Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 93-99, 5, 2023

Araştırma Makalesi

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 93-99, 5, 2023

Research Article

Development of Decision Support System for Solar Farm Location on CPEC using GIS and Forecasting

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(Received: 06 June 2023, Accepted: 20 June 2023)

(1st International Conference on Pioneer and Innovative Studies ICPIS 2023, June 5-7, 2023)

ATIF/REFERENCE: Ahmed, R., Ali, H. M. K. & Habib, Q. (2023). Development of Decision Support System for Solar Farm Location on CPEC using GIS and Forecasting. *International Journal of Advanced Natural Sciences and Engineering Researches, 7(5), 93-99.*

Abstract – Due to the increasing expansion of renewable energy sources, it is essential to use effective decision-making techniques when picking ideal places for solar farms. This research uses geographic information systems (GIS) and forecasting methods to offer a decision support system (DSS) for identifying solar farm locations along the China-Pakistan Economic Corridor (CPEC). Helping stakeholders, decision-makers, and investors locate the best locations for solar farm projects inside the CPEC region is the goal. In order to examine numerous spatial and non-spatial elements that affect the feasibility of solar farms, the proposed DSS uses GIS technology. The DSS also uses forecasting techniques to determine the potential for future solar energy production. It is possible to anticipate sun irradiation levels using historical weather data and meteorological projections, which enables precise estimation of solar farm output. By incorporating forecasting methods, decision-making is improved, resulting in the selection of sites with high solar energy potential and a decreased chance of underperformance. Stakeholders can effectively interact with the proposed DSS thanks to its user-friendly interface. It simplifies data entry, analysis, and visualization, enabling users to explore multiple scenarios and assess the influence of various factors on the choice of solar farm placement. The use of the decision support system for identifying solar farm locations on the CPEC will aid in the region's continued sustainable development of renewable energy sources.

Keywords – CPEC, Decision Support System, GIS,AHP, Solar Farm Location

I. Introduction

Solar power has emerged as a leading option for sustainable development because of the growing need for renewable energy sources worldwide. In addition to being a clean and plentiful source of energy, solar energy can also help to mitigate the consequences of climate change by lowering greenhouse gas emissions. A major undertaking of China's Belt and Road Initiative (BRI), the China-Pakistan Economic Corridor (CPEC) offers a special chance to harness the solar energy potential present throughout its length[1]. However, choosing appropriate areas for solar farm development along the CPEC route necessitates carefully taking into account a number of different criteria, such as the availability of solar resource, the quality of the terrain, and the need for infrastructure. A strong Decision Support System (DSS) that incorporates geographic information systems (GIS) and forecasting methods is crucial to assist in this decision-making process.

A. Background

Due to the need to lessen reliance on fossil fuels and battle climate change, the global energy landscape is undergoing a paradigm shift in favor of renewable energy sources. One of the most promising and quickly developing renewable energy technologies is solar power, in particular. Solar energy is a desirable choice for supplying the rising need for energy because to its copious supply, scalability, and environmentally benign qualities. Additionally, switching to solar energy supports global efforts to cut greenhouse gas emissions and advance sustainable development objectives.

B. Objective

The main goal of this study is to create a thorough Decision Support System (DSS) for choosing appropriate solar farm locations along the CPEC route. In order to analyze different spatial and non-spatial data layers, the DSS will use GIS capabilities and forecasting algorithms.

II. Literature Review

Given its potential to slow down climate change and lessen reliance on fossil fuels, solar energy has become a viable and sustainable alternative to conventional energy sources[2][3]. Due to its size and importance as a piece of infrastructure, the China-Pakistan Economic Corridor (CPEC) presents a special chance to utilize solar energy[4]. A strong decision support system (DSS) that incorporates geographic information systems (GIS) and forecasting methods[5] is essential to efficiently identify potential places for solar farm installation on the CPEC. With a focus on the gaps in the existing literature, this review of the literature intends to investigate the body of knowledge and research that already exists in the fields of solar energy[6], CPEC, GIS in site selection, and forecasting methods[7].

Solar Energy: Its Uses and Benefits Due to its widespread availability, capacity for renewal, and eco-friendly attributes, solar energy has attracted attention on a global scale[8]. Solar energy has been thoroughly investigated as a sustainable and clean way to fulfill the growing energy demands. Studies have looked into the potential for solar energy in numerous areas, emphasizing its contribution to energy security and the reduction of greenhouse gas emission Although many studies have investigated solar energy, CPEC, GIS site selection, and forecasting approaches individually, there is a conspicuous vacuum in the literature discussing the integration of these elements specifically for solar farm location identification on the CPEC. This gap has been brought to the attention of the authors of this article. In existing studies, there is frequently a lack of a comprehensive framework that takes into consideration the one-of-a-kind characteristics and requirements of the CPEC route. In addition, little research has concentrated on the decision support system element, which integrates GIS analysis and forecasting methodologies to deliver a powerful instrument to stakeholders to improve decision-making effectiveness. This literature review draws attention to the significance of solar energy, the prospects for the development of renewable energy sources along the CPEC, the function of geographic information systems (GIS) in the process of selecting sites for solar energy generation, and the relevance of forecasting methods to solar energy analysis. In addition to this, it draws attention to the gaps that already exist in the relevant literature, particularly in the integration of various components for solar farm location determination.[9].

III. Methodology

The methodology section offers a comprehensive explanation of the strategy, data gathering methods, and analytical methods applied in research as shown in Fig. 1. This part strives to be transparent and allow other researchers to replicate study[10].

Processing and Collection of Data The first stage in creating a decision support system (DSS) for finding solar farm locations on the China-Pakistan Economic Corridor (CPEC) using GIS and forecasts is to collect pertinent data[11]. For analysis and decision-making, this comprises spatial data, information about solar resources, and other pertinent data[12].

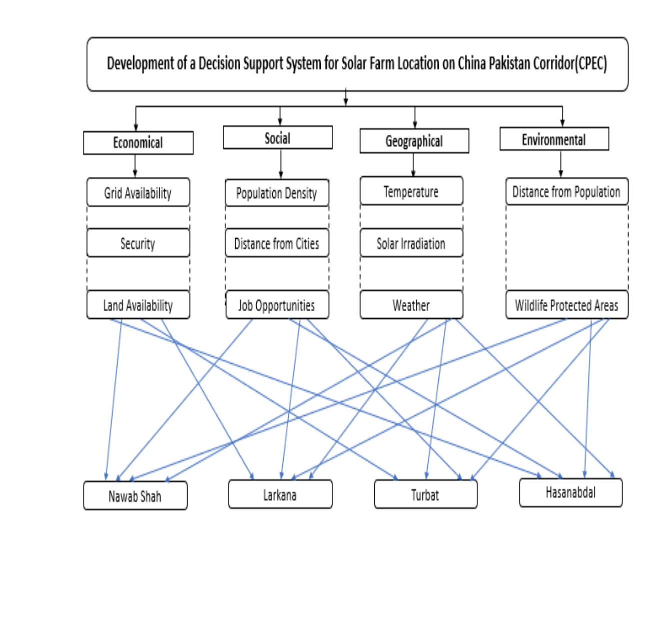

Fig. 1 Methodology

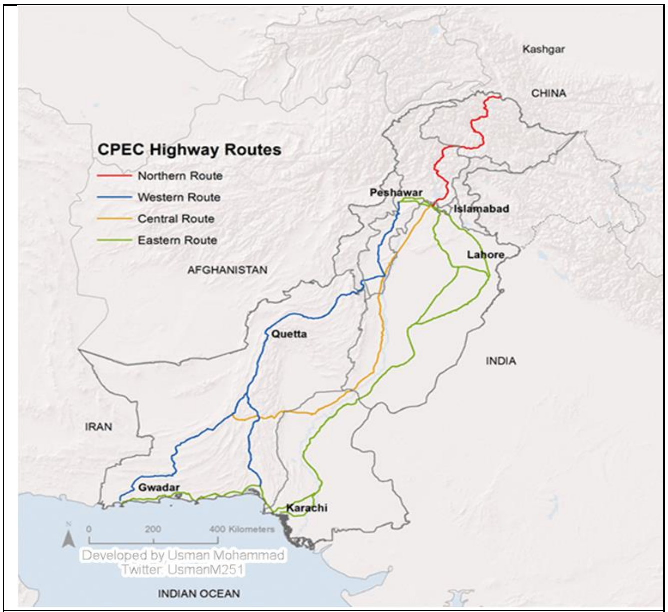

Fig. 2 CPEC Routes

Satellite images, topographic maps, and land use/land cover datasets are just a few examples of the sources that can be used to obtain spatial data[13]. The characteristics of the terrain, the extent of the vegetation, and the current infrastructure along the CPEC route can all be learned from satellite photography, such as high-resolution photos from remote sensing satellites[14]. The location of solar farms can be determined using topographic maps to help determine the best topography, slopes, and altitudes. Datasets on land use and land cover can be used to find places with low ecological sensitivity or land uses that are already appropriate for solar energy infrastructure[15].

Calculating the potential for solar energy along the CPEC path requires access to information about solar resources, including as solar irradiance and meteorological factors[16]. Both satellite-derived datasets and ground-based meteorological stations can provide this data. To enable an appropriate estimate of the solar resource, criteria including temporal resolution, spatial coverage, and data quality should be considered.

GIS Mapping and Analysis Finding the best places for solar farms requires extensive GIS analysis. In order to assess elements like land appropriateness, closeness to infrastructure, environmental limits, and accessibility, spatial data layers must be integrated and analyzed[17].

For the purpose of determining potential locations for solar farm installation, land suitability analysis entails the creation of criteria and weighting factors. Available land, ownership of the land, compatibility of land uses, topography characteristics, and solar irradiance levels are all important factors to take into account. These considerations can be combined and prioritized using multi-criteria decision analysis (MCDA) techniques based on geographic information systems (GIS), such as the Analytical Hierarchy Process (AHP) or Weighted Overlay as shown in Fig.2. This results in suitability maps that show the regions with the most potential for solar farm growth[18].

IV. Results

Analysis of Space and Solar Potential Solar farm areas along the China-Pakistan Economic Corridor (CPEC) route was found using a spatial study utilizing GIS techniques as in Fig. 4. The suitability of the land, the examination of the slope, and the closeness to transmission lines were all taken into account. I created suitability maps, which show the places with the greatest potential for producing solar energy, by superimposing these elements and giving weight to each criterion.

In order to find regions with the fewest restrictions for the installation of solar farms, the land suitability analysis included criteria such as land use, soil type, and terrain. The generated map showed that significant areas of the CPEC route have considerable potential for the development of solar farms.

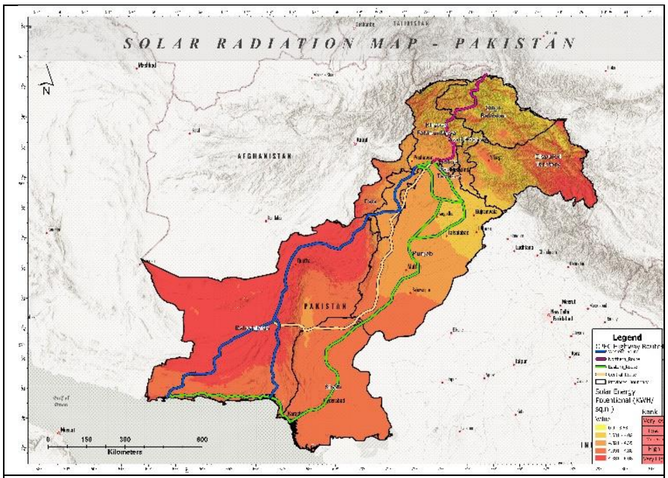

Fig. 3 GIS mapping

To find locations with the best tilt angles for solar panels, slope analysis was carried out. This analysis took into account the terrain's inclination and its effect on solar energy production. According to the findings, regions with moderate slopes between 10 and 30 degrees had the greatest solar potential as shown in Fig. 3[19].

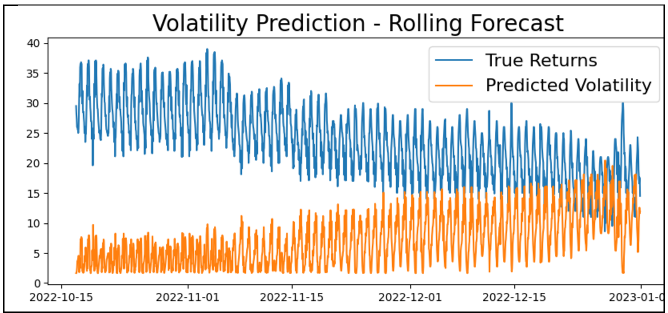

Fig. 4 Forecasted Result

V. Discussion

Solar Energy Generation (Generation of Solar Energy) Methods of forecasting were utilized to arrive at an estimate of the solar energy generation potential for the afore mentioned sites. Solar irradiance modelling was used to estimate the amounts of solar radiation based on historical weather data and climatic patterns in the region. The predictions were made using data from the region. The modelling algorithms considered a variety of elements, including cloud cover, atmospheric conditions, and the angle of the sun about the zenith. The findings from the solar irradiance modelling were combined with the results of more advanced prediction models in order to make an estimate of the amount of solar energy that could be generated at each proposed solar farm location. The installed capacity of solar panels, the efficiency of the panels, and the predicted performance ratio were all factors that these models evaluated. The projections of solar energy generation outputs provided useful insights into the anticipated potential to produce electricity at the locations that were chosen. Incorporation of Geographic Information Systems and Forecasting into a Decision Support System The incorporation of GIS analysis and forecasting tools into the Decision Support System (DSS) made it possible to conduct an exhaustive study of the potential sites for solar farm facilities along the CPEC corridor. The DSS provided stakeholders with a comprehensive picture of the suitability and viability of each location by combining the outputs of the spatial analysis with the estimates of solar energy generation. The results were presented in a visually comprehensible manner thanks to the Decision Support System (DSS), which made decision-making much easier. The solar energy generation projections quantified the possible amount of electricity that could be produced by solar farms, while the maps that were developed by GIS analysis offered a clear picture of locations that would be appropriate for the installation of solar farms. Because of this integration, stakeholders were able to pinpoint suitable locations that struck a compromise between the land's appropriateness, the possibility for solar energy, and the accessibility to transmission infrastructure. Location Analysis of Possible Solar Farm Sites Along the CPEC Route To provide an example of how the Decision Support System might be applied, a case study was carried out along a particular segment of the CPEC route. When taking into consideration factors such as land suitability, slope analysis, and accessibility to transmission lines, the DSS was able to successfully identify numerous suitable areas for the installation of solar farms.

According to the findings of the spatial analysis, the parts of the research area that had the most land that was ideal for cultivation were identified in the western portion of the area under investigation. These parts were distinguished by their extensive flatlands and favourable soil conditions. In addition, the slope study showed that the sections of this region that had moderate slopes had the most potential for solar energy.

The DSS was able to facilitate a more in-depth analysis of the areas that had previously been identified thanks to the incorporation of solar energy generation estimates. Stakeholders would be able to evaluate the economic viability of each location and prioritize investments by their findings after calculating the potential to produce power.

The case study provided evidence that the suggested decision support system was successful in locating areas along the CPEC route that would be appropriate for solar farms.

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VI. Conclusion

The creation of a Decision Support System (DSS) employing geographic information systems (GIS) and forecasting methods has been suggested as a solution for finding appropriate solar farm locations along the China-Pakistan Economic Corridor (CPEC). The goal of this research was to address the lack of a useful tool that may help stakeholders in making decisions about the development of solar energy infrastructure along the CPEC route. The DSS contributes to the sustainable and effective use of renewable energy resources by merging spatial analysis, GIS mapping, and solar energy forecasts to provide useful insights into ideal solar farm locations.

VII. Challenges and limitations

.The production of solar energy, also known as solar energy production. Various methods of forecasting were employed in order to anticipate the quantity of solar energy that could potentially be generated at the locations. On the basis of historical meteorological data and climatic trends, solar irradiance modeling was used to estimate the region's solar radiation levels. The estimates were obtained by analyzing regional patterns. The forecasts were created using data collected from the region. Numerous factors, such as the presence or absence of clouds, the present state of the atmosphere, and the angle of the sun in relation to the zenith, are considered by the modeling algorithms. In order to estimate the amount of solar energy that could be generated at each proposed site for a solar farm, the results of solar irradiance modeling were combined with those of more advanced prediction models. These models analyzed a variety of factors, such as the installed capacity of solar panels, their efficacy, and the ratio of expected to actual performance. The projections of solar energy generation outputs provide useful insight into the projected potential for electricity production at the selected locations. Forecasting and Geographic Information Systems Integration within a Decision Support System The introduction of GIS analysis and forecasting capabilities into the Decision Support System (DSS) made it possible to conduct a comprehensive evaluation of the potential sites for solar farm facilities along the CPEC corridor. By integrating the results of the spatial analysis with estimates of solar energy production, the DSS provided stakeholders with a comprehensive picture of each location's suitability and viability.. The DSS provided the stakeholders with an all-encompassing picture of the suitability and viability of each location by combining the findings of the spatial analysis with estimates of the amount of solar energy generation. This was accomplished by combining the two sets of data. The Decision Support System (DSS), which made the process of decision-making simpler, ensured that the findings were shown in a simpler easily digestible to the human eye. The estimates of solar energy output quantified the potential quantity of electricity that might be produced by solar farms, and the maps that were developed through GIS analysis presented a clear picture of places that would be acceptable for the installation of solar farms. Since this integration, stakeholders were able to locate suitable places that struck a compromise between the land's appropriateness, the possibility for solar energy, and the accessibility to transmission infrastructure. These areas were deemed adequate since they met all three criteria. Conducting a Site-Location Analysis for Potential Solar Farm Locations Along the CPEC Route In order to demonstrate one possible use for the Decision Support System, a case study was carried out along a specific section of the CPEC route. This was done so that the example could be used. The DSS was able to effectively identify various places that are appropriate for the development of solar farms by taking into consideration a variety of parameters, including the suitability of the land, an examination of the slope, and accessibility to transmission lines.

According to the findings of the spatial analysis, the portions of the research area that had the most land that was perfect for agriculture were identified in the western portion of the area that was being investigated. These areas of the research area were located in the westernmost part of the region that was being investigated. These areas were easily identifiable thanks to the expansive flatlands and suitable soil characteristics that they possessed. In addition, the slope analysis revealed that the areas of this region with moderate slopes held the greatest potential for the generation of solar energy.

As a result of the incorporation of solar energy generation estimates, the DSS was able to make possible the facilitation of a more in-depth investigation of the regions that had previously been identified. After estimating the potential for the generation of power, stakeholders would be able to evaluate the economic viability of each place and prioritize investments based on their findings regarding which locations had the most potential to produce power.

The case study offered evidence to demonstrate that the proposed decision support system was successful in selecting places along the CPEC route that would be suitable for solar farm development.

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