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UTILIZATION OF RENEWABLE ENERGY POTENTIALS FOR CLIMATE CHANGE MITIGATION, IN KADUNA STATE

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ABSTRACT

Alternative energy provisions depend largely on the availability of natural resources such as sunlight, wind or biomass, all of which are readily available in Nigeria. This research investigated the renewable energy potentials of Nigeria with special attention and consideration to solar energy potentials in Kaduna state. Geographical Information System (GIS) techniques were applied to map the solar energy potential sites of the study area using the spatial analysis tools in ArcGIS software 3.0. Results from the study revealed a strong correlation between the ground measured and satellite measured solar monthly mean

Introduction

Energy resources, supply and utilization play a significant role in the socioeconomic development, poverty eradication and security of a nation (Ajaelu &Okereke, 2020). Since the industrial revolution energy has been the driving force of modern civilization and technological development. All societies call for the service of energy to meet basic human needs such as cooking, heating and lighting. it is also required to run our machines for provision of portable water, mobility, communication and other generative processes (Edenhofer et al., 2011).

The United Nation (UN), (2015) assert that access to clean, affordable and environmentally friendly energy is an essential condition for the attainment of sustainable development (United Nations, 2015). Presently, fossil fuel is the world's most predominant energy source (International Energy Agency, IEA, 2010) for instance, in 2012, (IEA) confirmed that more than three-quarters amounting to 78.4% of total world energy demands in 2012 was fulfilled by fossils. In Nigeria over 80% of the current national energy supply is dominated by fossil fuels and fuelwood. These energy sources have adverse negative impacts to global environmental health and sustainability, as they increase greenhouse gas emissions that facilitates global warming and climate change (Sani, Aliyu & Nuhu, 2021; Akorede, et al, 2017)

A significant climate change has become one of the most serious environmental threats facing mankind worldwide due to its multi-faceted nature. The issue of climate change has become more threatening, not only to the sustainable development of socio-economic and agricultural activities of any nation, but to the totality of human existence (Dutse & Ibrahim, 2013). Renewable energy sources hold the key potential to displace greenhouse gas

daily values of global solar radiation in the study area, indicating that Kaduna state has significant potentials for harnessing solar energy. Further analysis revealed that the solar energy potential sites in the state can be classified into areas of high, moderate and low potentials. The maximum insolation values in Kaduna State were recorded between the Months of March and May. Therefore, the optimum times for harnessing solar energy in the area are the months of March and April. The research concluded with recommendations to raise awareness and encourage the use of solar energy sources to mitigate the impact of climate change.

Keywords: Renewable energy, Solar energy, Potentials, Climate change, Kaduna

emissions from fossil fuel energy source and thereby mitigating climate change (Edenhofer et al., 2011). Accordingly, global concern for sustainable development and climate change mitigation has brought concentration of energy policy makers towards renewable energy sources, since they provide energy, without emissions of greenhouse gases (GHGs) and are also abundant resource available for the future. This study therefore, seeks to examine the utilization of renewable energy potentials in Kaduna state for climate change mitigation. Specifically, the study examined solar energy potentials in Kaduna state and their level of utilization. The study will contribute to existing literature by providing information on solar energy potentials that will help in designing energy policies for promoting renewable energy utilization.

Materials and Methods

The Study Area

Kaduna state is located in north-central Nigeria (figure 1) although it belongs to the Northwest geopolitical regions of the country and lies between latitudes 9° 01' to 11°34' north of the equator and between longitudes 6°11' and 8°49' east of the Greenwich meridian. The state has an estimated land area of 42,481 square kilometers (16,594.14 square miles), which makes it the largest in the northwest geopolitical zone and has about 4.7 per cent of the Nigerian land area (NBS, 2009). The study area is delineated into political constituencies of three senatorial districts; each district constitutes of local government areas. There are 23 local government areas in the state with 255 political wards spread across.

Kaduna State is blessed with renewable energy resources, especially solar energy resources, which is attracting investors attention in recent years. Already a 50MW solar system was launched in 2011 with substantial investment from Snergent Powershare Groups. There also a partnership between Kaduna government and Quaint Global Energy Solutions to finance 50 MW solar power plant in Manchok in the Kaduna State. In 2017, Anjeed Innova Group (AIG) had proposed a plan to embark on Anjeed Kafanchan Solar Project to provide an initial plan of 10 MW but lately scaled up to 50 MW in the first phase, and this will be followed by 100 MW in the second phase. (Ahmad & Kabuga, 2019).

Figure:1. Map of Nigeria Showing Kaduna State.
Source: GIS Lab Department of Geography, Ahmadu Bello University, Zaria

Types and Sources of Data.

The data required and their sources are shown in table 1.

Table 1: Types of Data and Sources

S/No.	Types of Data	Source
1.	Administrative map of Nigeria	DIVA GIS
2.	Reanalysis solar radiation data	Copernicus
3.	Observed ground measured solar radiation data	Nigerian Metrological Agency (NiMet)

4.	Data on solar energy awareness and utilization	Questionnaire
5.	Literature Materials	Journals, text books thesis and internet materials

Source: Authors compilation

Sources of Data.

The different datasets used for the study includes primary and secondary data which contain both spatial and non-spatial attributes.

Primary sources

i. The Digital Elevation Model (DEM)
ii. The survey questionnaire. The questionnaire was used to collect socio demographic and solar energy awareness and utilization information.

The Secondary Data

This includes administrative map and solar radiation data, viz.:

i. Advanced Land Observation Satellite-1 Phased Array Type L-band Synthetic Aperture Radar ALOS PALSAR) data sets with 12.5m resolution DEM was downloaded from https://vertex.daac.asf.alaska.edu/#
ii. The administrative map of the Kaduna state was subset from Nigeria shape file that contained all the states of country. Sourced from www. divagis.com
iii. Satellite derived Solar radiation data was acquired from Copernicus and ground measured solar radiation data was collected from NiMet
iv. The survey questionnaire was used to collect sociodemographic characteristics of respondents and solar energy awareness and utilization related information from respondents selected from household.

Methods of Data Processing and Analysis

The data retrieved from satellites and ground measured solar radiation was analyzed using geospatial techniques. This was achieved using the spatial analysis tools in ArcGIS software. Data from survey questionnaire was subjected to both descriptive and inferential statistics (see Figure 3). More specifically, the three objectives of the study were achieved in the following order.

Objective I: This objective was achieved using spatial analysis tools in ArcGIS. In order to identify the solar energy potential sites, the map of the study area was used to delineate the Digital Elevation Model (DEM) of the area from Shuttle Radar Topographic Mapper (SRTM) data in ArcGIS environment. Then the maps were georeferenced based on the WGS 1984 Geographic coordinate system. Then, the slope and aspect maps of the area were generated from the DEM. Then, the solar radiation map, the DEM, the slope and aspect maps were ranked based on the Analytic Hierarchy Process (AHP). Finally, the solar radiation map, the DEM, the slope and aspect maps were integrated using weighted overlay to produce the map of solar energy potential sites in the study area.

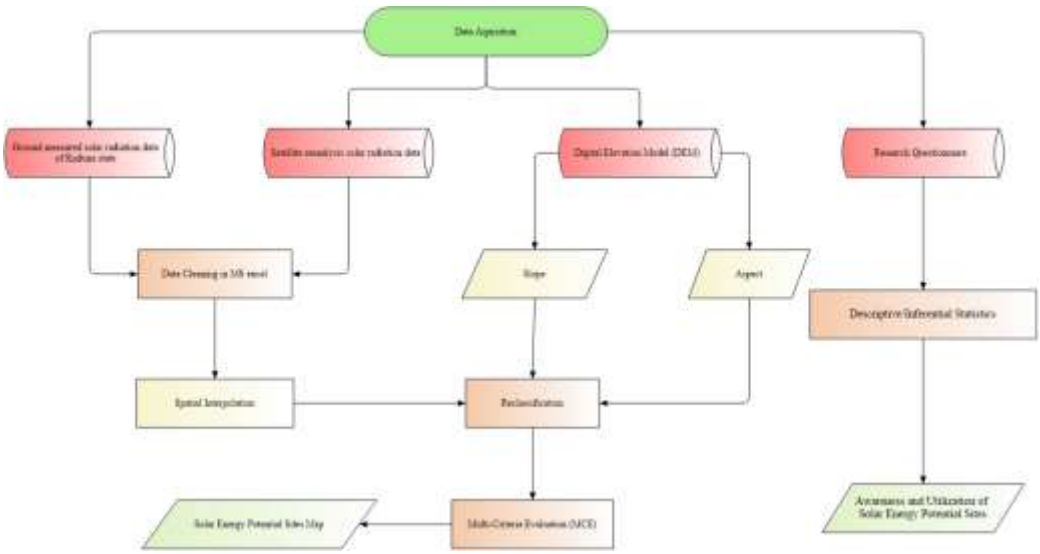

Figure 3: Methodology applied for this study

Results and Discussion

Ground-measured and Satellite Monthly Mean Daily Values

The pattern of ground-measured and satellite measured monthly mean daily values of global solar radiation in Kaduna state in table below revealed that based on ground measurement maximum monthly mean solar radiation values were recorded between march and April in Kaduna state. This can be attributed to the fact that the months of January, February, and March fall within the period of longer days and shorter nights experienced in the southern hemisphere. A longer day implies longer sunshine hours per day. Similarly, based on the solar radiation measurement results also indicates the insolation values remains high during the month of January, February and march in Kaduna state. This can be an element of the increasing sunshine hours observed from the winter solstice in the northern hemisphere. The finding revealed that Kaduna state has significant potentials for harnessing solar energy.

Table 2: Ground-measured and Satellite Monthly Mean Daily Values of Global Solar Radiation (kWh/m2/day) in Kaduna State for 1990-2020

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ground	6.72	6.95	6.78	6.13	5.32	4.83	4.57	4.68	5.40	5.92	6.83	6.82
Satellite	5.96	6.16	6.08	5.74	5.36	4.94	4.51	4.31	4.78	5.31	5.78	5.88

Source: NiMet and NASA Power LARC (2020).

Evaluation of Ground Measured and Satellite Solar Radiation Data

The graphic presentation of the ground measured and satellite measured monthly mean daily global solar radiation data in Kaduna state indicates that in comparison of the two values the maximum ground measured solar radiation values was found to be 6.79kWh/m^2/day, while the recorded satellite value was 6.19kWh/m^2/ day. Thus, the difference between the ground and satellite measured solar radiation values is very minimal (0.6kWh/m^2 /day). Similarly, the minimum ground measured solar radiation values was found to be 6.79kWh/m^2/day, compared to the recorded satellite value was 4.57kWh/m^2/ day. the minimum difference between the ground and satellite measured solar radiation values is 0.26kWh/m^2/day. This finding indicates

a strong correlation between the ground and satellite measured solar radiation data, indicating a high evidence of solar energy potentials.

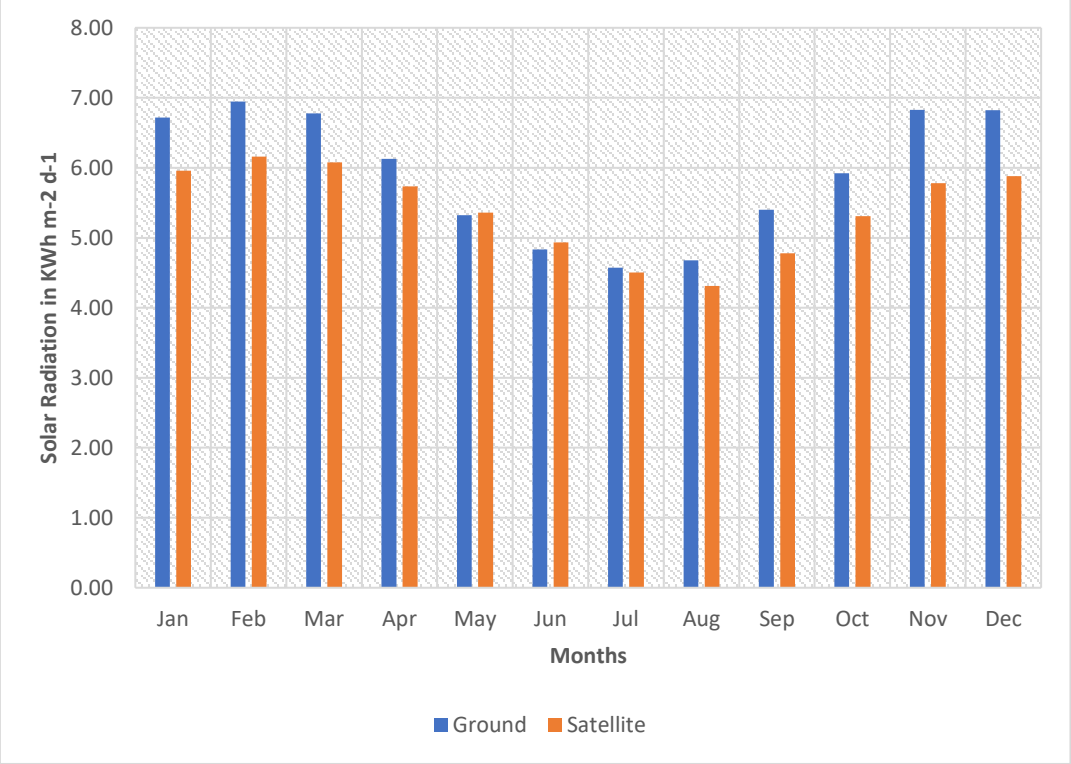

Figure 4: Monthly Mean Daily Values of Global Solar Radiation in Kaduna State ($KWhm^{-2}$ d^{-1})

The level of correlation between the two sources of radiation is further tested using the scatter plots in figure 4, the result indicates a strong positive relationship between the two sources of data. This implies that in the absence of one sources of radiation data, the other source can reliably serve as alternative

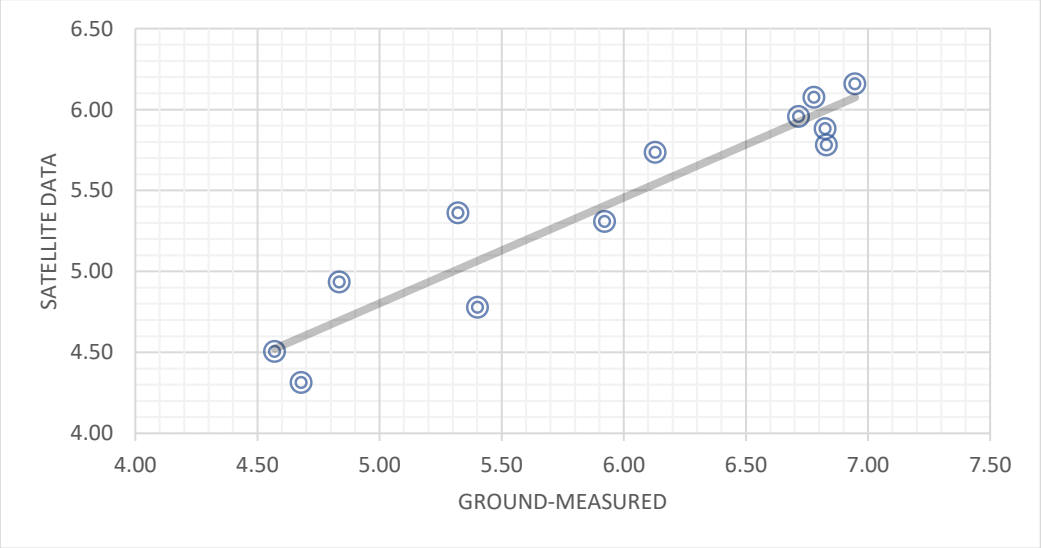

Figure 5: scatter plots showing the level of correlation between the two sources of radiation

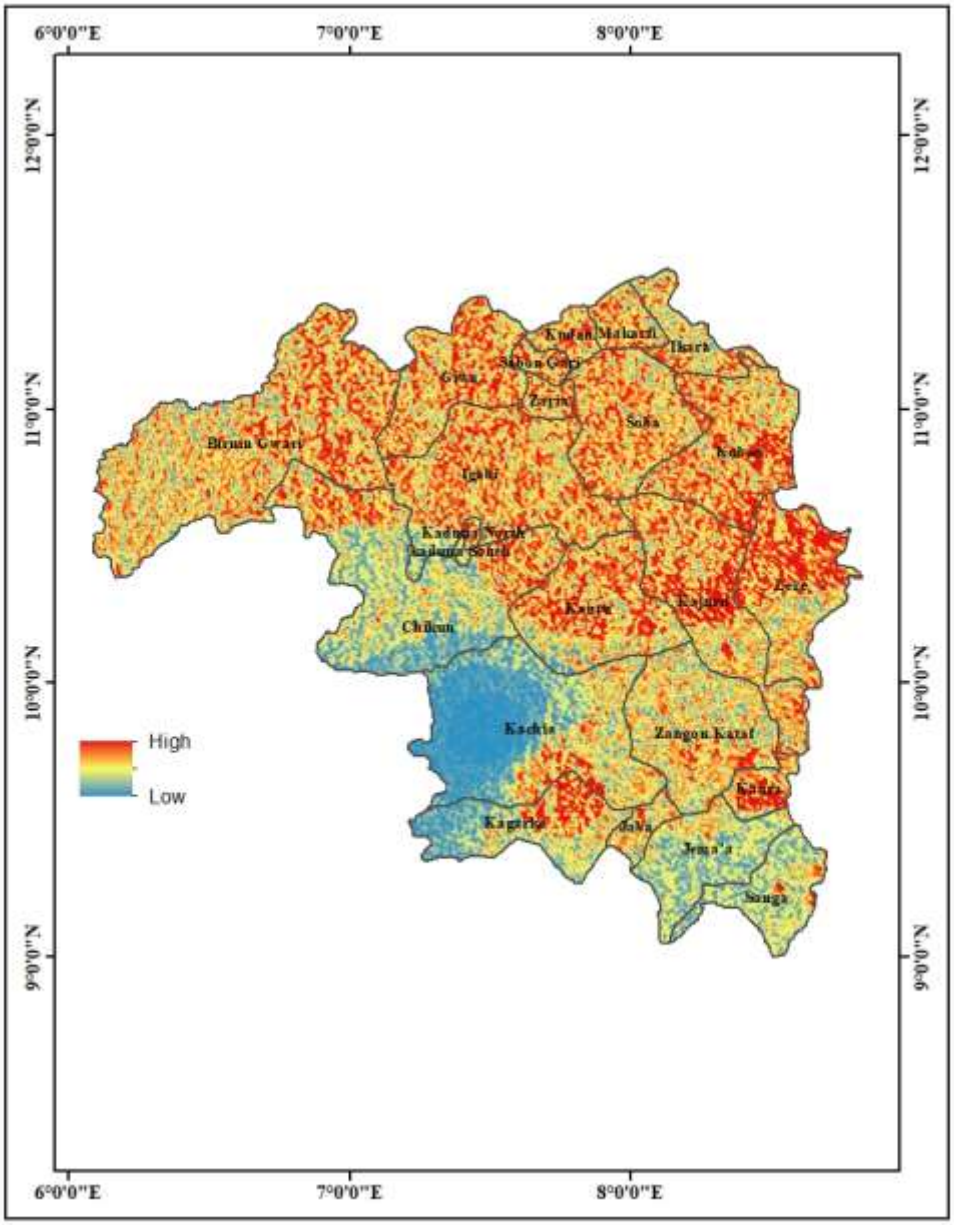

Figure 6: Solar Energy Potential Sites in Kaduna State

Analysis of Solar Energy Potential Sites in Kaduna State

Kaduna state solar energy potentials can be classified into three broad areas as indicated in figure. 3 below. These are areas with high potentials, areas with moderate potentials and areas with low potentials. From figure 3 the areas of high solar energy potentials incudes Kajuru, Lere, Kudan Zaria, Giwa, Sabon gari, Igabi, Soba, Kaduna north, Makarfi, Birnin gwari and Kaura local government areas of Kaduna state. These areas are the most suitable for harvesting solar energy in the state. The areas with moderate energy potentials are: Zangon-Kataf, Chikun, Kaduna south, Ikara, Jama'a, Sanga, Kagarko and chikun local government areas. While the

areas with low energy potentials are: Kachia, Jaba, Sanga and Jema'a Generally the results are an indication that kaduna state have good potential sites for harnessing solar energy

CONCLUSION

The study brought to light the opportunities associated with renewable energy sources; energy security, energy access, social and economic development and climate change mitigation and reduction of environmental and health impacts. The study brought to light the potentials and opportunities associated with renewable energy sources, particularly climate change mitigation and reduction of environmental and health impacts. Based on the result findings the satellite data and ground measured monthly mean daily values of global solar radiation recorded in Kaduna state showed enormous potential for harnessing solar energy which can be classified into areas of high, medium and low potentials. The maximum insolation values in Kaduna State were recorded between March and May. Therefore, the optimum times for harnessing solar energy in the area are the months of March and April. From the findings, the following recommendation were made that can help promote utilization of solar energy as alternative power sources.

Recommendations

i. Awareness Campaign. Government should carryout extensive awareness campaign on the advantages derivable from renewable technologies such as solar energy through environmental education.
ii. Promotion of Public -Private Partnership. Government should promote public-private partnership on renewable energy deployment as most efficient means of investing in renewable energy technology project
iii. Provision of Subsidize and Incentives. Government should provide subsidize on the cost of importation of renewable energy technology especially solar PV to bring down the high cost in Nigeria, and make it affordable.
iv. Creation of conducive environment. Government should create a conducive environment for Private individuals and organizations to invest in solar technologies in the country.
v. Funding. Government should provide adequate funding of solar technology researches and development initiatives in Nigeria tertiary Institutions so as to develop solar PVs with increased efficiency that will

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