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ASSESSMENT OF INEQUALITY IN THE DISTRIBUTION OF WATER FACILITIES IN LAPAI, NIGERIA

OCENA NIERÓWNOMIERNOŚCI DYSTRYBUCJI URZĄDZEŃ WODNYCH W LAPAI W NIGERII

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Abstract

Rapid urban growth and expansion pose daunting challenges in urban areas of the developing world. These challenges include the provision and equitable distribution of sustainable public water supply facilities. This study therefore aimed at assessing the extent of spatial inequality in the distribution of water facilities provision among major segments in Lapai urban centre, Nigeria to aid policy formulation and framework in achieving sustainable water supply. This study utilizes the Gini coefficient composite statistical tool to examine the distribution inequality of three main sources of public water facilities in the study area, which includes; hand pump boreholes, motorised boreholes, and wells. The study area is divided into four quadrants (quadrants A, B, C, and D). It was found out that 17.31%, 21.15%, and 37.50% Gini coefficients were recorded for hand pump boreholes, motorised boreholes, and well facilities. This indicates that there is inequality in the distribution of public water supply facilities among the four quadrants in the study area. It was therefore recommended that both the public and private sectors should provide public water facilities equitably to achieve Sustainable Development Goals (SDGs).

Keywords: Distribution, inequality, Gini coefficient, Sustainable Development Goals, Urban growth, Water facilities

Streszczenie

Szybki rozwój i ekspansja miast stanowią trudne wyzwania w obszarach miejskich rozwijającego się świata. Wyzwania te obejmują zapewnienie i sprawiedliwą dystrybucję publicznych urządzeń wodociągowych. W związku z tym badania miały na celu ocenę zakresu przestrzennych nierównomierności dystrybucji wody w głównych obszarach centrum miejskiego Lapai w Nigerii w celu wsparcia formułowania polityki i ram w osiąganiu zrównoważonego zaopatrzenia w wodę. W niniejszym opracowaniu wykorzystano złożone narzędzie statystyczne ze współczynnikiem Giniego w celu zbadania nierównomierności dystrybucji trzech głównych publicznych obiektów wodociągowych na badanym obszarze, w tym: odwierty z pompą ręczną, odwierty z napędem silnikowym i studnie. Badany obszar podzielony jest na cztery ćwiartki (ćwiartki A, B, C i D). Stwierdzono, że współczynniki Giniego 17,31%, 21,15% i 37,50% odnotowano dla odwiertów z pompą ręczną, odwiertów silnikowych i obiektów studniowych. Wskazuje to na nierównomierność w rozmieszczeniu publicznych urządzeń wodociągowych w czterech ćwiartkach badanego obszaru. W związku z tym zalecono, aby sektor publiczny i prywatny zapewnił sprawiedliwe dostęp do publicznych obiektów wodociągowych tak, aby osiągnąć cel zrównoważonego rozwoju (SDG).

Słowa kluczowe: dystrybucja, nierówność, współczynnik Giniego, cele zrównoważonego rozwoju, rozwój miast, obiekty wodne

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1. INTRODUCTION

Rapid urban growth and expansion pose daunting challenges for human settlements most especially in recent decades (UN-Habitat, 2015). For the first time in human history, more than half of the human population lives in urban areas. The United Nations figure shows that in 2014, 54 percent of the world's population is urban residence and it is expected to continue to grow so that by 2050, 66 percent of the world population will be urban dwellers (United Nations, 2014). In Africa, the common challenges brought by population growth are wide-spread poverty and interrelated threats to the human habitat most especially in terms of utilities and services such as domestic water and sanitation (UN-Habitat, 2014). Western Africa is the continent's fastest urbanizing sub-region after Eastern Africa. The sub-region is projected to increase its share of urban dwellers from 44.9 percent urban in 2011 to 49.9 percent by 2020, and 65.7 percent by 2050 (UN-Habitat, 2014). Nigeria being the most populous country in Africa, have serious consequences of this regional urbanization estimates. Consequently, this has pushed urban utilities and services into a pathetic situation which has caused shortages in urban water supply services that does not meet the domestic need of urban residents (UN-Habitat, 2014).

Uncontrolled urbanization increases spatial inequality (UN-Habitat, 2010). The inequality exists where some regions benefit more from facilities and services than others (Tammaru et al., 2019). From a neoclassical perspective, unless regions and their cities have identical exposure to facilities and similar comparative advantage, urbanization is likely to increase spatial inequality (Cha et al., 2017).

According to Wei (2015), spatial inequality is the unequal amounts of qualities or resources (water, vegetation, soil, mineral, and atmospheric) and services (medical and welfare) depending on the area or location. Spatial inequality is very common in developing countries (Renkow, 2006). Where there exists an imbalance in development among different spatial units in the same geographic unit, which is one of the challenges facing sustainable water supply in developing cities (Mycoo, 2018).

In Lapai town, the problems of water supply are glaring and manifest themselves in three different forms (i.e adequacy, quality, and accessibility). The inadequacy of water supply is evidenced by the number of people seen around the available streams and earth wells scouting for water whose quality is quite doubtful, thus the problems accompanying the consumption of unsafe (untreated) water such as cholera, diarrhea, and guinea worm infections cannot be ruled out. This is also coupled with the uneven distribution of public water facilities.

Although, water need is to be supplied by all the sources available in the town including pipe-borne water, boreholes, wells, streams, and rain harvesting. Niger State Water Board (NSWB) is the sole supplier of pipe-borne water in Lapai and however, at the moment it is unfortunately not supplying any amount of water required by the inhabitants. Thus, other sources remain the only sources to meet the needs to achieve sustainability and given the exponential growth in the population due to the establishment of Ibrahim Badamasi Babangida University Lapai (IBBUL).

The rapid spatial extension of the town in the last decade has not been fully supported by infrastructural developments. While the town grew spatially, expansion of water supply service did not. There has been a wide gap, particularly in the water supply service when compared with other infrastructural developments in the area. In addition to this, the available water facilities on the ground are not unequally distributed which could make it difficult to ensure sustainability as required by the SDGs specifically the SDG 6. Hence, these necessitate new research to critically look into the extent of spatial inequality of available water facilities in Lapai to aid policy formulation and framework in achieving the SDGs. This study therefore aimed at assessing the extent of spatial inequality in the distribution of water facilities provision among major segments in Lapai urban centre, Nigeria to aid policy formulation and framework in achieving sustainable water supply.

2. LITERATURE REVIEW

SDG 6 known as 'the water goal' attracted a lot of literature suggesting formulation of policies, programs, frameworks, and methods in achieving it. For example, Hall et al. (2017) present a micro-level modeling approach that can quantitatively assess the impacts associated with rural water interventions that are tailored to specific communities. It focuses on how a multiple-use water services (MUS) approach to SDG 6 could reinforce a wide range of other SDGs and targets. Mycoo (2018) using Trinidad as a case study, analyses water governance challenges in meeting SDG 6, which addresses the sustainability of water resources by generating a blend of policies, good practices, and tools to confront growing threats to water security and to attain sustainable development. Giupponi, Gain, & Farinosi (2018) examines the spatial assessment of water use efficiency (SDG 6) for regional policy support. Ortigara et al. (2018) examine issues on how those involved in education, training, and research could contribute to enabling and accelerating progress towards achieving SDG 6. These studies were limited to frameworks, policy guidelines, country reports, and good practices without considering spatial inequality in the distribution of water facilities.

Measuring spatial inequalities is one of the major requirements of the SDGs (Cole et al., 2018; Winkler & Satterthwaite, 2017). Spatial inequalities of water facilities and provisions have been assessed by several works of literature. For instance, Cole et al. (2018) examine spatial inequality in water access and water use in South Africa where it is suggested that there is a high level of inequality in the distribution of water facilities which could delay success in achieving the SDGs. Adams (2018) who examines intra-urban inequalities in water access among households in Malawi's informal settlements opined that households and neighbourhoods in predominantly poor and under-resourced urban settings suffer water accessibility compared to others. Chaudhuri & Roy (Chaudhuri & Roy, 2017) confirmed rural-urban spatial inequality in water facilities provision among the households in India.

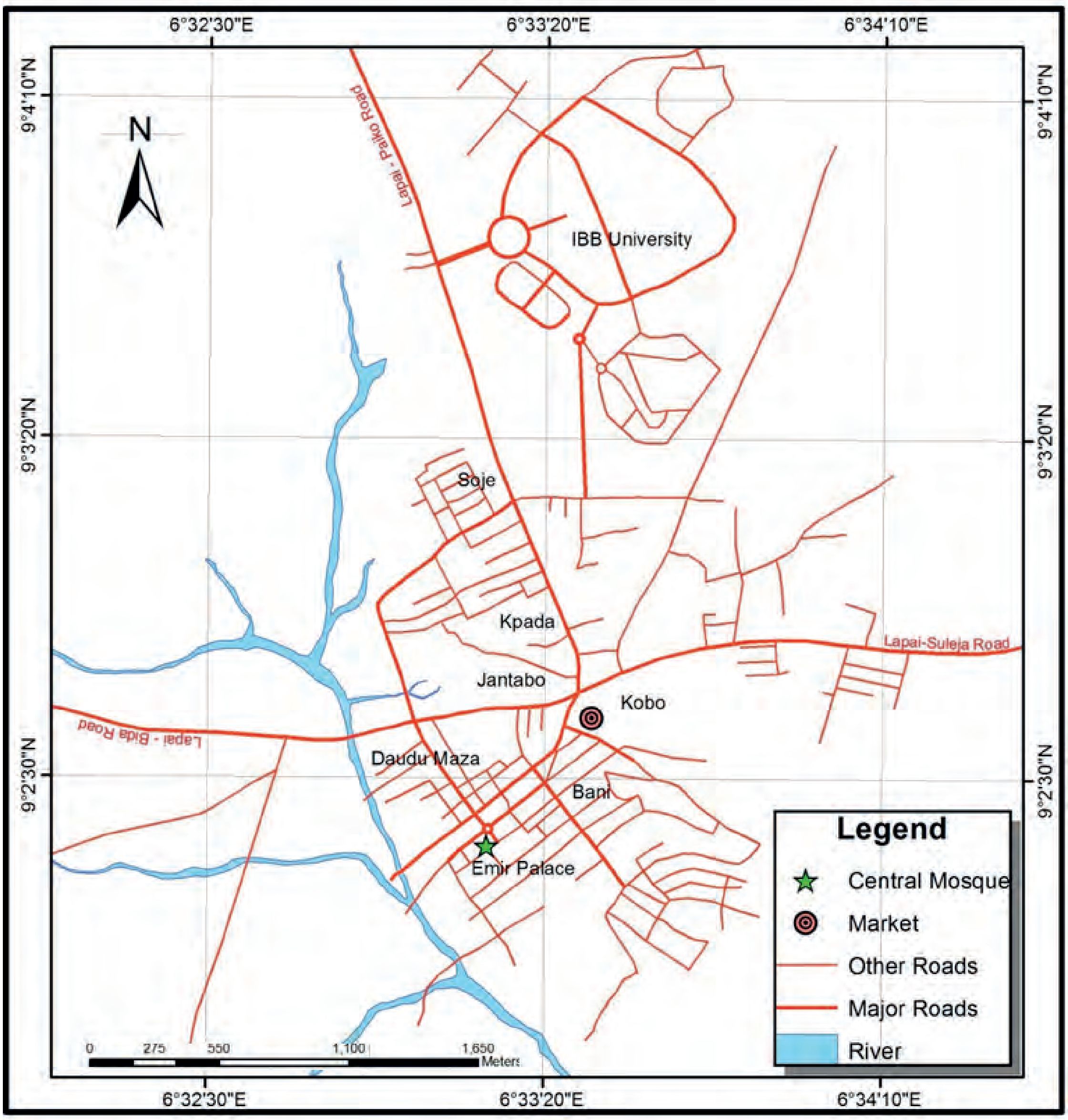

Fig. 1. Lapai Town in Niger State of Nigeria
Source: Ministry of Lands and Housing, Minna (2018).

environment

Afifah et al. (2018) argued that there are inequalities in access to improved drinking water and sanitation by subnational region in Indonesia, where monitoring within-country inequality indicators serves to identify underserved areas, and is useful for developing approaches to improve inequalities in access that can help Indonesia make progress towards the 2030 Agenda for sustainable development. Cassivi, Waygood, & Dorea (2018) also argued that in Ethiopia there is inequality in water accessibility in terms of collection time. He et al. (2018) discovers spatial inequality of access to improved drinking water supply in Nepal where it was argued that without addressing the problem it could be very difficult to attain the SDGs. Ohwo (2019) argued that achieving the SDGs particularly the SDG 6 requires the elimination of all forms of inequalities. However, studies on inequalities in water facilities provisions are not found in the study area.

3. RESEARCH METHODOLOGY

3.1. Study Area

Lapai is located within latitude 9°03′00″N and Longitude 6°34′00″E. Lapai is a medium town and covers an area of 3,730 Km^2 with an estimated population of 12, 859, based on the census (NPC) of 2006. The town is about 56 Km East of Minna, Niger State Capital. Lapai Local Government Area of Niger State is situated in a rural setting, and the major occupation of the people is farming. Few are either employed in white-collar jobs or are involved in private businesses. The locational map of the study area is shown in Figure 1.

3.2. Data and Materials

The locational position of water facilities in terms of X and Y coordinates were taken using hand-held GPS before further analysis, to provide detailed information on the nature and condition of the existing water facilities. The total numbers of public water facilities found in the study area were 45, which include 2 public water taps, 26 motorised boreholes, 13 hand pump boreholes, and 4 wells (see Table 1 for details). Average water supply by these facilities per day is: hand pump borehole, 1,500 litres; motorised borehole, 6,000 litres; well, 500 litres. Data needed for Gini coefficient analysis on the motorised boreholes, hand pump boreholes, and wells were collected, The data on the public taps is excluded because it was not functional as at the time of the study.

Table 1. Number of Public Water Facilities by Quadrants

Public Water Facilities	Quadrant A	Quadrant B	Quadrant C	Quadrant D
Hand Pump Borehole	3	2	3	5
Motorised Borehole	5	4	6	11
Well	1	0	2	1

Source: Authors' fieldwork, 2018.

3.3. Gini coefficient

The Gini coefficient was used for the measurement of the inequality of water facilities distribution in Lapai. This is because Gini is considered to be one of the best measure of inequality. In this research, the Gini coefficient plots the proportion of the total facilities provided which forms the (y-axis) by the bottom x% of the water facilities. The town was divided into four quadrants where each quadrant was measured using its Gini index. Gini coefficient measures from 0% to 100%, where 0% indicates perfect equality and 100% indicates perfect inequality. This means that the higher the Gini coefficient, the higher the level of inequality. According to WHO (2003) average water demand per capita per day for drinking, cooking and personal hygiene is at least 15 litres. Water deficit is calculated by subtracting water supply from demand. Gini coefficient was also adopted in examining inequality in water deficit across the quadrants in the study area.

4. FINDINGS AND DISCUSSION

Water facilities found in each quadrant were recorded to calculate a water facilities provision Gini Coefficient. To obtain a better measure of the inequality of water facilities, all the records of each type of water facility for each quadrant were grouped before determining the water facilities' Gini Coefficient. However, the public tap facilities were not considered due to their non-functionality as discussed earlier.

From Figure 2 it is clear that spatial inequality exists among all the variables. The inequality coefficient is 17.31% for Hand Pump Borehole facilities, 21.15% for Motorised Borehole facilities, and 37.50% for Well facilities in the study area. This indicates that public well facilities are the most unequal water facilities among the quadrants in the study area.

The inequality as represented by the Gini coefficient is better appreciated with the use of a graphical device known as the Lorenz curve. Lorenz curve demonstrates graphically the magnitude of

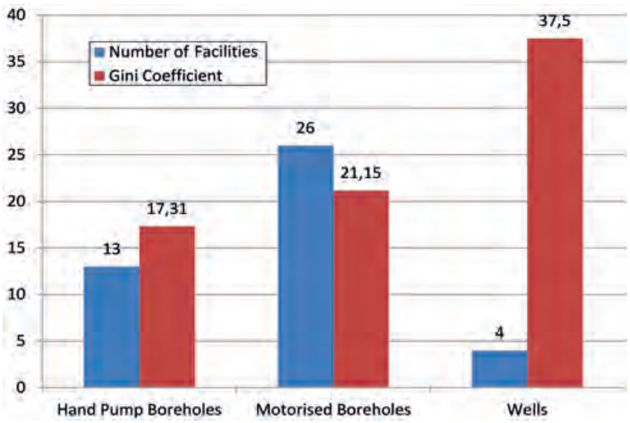

Fig. 2. Gini Coefficient for Water Facilities Distribution
Source: Authors' fieldwork, 2018.

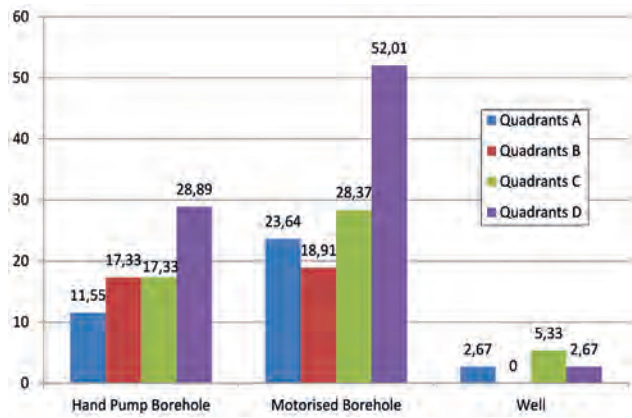

Fig. 3. Contributed Gini Coefficients for Each Quadrant by Water Facilities
Source: Authors' fieldwork, 2018.

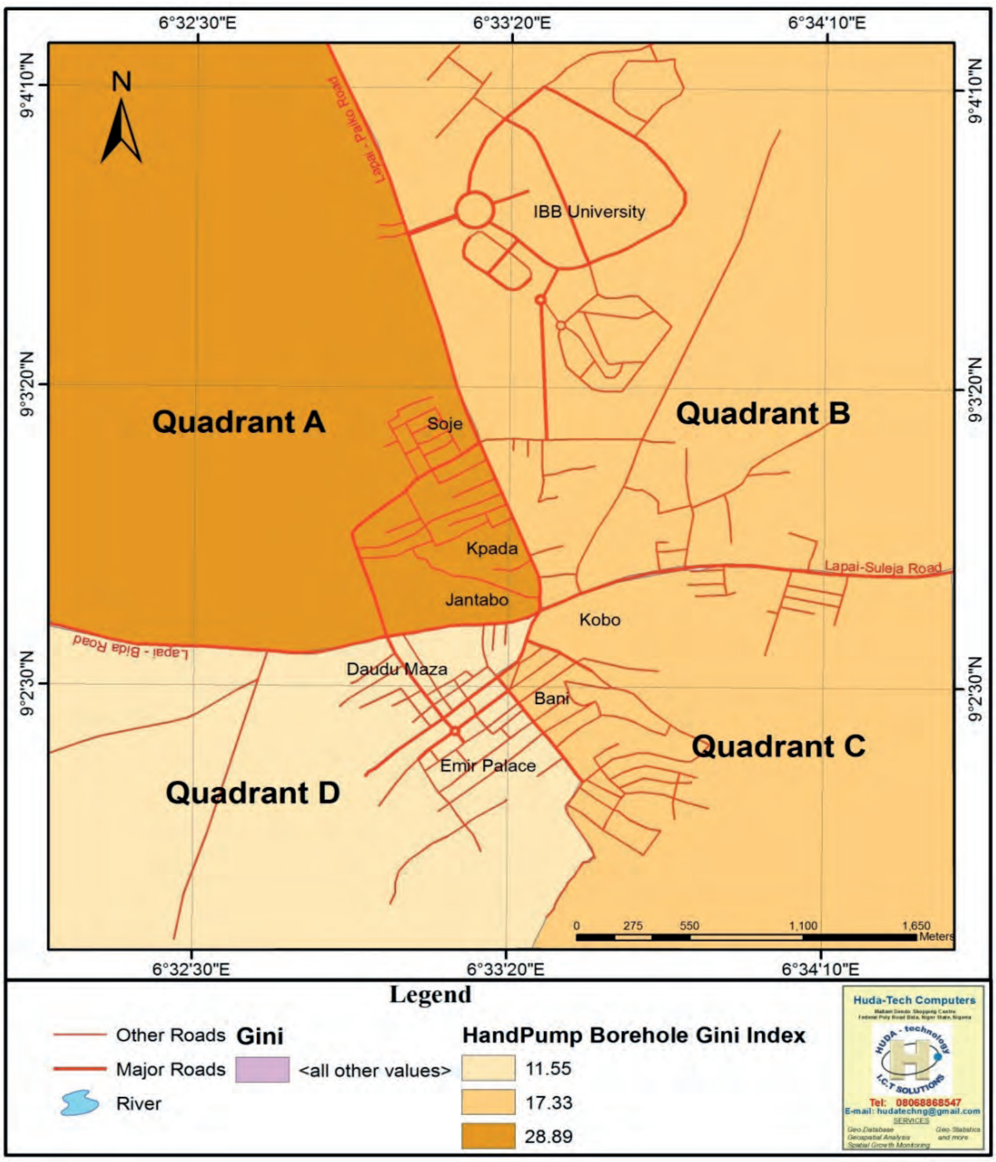

Fig. 4. The Gini Coefficient Map of Hand Pump Borehole to different Quadrants
Source: Authors' fieldwork, 2018.

inequality. In the Lorenz curve, a straight line diagonal of 45^{o} indicates perfect equality (see Appendix). This is equivalent to zero Gini coefficients. Among the variables shown, are the number of public wells representing the highest Gini coefficient followed by several motorised boreholes and the number of hand pump boreholes representing the smallest.

The Gini coefficient is more spatially presented in maps.

Results in Figure 3 are spatially represented in maps (Figures 4, 5, and 6). These results signify the densities of contributed Gini coefficients. The results of the research show the variation in the contribution of quadrants against each water facility in terms of their Gini coefficients. The hand pump borehole facilities in quadrant "D" contributed higher with 28.89% Gini coefficient, quadrant "D" also contributed higher in terms of motorised borehole facilities Gini coefficient with 52.01%, while quadrant "C" contributed higher in terms of public well facilities Gini coefficient with 5.33% respectively.

Figure 4 shows the contribution of quadrants to hand pump borehole facilities' Gini coefficient. The result revealed that quadrant "A" contributed more in terms of the Gini coefficient of hand pump borehole with a 28.89% Gini coefficient, followed by quadrant "B and C" which contributed 17.33% Gini coefficient each and quadrant "D" which contributed lower with 11.55% Gini coefficient.

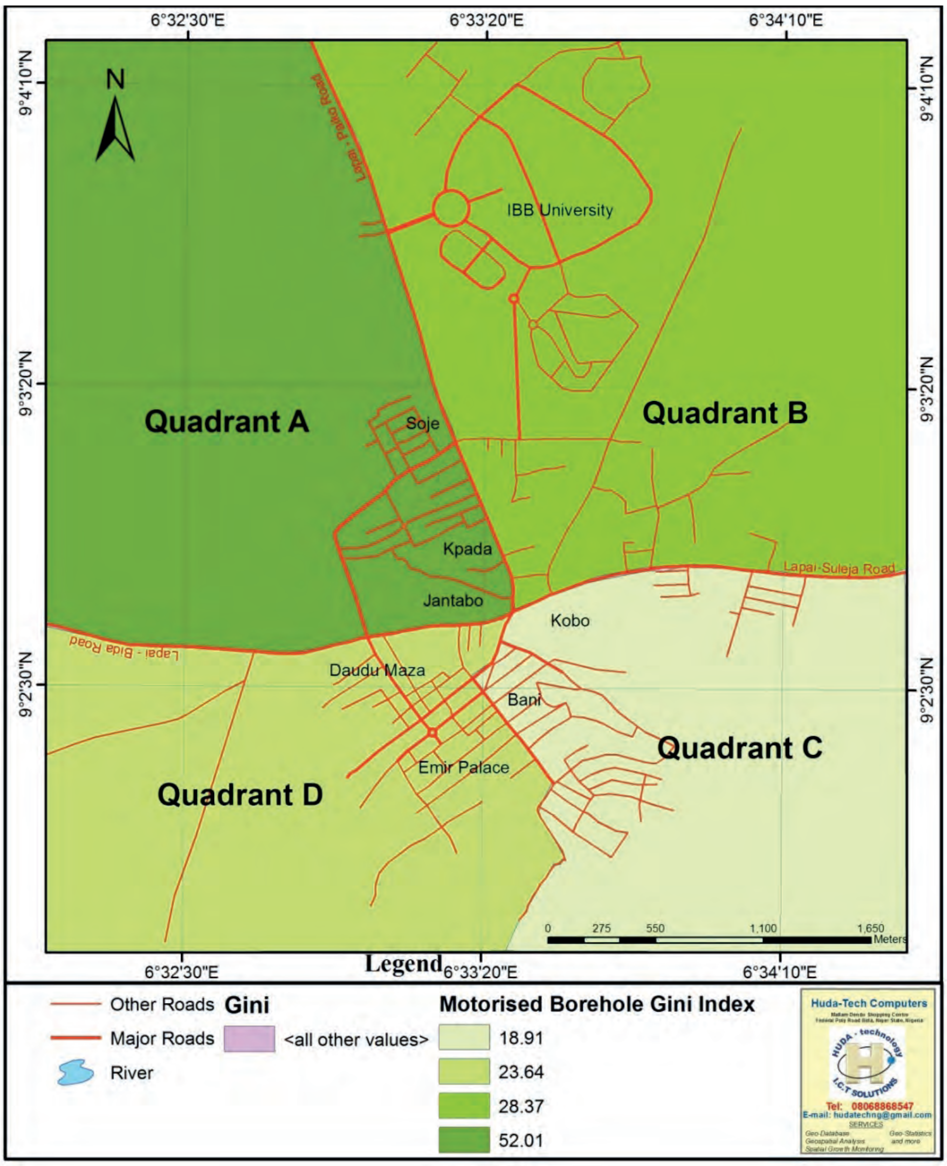

Fig. 5. The Gini Coefficient Map of Motorised Borehole to different Quadrants
Source: Authors' fieldwork, 2018.

The results in Figure 5 revealed that quadrant “A” contributed more in terms of Gini coefficient of motorised borehole with 52.01% Gini coefficient, followed by quadrant “B” which contributed 28.37% Gini coefficient, quadrant “D” contributed 23.64% Gini coefficient, while quadrant “C” contributed lower with 18.91% Gini coefficient.

Figure 6 revealed that quadrant “B” contributed more in terms of the Gini coefficient of public well facilities with a 5.33% Gini coefficient, followed by quadrant “A” and “D” which contributed 2.67% Gini coefficient each and quadrant “C” contributed 0.0% Gini coefficient respectively.

In summary, the results of field analysis show the variations in the contribution of quadrants against each public water facility in terms of their Gini coefficient.

The study revealed that there is inequality in the provision of water facilities in the study area. This result is similar to that of Cole et al. (2018) who confirms spatial inequality in water access and water use in South Africa and argued that a high level of inequality in the distribution of water facilities could make SDG 6 not achievable. Also, the result is in line with He et al. (2018) who discovers spatial inequality of access to improved drinking water supply in Nepal where it was argued that without addressing the problem, attaining the SDGs particularly SDG 6 could not be realistic.

Furthermore, population of the residents, water demand, water supply and water deficit were considered to further assess the inequality in the provision of water facilities in the study area.

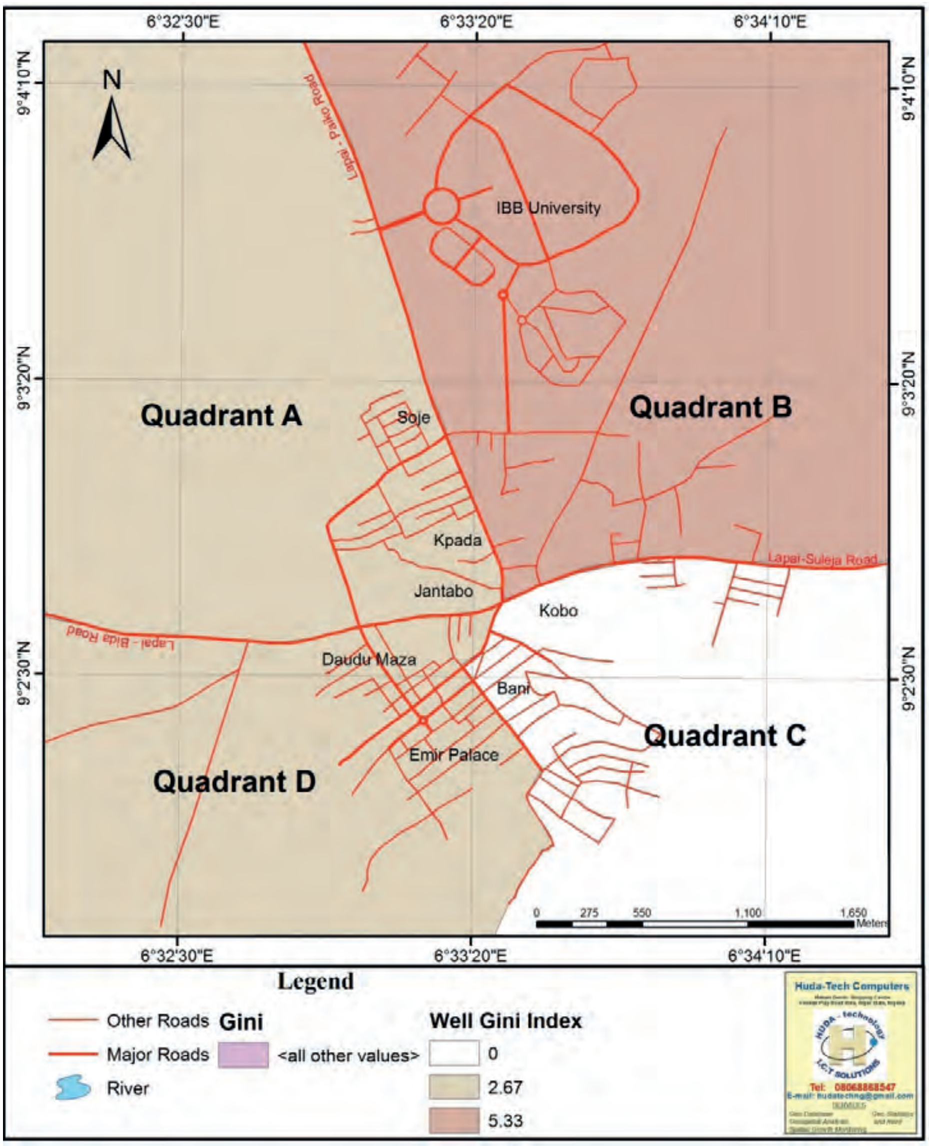

Fig. 6. The Gini Coefficient Map of Well to different Quadrants
Source: Authors' fieldwork, 2018.

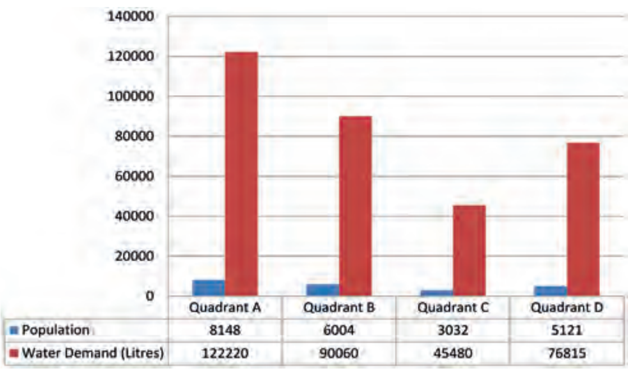

Fig. 7. Population and Water Demand
Source: Authors' fieldwork, 2018.

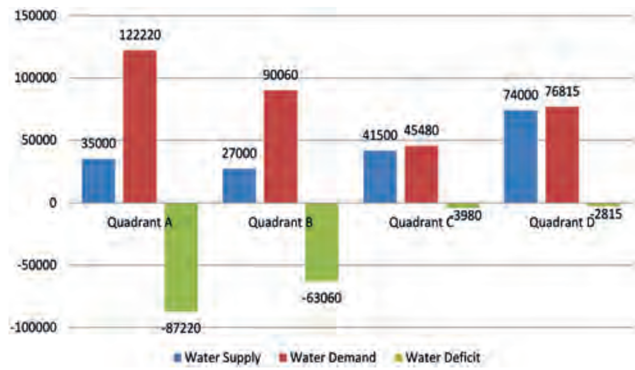

Fig. 8. Water Demand, Supply and Deficit
Source: Authors' fieldwork, 2018.

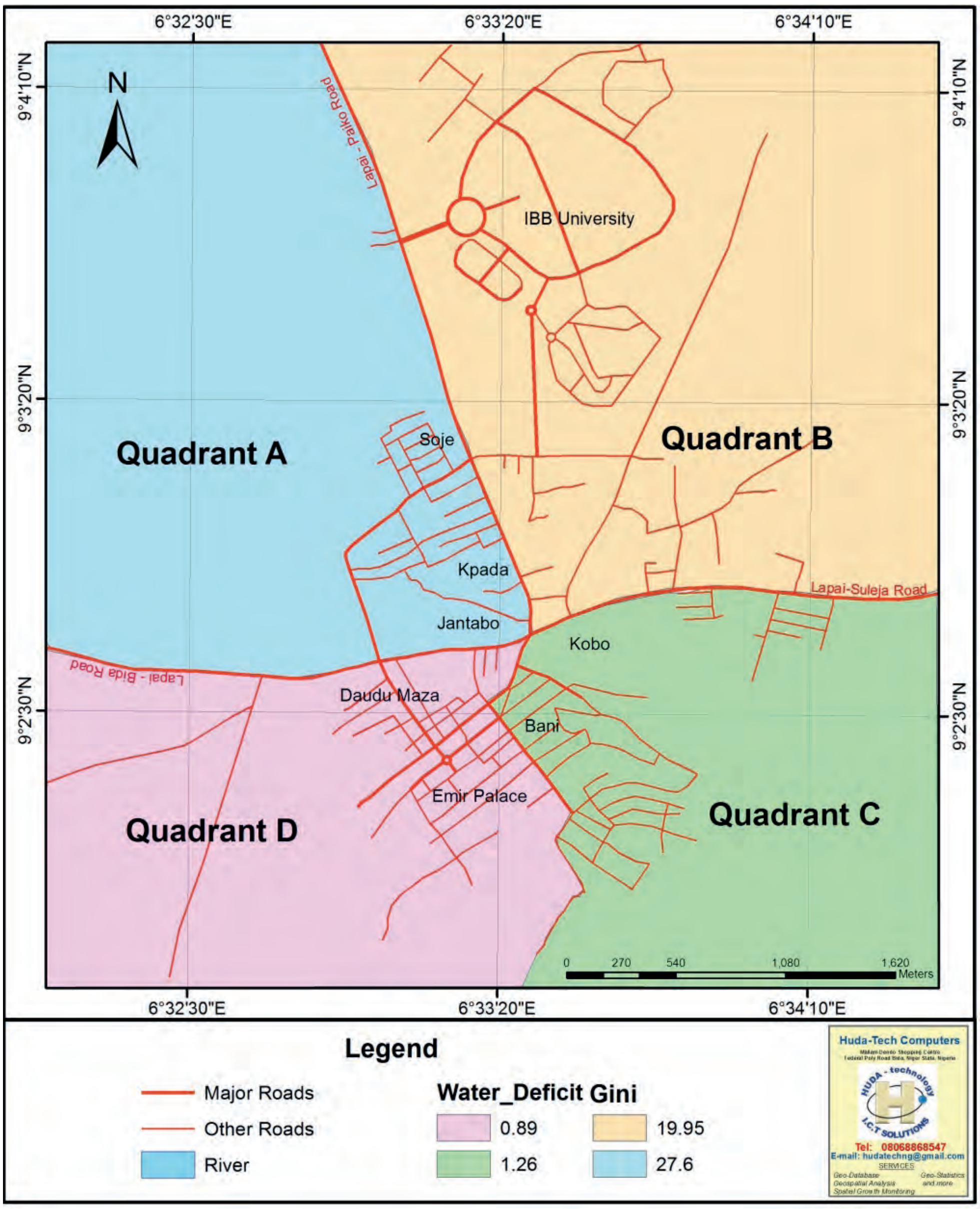

Fig. 9. The Gini Coefficient Map of Water Deficit
Source: Authors' fieldwork, 2018.

The study revealed in Figure 7 that Quadrant A has highest population of residents with 8,148 persons and about 122,220 litres of water need per day, while Quadrant C has lowest population with 3,032 persons and about 45,480 litres of water needed per day.

Findings of the study revealed in Figure 8 the water demand, supply and deficit across all the quadrants. It revealed that Quadrant A has highest water deficit with -87,220 litres per day i.e. additional 87,220 litres of water is needed per day by the quadrant to meet its need. Also, the findings revealed that Quadrant D has lowest water deficit with -2,815 litres per day, i.e. about 2,815 litres of water is needed per day by the quadrant to meet its water need.

Findings of the study revealed that Quadrant A has the highest contribution to the inequality in a water supply deficit in the study area with 27.6% Gini coefficient. This is followed by Quadrant B with 19.95% Gini coefficient and the least by Quadrant D with 0.89% Gini coefficient. The findings imply a very wide variation in the provision of public water facilities in the study area. Despite the high population in Quadrant A, it has the highest level of a water supply deficit, which indicates that population is not considered when providing these facilities.

The findings of this study have proven a high level of spatial inequality in terms of water facilities provision and water supply deficit. Studies have proven that spatial inequality in water supply facilities may hinder the achievement of the SDGs, particularly the SDG6 (Wei, 2015). The findings have also provided an aspect of the monitoring framework for the SDG6, this is another aspect that is paramount in achieving the goal (McIntyre, 2018).

5. CONCLUSION

The study shows a variation in the contribution of quadrants against each public water facility in terms of their Gini coefficient. This indicates that there is inequality in the distribution of public water supply facilities among the four quadrants in the study area. Also, the facilities provided did not commensurate with the population of the spatial segments of the town. There is a high level of water deficit across all parts of the town, where in some cases water deficit is more than the supply. The water supply deficit is also highly unequally across the spatial segments of the study area. This high level of inequality in the distribution of water facilities could make it difficult to achieve the global agenda for sustainable development in the year 2030. This study serves as an eye-opener for policymakers particularly those in charge of the SDG 6 framework. It was therefore recommended that both public and private sectors should provide public water facilities equitably to achieve SDGs (particularly, the SDG6).

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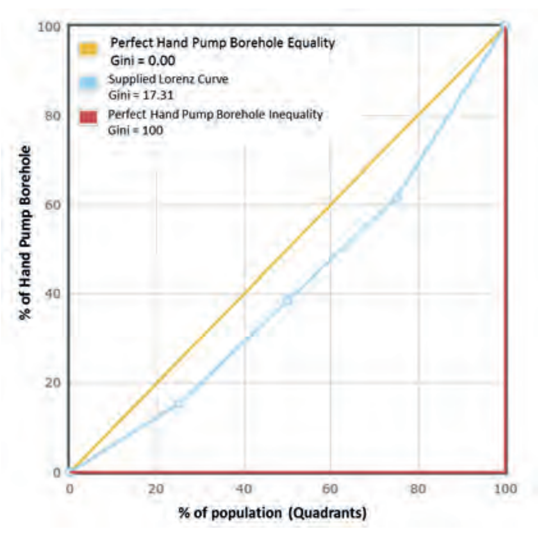
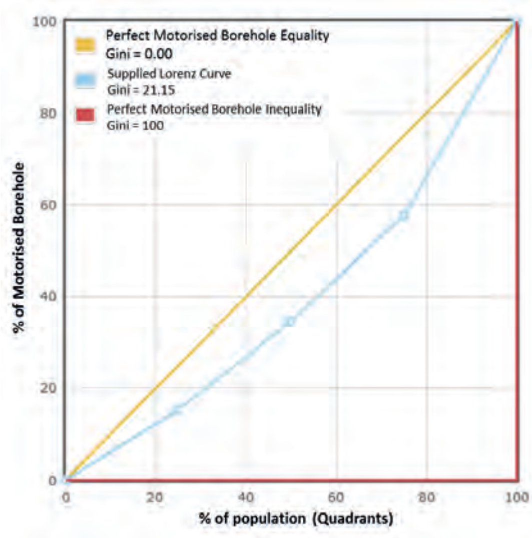
APPENDIX

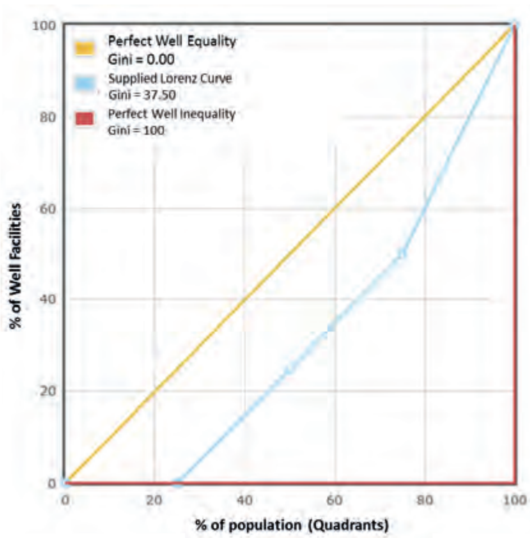
Lorenz Curves



Lorenz Curve of Spatial Inequality in Number of Hand Pump Borehole Facilities



Lorenz Curve of Spatial Inequality in Number of Motorised Borehole Facilities



Lorenz Curve of Spatial Inequality in Number of Well Facilities

Water Supply by Facilities

Public Water Facilities	Quadrant A		Quadrant B		Quadrant C		Quadrant D	
	No. Facilities	Water Supply (Litres)	No. Facilities	Water Supply (Litres)	No. Facilities	Water Supply (Litres)	No. Facilities	Water Supply (Litres)
Hand Pump Borehole	3	4500	2	3000	3	4500	5	7500
Motorised Borehole	5	30000	4	24000	6	36000	11	66000
Well	1	500	0	0	2	1000	1	500
Total		35000		27000		41500		74000