively inferred that the more the rainwater, the better for COVID-19 management practices.

By implication, the study indicates that it is possible that if neighboring plant cover on streams are removed, there could be accelerated evaporation, surface runoff, and concomitant discharge, and soil erosion as earlier noted by Faniran and Ojo (1980) in their study. This is considered plausible in view of similar studies which affirms that soil erosion worsens soil infertility as a result of loss of nutrient and organic matter while also reducing the quality of water through increased turbidity (Brown and Froemke, 2012). Therefore, effort should be made by relevant authorities incharge of drainage basin management to ensure that areas

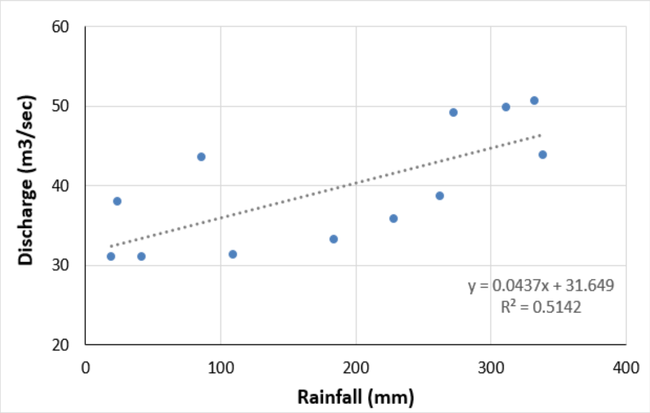


Figure 7. The regression line for rainfall versus catchment discharge

Table 2. Correlation Coefficient table for rainfall versus catchment discharge

Rainfall (X)	Discharge (Y)	X - M_x	Y - M_y	$(X - M_x)^2$ =SSx	$M_y)^2$= SSy	$(X - M_x)(Y - M_y)$
18.82	31.1	-165.433	-8.592	27368.188	73.817	1421.348
41.54	31.1	-142.733	-8.592	20372.804	73.817	1226.317
109.47	31.4	-74.733	-8.292	5585.071	68.752	619.664
184.21	33.3	-0.033	-6.392	0.001	40.853	0.213
228.45	35.8	44.267	-3.892	1959.538	15.145	-172.271
262.47	38.7	78.267	-0.992	6125.671	0.983	-77.614
338.95	43.8	154.767	4.108	23952.721	16.878	635.833
311.32	49.8	127.067	10.108	16145.938	102.178	1284.432
332.71	50.6	148.467	10.908	22042.351	118.992	1619.524
272.94	49.1	88.667	9.408	7861.778	88.517	834.206
86.13	43.6	-98.133	3.908	9630.151	15.275	-383.538
23.78	38.0	-160.433	-1.692	25738.854	2.862	271.4
ΣX=2210.8	ΣY=476.3	Mx=184.233	My=39.692	Σ=166783.067	Σ=618.069	Σ=7279.513

suitable for agriculture and stream network are carefully managed to maximize the inherent potentials and minimize environmental hazards that may result from watershed mismanagement. The ecological implication of the study, as previously noted by Aziegbe (2006) in similar findings, is that water that does not infiltrate into the ground or evaporate, it remains on the surface of the earth; hence, the term surface water and, when under the influence of gravity, it finds its way as water discharge or runoff which if not controlled might result to gully erosion. Having gullies in COVID-19 pandemic infected areas may be multiple tragedies to manage. For instance, during a heavy storm, there is bound to be an increase in water discharge as observed in this study, and coupled with a steep slope, loose soils, changes in forest cover, uncoordinated urban developments, and indiscriminate cultivation, the tendency to experience flood and erosion may be further heightened as demonstrated in previous similar studies (Odemhero, 1984; Shaba, 2003).

On socio-economic dynamics especially with respect to food sufficiency and security, it is expedient to note that if hunger and over-stretching of women and children are to be minimized in rural Oshiomo, the need to adopt all-year-round large-scale irrigation farming is advocated. This is because the study area is favored in terms of sufficient rainfall and drainage discharge. The above is corroborated by the findings of Carreras, Saha, and Thompson (2020), whose results from the initial round of research conducted in 7 countries – Ghana, Ethiopia, Nigeria, Tanzania, Kenya, Malawi, and Zimbabwe observed that the impact assessment of COVID-19 on food supply systems and sustainable rural livelihoods in Sub-Saharan Africa is a sure way to cushion the attendant effects on the people. Indeed, the above is equally analogous to the findings made by Egwue *et al.*, (2020).

Conclusion

In rural Africa, like the Ossiomo watershed, the study area, access to government pipe born water is a luxury hence, relying on rain harvesting and available stream water by the rural poor. Since one of the management practices for COVID-19 is the washing of hands with water, viz-a-viz with keeping to non-pharmaceutical protocols, it became very expedient to examine the hydrometeorological water sources in Ossiomo Watershed. These include rainfall and drainage discharge. The study was then conducted under the hypothetical assumption that "*there is no significant correlation between rainfall and catchment discharge in Ossiomo watershed in Edo State, Nigeria.*" This became necessary in view of the need to have adequate water for COVID-19 management for both domestic, health, and industrial uses. Geo-spatially and statistically analyzing a thirty-one-year (1984 – 2014) rainfall data and simulating the rainfall map using the GIS IDW interpolation technique, the study indicates a northward decrease in rainfall intensity with a strong correlation between precipitation and catchment discharge (r = 0.717). However, with regards to specific stations examined, a significant disparity in catchment discharge within the study area was observed as Ossiomo River, at Ologbo village, recorded more than half of the total discharge (i.e., 82.5 m^3/S), which account for more than half of the total discharges (i.e., 52.2% of total discharge). It is important to note that Ossiomo River is also a recipient of all the other stream discharges from Benin stream (32.3m^3/S, 20.2% of total discharge), Ossiomo stream at Abudu (26.4 m^3/S, 16.6%), and Okhunmwan stream at Ugonoba (17.6 m^3/S, 11.2%). With a high discharge noticed at Ossiomo River at Ologbo, the damming and construction of a mini hydroelectric power station is recommended. Continuous monitoring of the gauge stations is also recommended to provide readily available data necessary for Fadama agriculture for decision-making and policy implementation on watershed development and health management. The need for reliable water sources corroborates the claim by Chattopadhyay (2020) which states that forceful and unintended urbanization in addition to the replacement of lakes and wetlands further reduces the city's ability to manage water scarcity. Implicitly, COVID-19 pandemic and its attendant consequence of job loss, morbidity and mortality has clearly shown that safe drinking water and access to reliable healthcare services are fundamental to saving lives. Therefore, governments via its relevant Ministries, Departments and Agencies (MDAs) should ensure the continuous provision of portable water to all in the country, thus targeting the vulnerable and poorest in sub -Saharan Africa where pipe-borne water is not available in required quantity and quality.

Acknowledgments

The authors of this article frankly express no conflict of interest. The materials consulted in the course of preparing this technical paper are acknowledged with citations and references while thanking the unanimous reviewers and publisher.

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