MODELLING POTENTIAL SITES FOR SOLAR PV PLANTS IN NORTHWEST NIGERIA USING GEOINFORMATION TOOLS

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Overview

Availability of energy has been a herculean task for most developing countries particularly in Africa. Nigeria which prides herself as the giant of Africa has been battling for decades to provide electricity for a population which has increased to over 180 million as at 2016. Indeed the highest ever recorded quantum of power generated is put at 5320 mW indicating a worrisome average of 0.030 kW per person. It is therefore needless to emphasise that the country needs to diversify sources of energy generation for the teeming population of the country. Solar, a readily available renewable natural resource, is much available particularly within the northern fringes owing to its inherent climate dynamics involving high temperature and sunshine values compared to the southern part of the country. Since Nigeria is highly dependent on the gridded hydro-electricity and gas-fired power plants, there are no clear-cut regulatory guidelines for the coordination of nature-based energy sources. Also, the available solar energy projects are merely designed for a single-unit household utility. Most extensive measures are based on demonstrations and fragmentary demonstrations which are inadequate to resolve power supply challenges of the country. The NREL (National Renewable Energy Laboratory) of the United States has developed a series of spatially delineated and designed framework for mapping potential sites for location of of solar farms. A fundamental part of this is the use of spatial measures which are advanced by geo-information technologies. Geoinformation technologies particularly remote sensing and geographic information systems (GIS) have been found very useful for spatial decision making systems for a myriads of spatial purposes. These tools have been recognised as critical to mapping of potential cites of renewable energy sources including solar, wind and biomass. This technology is applied to the north-western axis of Nigeria in order to define local areas that are suitable for the location of solar photovoltaic plants.

This paper is sectioned in five. Section one provides the introduction. The second section presents a succinct description of the study area. Section three describes the methodology including the data, and the various modelling methods used in the study. The empirical results were discussed in section four. And, the conclusion remarks were presented in section five.

Methods

Reviewed literature has shown that series of factors are fundamental to exploit solar energy in any region. Hence, for spatial decision making multi-criteria evaluation (MCE) framework was designed and implemented for this study. The MCE framework was divided into three group of variables. First is the climate group consisting solar radiation, average temperature, sunshine and relative humidity. The second group defined as environmental consist of land elevation, slope and landuse & landcover (LULC). The final group are socioeconomic distance operators including proximity of streams, proximity to water bodies, proximity to roads and proximity to urban centres. Each of these factors with their respective variables were subjected to fuzzy analytical hierarchy process (AHP) involving each of the variables and factors to model possible areas of solar energy exploitation. With the respective hierarchy score, the MCE was effected based attachment of weight values and the suitable areas were modelled using weighted overlay analysis to generate the suitable areas for the installation of solar energy exploitation equipment. The fuzzy AHP was implemented using TerrSet raster based software while ArcGIS 10.2 standalone software was used for mapping of all the stated variable as well as MCE using the weighted overlay analysis with the modelbuilder tool.

Results

The results obtained indicated that climate with weight AHP value of 51.02% is the most important factor to be considered in the choice of location of solar PV plant in Nigeria. This is influenced mainly by solar radiation and temperature with weight values of 30.5% and 9.15% respectively. The least considered variable is land slope (environmental factor) with weight AHP value of 6.45%.

Also, the result of the study showed that 90% of the area is suitable for location of solar PV plants, 60% of which fulfilled all the specified criteria indicating first-rate location possibilities. Out of the seventeen local government areas (local councils) within the study area, six are excellently suitable for exploiting solar energy resources. Albeit,

the restricted areas including hilly, mountainous areas well as forest and game reserves constitute 1.47%, this affirms the extent of suitability of the area for the siting solar energy exploiting plants.

Conclusions

Land suitability study is important to define best location of projects of different scales and purposes. Solar energy is nature driven alternative to energy challenges being faced by most developing countries of the tropics particularly Nigeria. All considered factors and their constituent variables indicate that the north-western axis of Nigeria is suitable for the citing of solar PV plants. Local natural flow resources therefore has the potential to provide wholesome direction and environmentally friendly alternative energy substitute as a means to curtail over-dependence on hydro-power or gas fired power plants in the country. It is anticipated that government at various level will adopt this technology to resolve Nigeria's never-ending power challenges.

References

Datta, A. & Karakoti, I. 2010. Solar resource assessment using GIS & remote Sensing techniques. Paper presented at the 11th ESRI India User Conference, 20 p.

Hammer, A., Heinemann, D., Hoyer, C., Kuhlemann, R., Lorenz, E., Müller, R., Beyer, & H. G. 2003. Solar energy assessment using remote sensing technologies. Remote Sensing of Environment, 86, pp. 423–432.

Huang, Y., Chen, Z., Wu, B., Chen, L., Mao, W., Zhao, F., Wu, J., Wu, J. & Yu, B. 2015. Estimating roof solar energy potential in the downtown area using a GPU-accelerated solar radiation model and airborne LiDAR data. Remote Sens. 7, pp. 17212–17233.

Noorollahi, E., Fadai, D., Shirazi, M. A. & Ghodsipour, S. H. 2016. Land suitability analysis for solar farms exploitation using GIS and fuzzy analytic hierarchy process (FAHP)—A case study of Iran. Energies, 9, pp. 1 – 24.

Oloo, F., Olang, L., Strobl, J. 2016. Spatial modelling of solar energy potential in Kenya. International Journal of Sustainable Energy Planning and Management, 6, pp. 17–30.

Ramachandra, T. V. 2007. Solar energy potential assessment using GIS. Energy Education Science and Technology, 18(2), pp. 101–114.

Santos, T., Gomes, N., Freire, S., Brito, M. C., Santos, L., & Tenedório, J. A. 2014. Applications of solar mapping in the urban environment. Applied Geography, 51, pp. 48–57.

Taha, L. G. E. & Effat, H. A. 2015. GIS-Based estimation of potential solar energy on flat roofs in Maadi, Cairo, using true ortho world view image and digital surface model. International Journal of Advanced Remote Sensing and GIS, 4 (1), pp. 1092–1108.

Tooke, T. R. 2013. Opportunities for mapping rooftop solar energy using LiDAR: An introduction for BC local governments. Climate Action Secretariat. British Colombia, 19 p.