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Maximizing The Efficiency Of Wind And Solar-Based Power Generation By GIS And Remotely Sensed Data In Qatar

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Abstract

Qatar has a high potential to develop renewable energy generating systems spatially through solar and wind-based technologies. Although, substantial initiatives have been undertaken in Qatar to reduce the high per capita emissions of the Greenhouse Gases (GHG), solar and wind-based energy generation can also significantly contribute to the mitigation of climate change. The mean Direct Normal Irradiance (DNI) of Qatar is about 2008 kWh/m2/y, which is suitable to develop solar power systems, knowing that 1800 kWh/m2/y is enough to establish Concentrated Solar Power (CSP) plants. Although, the cost factor for developing the solar based power generation systems is about twice the gas based power generation, it generates environmental friendly energy along with keeping the limited gas resources. Moreover, being aware that 3 m/s is the critical wind speed to generate power, Qatar experiences wind speed over the critical speed in almost 80% of time that is a great potential to develop wind-based energy systems. In terms of economic feasibility, the minimum requirement of number for full load hours is 1400 while the number for Qatar is higher than the critical value. Furthermore, establishing wind power plant is cheaper than the gas-based one in off-shore locations even though the power generation is lower. This paper explains a methodology to determine the most suitable sites for developing the solar and wind-based power plants in order to maximize the efficiency of power generation using remote sensing and GIS. Analyses are carried out on two sets of spatial data derived from a recent Landsat 8 image such as land cover, urban and built-up areas, roads, water sources, and constraints, along with bands 10 and 11 (thermal bands) of same sensor for the year 2014, a DEM (Digital Elevation Model) derived from SRTM V2 (Shuttle Radar Topography Mission) to generate slope, aspect, and solar maps, and wind data obtained from Qatar meteorology department. The data are used to conduct two parallel Multi-Criteria Evaluation (MCE) techniques based on each objective of development (solar, and wind power plant development) through the following stages: (1) data preparation and standardization using categorical data rescaling, and fuzzy set membership function, (2) Logistic Regression-based analysis to determine suitability of each pixel for desired objective of development. The analysis produces two distinct suitability maps such that each one addresses suitable areas to establish solar, and wind power plants. The obtained suitability maps then are processed under a multi-objective land allocation model to allocate the areas that show the highest potential to develop both solar and wind-based power generation. Results show that the off-shore suitable sites for both objectives are mainly distributed in the north and north-west regions of Qatar.