Electricity usage as a proxy for measuring wealth in Nigeria (Project Summary)

1. Introduction

Eradicating poverty is a pressing challenge and has been defined as the first sustainable development goal that needs to be achieved by 2030. To this end, different poverty alleviation programmes, including cash transfers, microfinance, and rural employment guarantees, have been initiated across developing countries. Nevertheless, such programmes require monitoring and evaluation to understand the impacts of these initiatives and ensure accountability and transparency, adjustment of shortcomings, and scaling of solutions. In monitoring and evaluating such initiatives, both direct and indirect approaches are used for monitoring and evaluation. The former often involves surveys, while the latter uses an indicator or a proxy for poverty. This project leans towards the latter approach.

2. Aim

Electricity use correlates with economic activity, which generates income for individuals. Given this concept, this project aimed to assess how electricity usage could serve as a proxy for determining wealth levels in Nigeria. It explores electricity usage across four years (2012, 2015, 2018, and 2021) in rural and urban areas within Nigeria to assess its function as a proxy for wealth.

3. Methods and Data

3.1 Demographic and Health Surveys (DHS)

The Demographic and Health Surveys (DHS) are household surveys providing data on various monitoring and evaluation indicators regarding population, health, and nutrition.[1] These surveys are nationally representative.[1] An important indicator provided by the DHS is the Mean Wealth Index (MWI). The MWI is an indicator of wealth for a particular household and is computed based on asset ownership (e.g., bicycles, refrigerators, televisions).[2] For this project, the MWI served as the wealth variable for which electricity usage is to serve as a proxy. Also, individual households were categorised into clusters for this project, which entailed grouping them into urban or rural clusters, given information from the DHS survey. For more information, please see the R script in my GitHub.

3.2 Visible Infrared Imaging Radiometer Suite (VIIRS) Nightlight Satellite Data

The VIIRS nightlight data measures global daily visible and near-infrared light used in earth system science.[3] VIIRS data often serves as a proxy for electricity use, as bright pixels in a VIIRS image indicate electricity use and darker pixels indicate little to no use. As such, higher pixel (nightlight) values suggest higher electricity use. This study employed VIIRS images to measure electricity use across four years with three-year intervals (2012, 2015, 2018, and 2021). To extract the pixel value of the DHS clusters, spatial data of the DHS clusters were imported into the ArcGIS software, overlain on VIIRS images and extracted. The extracted pixel (nightlight) values served as a proxy for electricity use within the clusters.

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[1] The Demographic and Health Surveys (DHS). Accessed December 30 2023. https://dhsprogram.com/Methodology/Survey-Types/DHS.cfm

[2] The Demographic and Health Surveys (DHS). Accessed December 30 2023. https://dhsprogram.com/topics/wealth-index/#:~:text=The%20DHS%20wealth%20index%20categorizes,a%20household's%20cumulative%20living%20standard.

[3] EarthData. "Nighttime Lights." Accessed December 30 2023. https://www.earthdata.nasa.gov/learn/backgrounders/nighttime-lights#:~:text=The%20Visible%20Infrared%20Imaging%20Radiometer,Earth%20system%20science%20and%20applications

4. Results

4.1 Distribution of Urban and Rural Clusters

The dataset comprised a total of 1,382 clusters. As illustrated in **Figure 1**, rural clusters made up a larger share of the dataset. Rural clusters totalled 806, while urban clusters totalled 576 in the dataset. Given that these clusters were derived by consolidating individual households from the DHS dataset, more rural households were surveyed. **Figure 2** disaggregates the urban and rural clusters at the state level in Nigeria. Lagos State with 49 urban clusters accounts for the largest number of urban clusters. Anambra (32), Oyo (30), and Abia (28) States also comprised high urban clusters. In contrast, Akwa Ibom (34), Jigawa (34), and Benue (33) States accounted for the highest number of rural clusters (***Figure 2***).

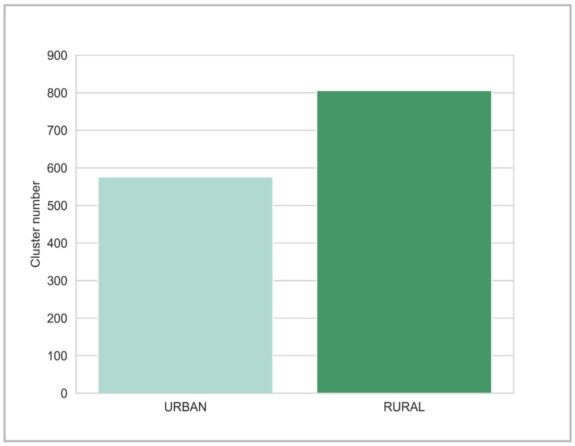

Fig 1. Distribution of urban and rural clusters.

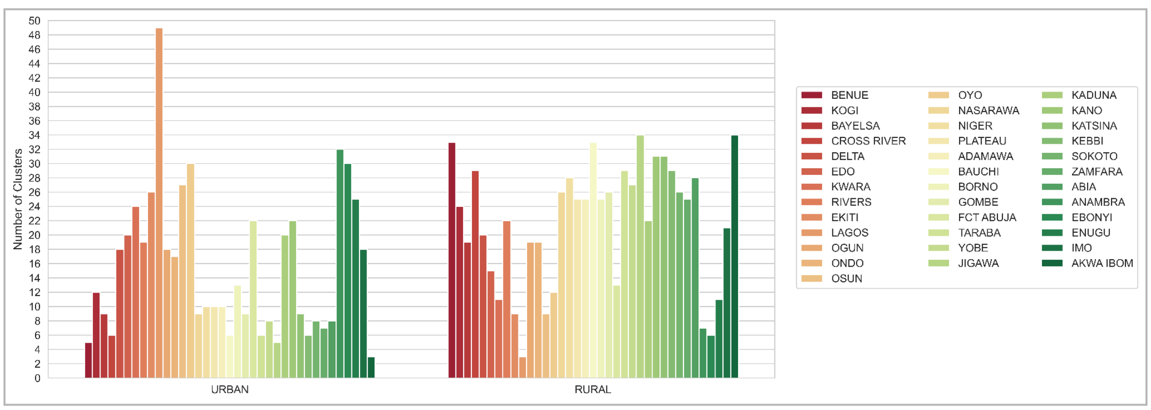

Fig 2. Distribution of urban and rural clusters across Nigerian States and its FCT (Federal Capital Territory).

4.2 Distribution of Nightlight Values (Electricity Usage)

The mean nightlight value across the years of consideration shows a general rise (***Figure 3***). **Figure 3** highlights that in 2012, the average nightlight value across all clusters was about 1.6. This figure experienced an increase to 1.9 in 2015 but dipped slightly to 1.8 before returning to 1.9 in 2021 (***Figure 3***). The general increase in mean nightlight value between 2012 and 2021 translates to a higher increase in electricity usage within the clusters. To explore this increase in electricity usage across urban and rural clusters, **Figure 4** presents the mean nightlight value within each cluster group across the four years.

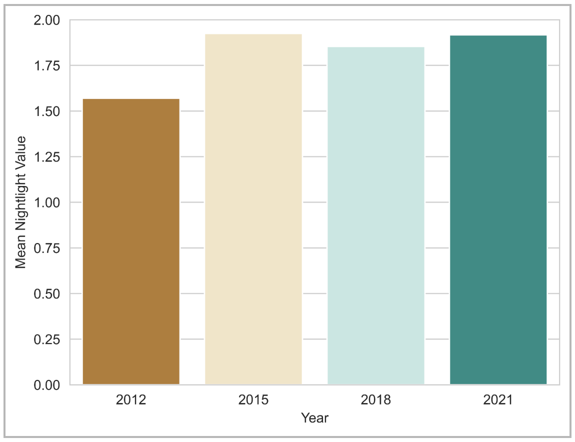

Fig 3. Mean nightlight value across four years.

Overall, urban clusters demonstrate a higher mean nightlight value compared with rural clusters. Considering commercial activities primarily occur within urban areas, electricity demand and usage tend to be higher than in rural areas. Nevertheless, both urban and rural clusters experienced an increase in electricity usage (i.e., nightlight value) between 2012 and 2021 (***Figure 4***). The mean nightlight value of urban clusters was around 2.8 in 2012, growing to 3.2 in 2015 and remaining relatively stable till 2021. For rural clusters, the average nightlight value stood at 0.7 in 2012 but rose to 1 by 2021 (***Figure 4***). Although there has been a general increase in electricity usage at the cluster level (i.e., urban and rural), ***Figure 5*** explores if a similar pattern has occurred at the state level.

Fig 4. Mean nightlight value across urban and rural clusters across four years.

Figure 5 presents the electricity usage of clusters across the Nigerian states for the years under consideration. Based on the clusters sampled, 33 of the 37 Nigerian States (including the FCT) have experienced an increase in electricity usage. Only four States (Edo, Enugu, Jigawa, and Kogi) saw a decline in electricity usage (***Figure 5***). The steepest decrease occurred in Edo state, where the nightlight value fell from 2.9 in 2012 to 1.6 in 2021. Conversely, the most significant increase in nightlight value occurred in Kano state, which rose twofold from 1.8 to 3.6 between 2012 and 2021 (***Figure 5***). Across all States, Lagos demonstrated the highest nightlight value between 2012 and 2021 (***Figure 5***). Lagos is the most populous Nigerian State and also the nation's commercial capital. These socioeconomic factors explain its high electricity usage compared with other states. Nightlight value in Lagos State remained relatively stable across the four years, with an average of around 12. Like Lagos State, Rivers State demonstrated high nightlight values, beginning at 5.3 in 2012 and increasing to 5.7 in 2021. By 2018, this figure fell to 4.2 but rose to 5.5 in 2021 (***Figure 5***).

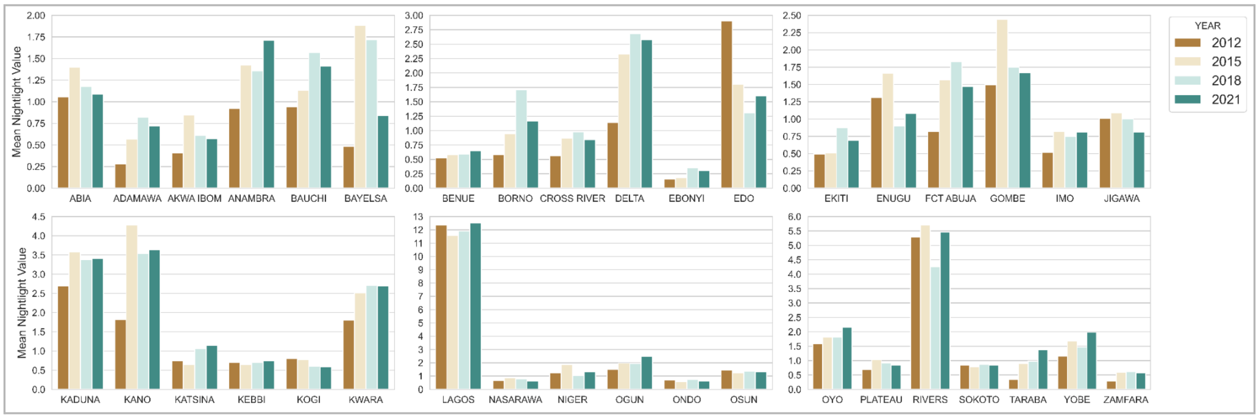

Fig 5. Mean nightlight value across Nigeria's 36 states and FCT in 2012, 2015, 2018, and 2021.

4.3 Correlation of Nightlight Values (Electricity Usage) to Wealth

To assess how electricity usage can serve as a proxy for wealth in Nigeria, I assessed the correlation between the Cluster Mean Wealth Index and the nightlight values across each year which is shown below in **Figure 6**.

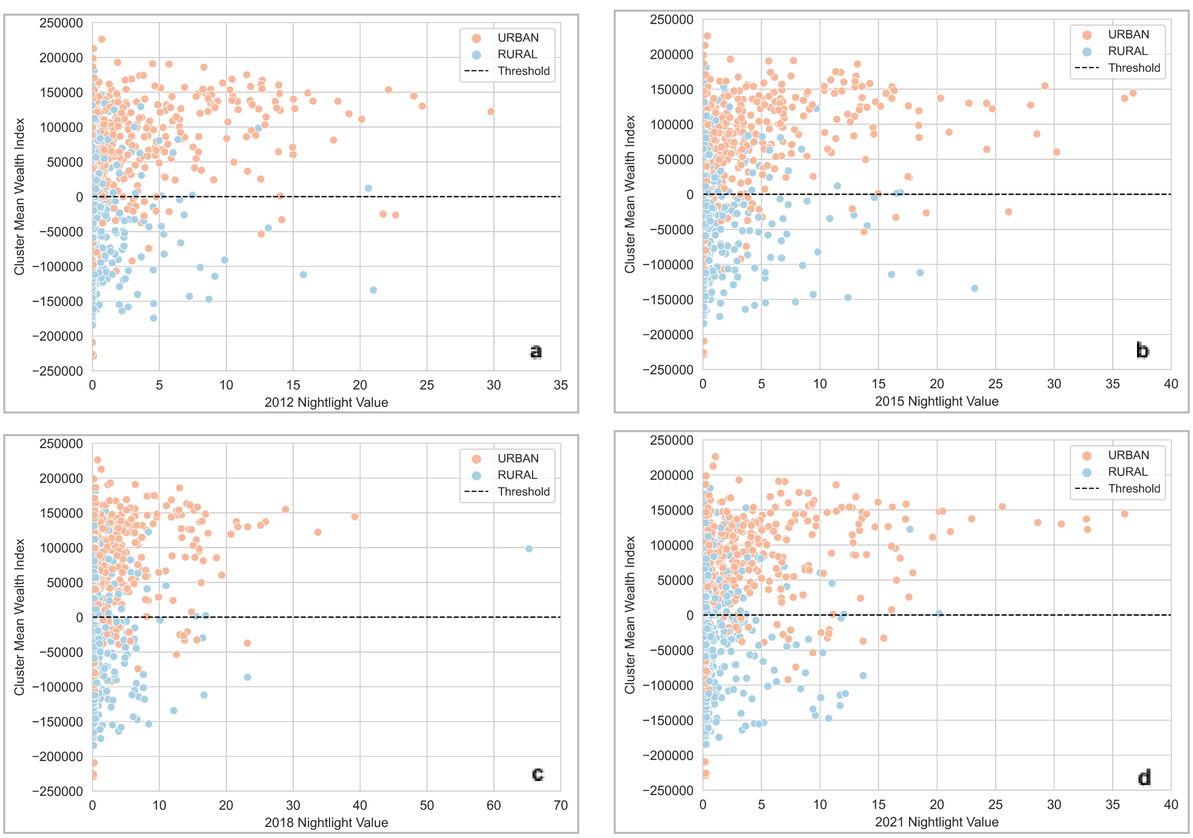

Fig 6. Cluster Mean Wealth Index (CMWI) as a function of nightlight value in **a.** 2012, **b.** 2015, **c.** 2018, and **d.** 2021.

Figure 6 illustrates some trends across the four years. Firstly, the nightlight value of the majority of clusters falls between 0 and 20. Secondly, as pixel values increase, the number of rural clusters (i.e., blue dots in **Figure 6**) decreases. However, despite the majority of clusters with nightlight values higher than 20 being urban clusters (i.e., red dots in **Figure 6**), the wealth index of these clusters doesn't increase. In other words, the wealth index doesn't increase proportionally to the nightlight value. Finally, the majority of clusters that fall below the threshold[4] (black dashed lines in **Figure 6**) and have a negative CMWI are rural clusters. Although these clusters falling below the threshold have similar pixel values to urban clusters, the CMWI of these clusters is still lower.

Given these trends, an important question arises: Why do most rural clusters fall below the threshold despite similar nightlight values to some urban clusters? I believe the methodology for computing the CMWI can answer this question. The mean wealth index is computed based on different assets such as bicycles, televisions, refrigerators, access to water, sanitation facilities and electricity. Therefore, relying solely on electricity access as a proxy for the DHS wealth index would prove insufficient.

5. Conclusion

This study sought to assess how electricity usage could serve as a proxy for measuring wealth. Employing data from the DHS program and VIIRS satellite, it explored the correlation between these variables. The findings revealed urban clusters generally have higher nightlight values than rural clusters, given their functions as commercial hubs. Urban clusters also demonstrated higher wealth levels than their rural counterparts. Nevertheless, the study failed to find a significant correlation between the nightlight values and the wealth index. This can be attributed to how the wealth index is computed and its use of varied indicators. To explore how the analyses for this study were performed, I refer readers to the jupyter notebook in my GitHub.

[4] I consider this threshold to be the poverty line. Identifying an established poverty line for the DHS wealth index has proven elusive and as such this poverty line was self-defined.