Blood Donation Management System for Ziyarat Al-Arabaeen:

A User-Friendly App.

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Abstract:

A user-friendly Windows application known as “the Blood Donation Management System” was created using C# and SQL Server. The goal of this application is to handle donor information and blood inventory effectively. It provides a complete solution for blood banks and donation facilities to organize their processes and guarantee a steady stream of blood donation activities that could be utilized during the Arbaeen pilgrimage. By encouraging the crowds to donate blood, so that the blood banks may have sufficient amounts of different blood types. Also, in the case of a crisis, there will be an instant transfusion of blood if needed. The application's core feature include a blood inventory management that enables the blood bank authorized personnel to keep track of the availability of various blood types, while the application gives an accurate report of the blood stock. It offers up to date data on blood types quantities and expiration dates, ensuring that the blood supply is continuously kept at the best possible state for blood storage. The donor data management makes it possible to capture and maintain crucial donor information, including age, the time since the previous donation or surgery and donor’s contact information in case of lack of certain blood type, the donors may be contacted to donate one more time. This information are essential for preserving a large pool of candidate donors and guaranteeing a secure process of blood transfusions. Also the application contains user authentication to assure secure management of donors private information and preventing blood supplies from being drawn to black market. Information concerning donors and blood inventories are kept private and accurate due to the access control mechanism. On the home interface, the application facilitate navigation through the application’s modules using dashboard display.

Keywords: Blood donation, Management system, User-friendly App., Blood bank, Donor data, Donor engagement, Blood transfusion, Zeyart AL-Arbaeen.

1. Introduction

Healthcare facilities must manage blood donations and inventories in order to maintain a steady supply of blood for transfusions. It is essential to provide strong solutions that streamline the donor data management process and guarantee efficient inventory control given the improvements in technology and the rising demand for effective blood bank systems. By utilizing Visual Studio C# and SQL Server to develop and construct a blood donor data management system with group-based donation tracking and inventory control, this project seeks to overcome these difficulties [1].

Blood banks are essential to the healthcare system because they make it easier to collect, test, store, and distribute blood and its constituent parts. To guarantee the availability of suitable blood units when required, precise and effective monitoring of donor data and blood inventory is essential [2]. Additionally, it's crucial to have a proper donation interval for the blood donors' health and wellbeing. Therefore, it is essential to create a complete system that integrates inventory control, group-based monitoring, and donor information management [3].

Because of its flexibility and considerable efficiency, Visual Studio C# was preferred as the programming language to create interfaces for the application. The IDE provides a varied range of tools and frameworks that make it feasible to implement to build user-friendly interfaces for the application [4]. Also choosing SQL server as database management system based on its reliability of managing large-scale

databases and provide up to date centralized support for the blood and donor's data [5].

Creating this application to achieve an effective inventory control system based on blood types, inflict a minimum donation interval of six months, and construct a blood donor management system that allows for managing the donor's information. In the blood stock identifying the blood type will give precise report of the amounts of each blood type in the inventory[6].

The paper will provide a system architecture that trial the difficulties facing blood donation process, the rules, and the present blood bank systems. Utilizing well managed and good database management system for effective data storage and retrieval [7].

The application's ability to reliably store and retrieve donor data, enforce the donation interval limit, and maintain accurate inventory levels will all be tested using a variety of use cases. The system's performance will be assessed based on its capacity to manage multiple requests at once, maintain ideal response times, and guarantee data integrity [8].

By offering a complete blood donor data management solution, the study's results are anticipated to help blood banks enhance their systems [9]. Inventory control, group-based donation tracking, and efficient and dependable donor data storage will all be made possible by the combination of Visual Studio C# and SQL Server. The system that has been created will ultimately improve the effectiveness of blood donation procedures, streamline the administration of blood

inventories, and facilitate the prompt availability of suitable blood units for transfusion purposes [10].

2-Benefits of this study

For healthcare organizations as well as those engaged in the blood donation processes, the creation, and deployment of the blood donor data management system, combining group-based donation monitoring and inventory control, would result in considerable benefits. The initiative aims to overcome current blood bank system difficulties and provides the following advantages [11]:

1-Enhanced Efficiency in Donor Data Management:

The system's user-friendly interface will ease procedures like registration, appointment scheduling, and monitoring contribution history while streamlining the maintenance of donor information. Healthcare workers will have more time to concentrate on offering high-quality treatment and services by minimizing manual paperwork and administrative responsibilities.

2-Improved Donor Engagement and Participation:

Active donor involvement and participation in blood donation activities will be encouraged by the user-friendly system interface. Donors will have access to a practical platform where they can update their contact information, make appointments, and get alerts about new contribution possibilities. A greater sense of engagement and commitment will be fostered by improved communication between blood banks and donors.

3-Accurate Tracking of Group-Based Blood Donations:

The system will accurately record blood donations depending on the blood group of the donor by including group-based donation tracking. Having a minimum 6-month gap between donations can benefit donors' health and wellbeing and limit excessive blood loss. This function will help to keep a steady and dependable supply of blood units for transfusion needs.

4-Efficient Inventory Control and Blood Stock Management:

The inventory control module will make it possible to handle blood supply effectively. Real-time updates and precise inventory levels will be provided via automated deductions from the stock depending on the blood type indicated before each donation. The danger of shortages or wastage will be reduced thanks to this optimization, which will also promote the prompt availability of appropriate blood units for transfusion needs.

5-Enhanced Data Integrity and Security:

In order to guarantee the quality and consistency of donor information and inventory records, the project will put in place strong data integrity procedures. The system will safeguard confidential donor information by using cutting-edge security techniques including access limits and encryption. Data backups and recovery tools will also provide protection against data loss or corruption.

6-Contribution to Healthcare Services and Patient Care:

The newly created system for managing blood donor data will make a big difference in how well healthcare services are provided. It will help medical practitioners make wise judgments about managing blood inventory by giving blood banks an effective and dependable tool for operations. This will guarantee that adequate blood units are available for transfusion when necessary, improving patient care outcomes and helping to save lives.

Overall, this study results will be highly advantageous to hospitals, blood banks, donors, and patients. The project will encourage an atmosphere of enhanced healthcare service delivery and better patient care by streamlining donor data administration, assuring accurate monitoring of blood donations, improving inventory control, strengthening data security, and encouraging efficient blood bank operations.

3-Study Objectives and Problem Statement

Here, we discuss the study's goals and the issues with the current blood bank systems that were found. The following goals are the focus of the study:

1-Develop a User-Friendly Blood Donor Data Management System:

The main goal is to provide an intuitive and user-friendly interface that makes it simple for donors to sign up, change their contact information, schedule donations, and view their gift history. The method aims to promote engaged, active donor participation.

2-Implement Group-Based Donation Tracking:

The project will include tools for tracking blood donations depending on the blood type of the donor. In order to protect the health and wellbeing of donors, it will impose a minimum 6-month gap between donations. To prevent donations before the required amount of time has passed, exact records of donation dates and amounts will be kept.

3-Ensure Efficient Inventory Control:

for efficient management of blood supply it is crucial to create inventory control. Based on the blood type of each donation, the system will immediately update the inventory, providing precise and real-time tracking of the blood supply.

4-Ensure Data Integrity and Security:

To guarantee the constancy and accuracy of donor information and inventory data, it is important to utilize used authentication. The application will provide data integration, backup and recovery procedures to prevent data loss or corruption.

5-Conduct Comprehensive Testing and Performance Evaluation:

The application's functionality, reliability, and practicality must tested regressly. By testing a number of use cases, including donor registration, inventory control, and data retrieval. The application's ability to manage many requests simultaneously, retain ideal response times, and assure data integrity under many load levels will be evaluated in terms of performance.

6-Contribute to the Improvement of Blood Bank Systems:

The goal of the application is to improve blood bank operations by offering a comprehensive solution for donor data management and inventory control. The pplication aims to increase efficacy, simplify procedures, and assure the rapid availability of suitable blood units for transfusion needs.

The existing applications handling blood donation process have several malfunctions that our application is trying to resolve:

1-Inefficient Donor Data Management: Traditional paper-based and manual donor data management procedures take a lot of time, are prone to mistakes, and are inefficient, which makes it difficult to

keep a donor database that is both structured and current.

2-Lack of Group-Based Donation Tracking: It is challenging to manage blood inventory among several blood groups since many existing systems lack group-based donor monitoring, which can cause imbalances and possible shortages.

3-Inaccurate Monitoring of Donation Intervals: The quality of given blood units is compromised by the current systems' frequent inaccuracies in monitoring and enforcing minimum donation intervals, endangering the health of donors.

4-Inefficient Inventory Control: Blood shortages or surplus inventory can be caused by manual blood unit and stock level tracking, which raises expenses and compromises patient care.

A comprehensive blood donor data management system that incorporates group-based donation monitoring and effective inventory control is needed to address these issues. The project intends to increase the overall efficiency and effectiveness of blood bank operations by achieving these research objectives.

4. Methodology:

4.1. System Design: Overview and Database Structure

In order to effectively store and manage the data, a thorough database design is created during the system design phase [12]. The data model, which functions as a database design diagram and documents and illustrates the fundamental structure of the database, is a crucial part of this design. The Figure (1) gives a general overview of the system, including its architecture and user interfaces.

The system architecture is created to guarantee the seamless integration of diverse components, facilitating efficient processing and smooth data flow.

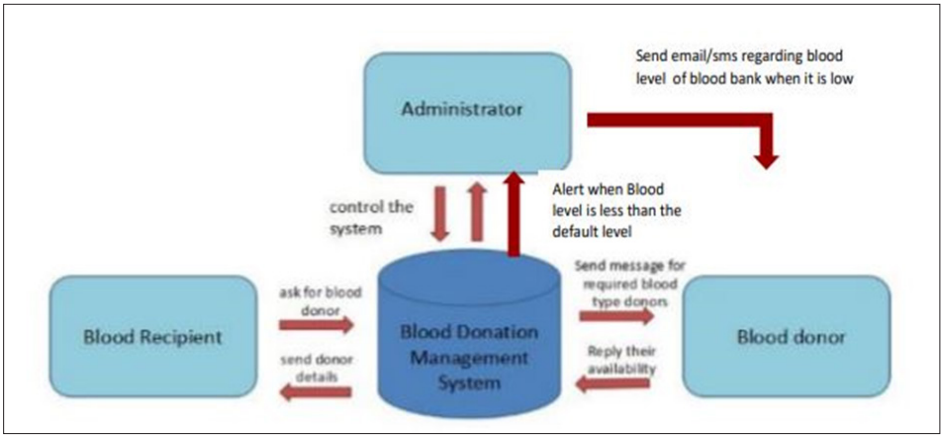

Figure (1) Overall System Architecture

4.2. Design and Implementation: User Interfaces

The user interfaces of the program are created to offer a fluid user experience and effective communication with the system. Below is a list of the key user interface modules:

1-Entry Interface:

Users are shown the entrance interface when the application is launched. Users are prompted to enter their login and password on this screen to authenticate. When the submitted credentials are successfully verified, the system allows access to the main program interface as shown in Figure (2)

Figure (2) Login Interface

2. Main Interface: Navigation and Functionality

All other interfaces in the program may be navigated through the main interface, which acts as the application's core hub. It offers users a tailored experience by displaying their authority, name, and

profile image. The main interface has seven buttons, each of which represents a different function, plus an exit button to end the program:

1. New Donor: registration process of new donors is achieved with this interface, giving essential information for the blood donation.
2. Old Donor: revealing the former donation history by the donor id and the possibility of new donation process, which is labeled "Old Donor."
3. Update Donor: any modification on donor data such as contact information and medical history.
4. Blood Stock: provide precise statics of the amount of each blood type in the inventory while withdrawal or donate.
5. Blood Product: details about various blood types and their expiry date that must be predetermined at the donation date.
6. Users: the users with permissions may access and manage user accounts.
7. Exit: this interface will terminate the application that may easily close it by pressing the exit button.

The main interface's simple design makes it easy to navigate and provides quick access to all features. The interface try for to increase user engagement and efficiency while engaging with the application.

Figure (3) Home Interface

3. New Donor Interface: Adding and Managing Donor Data

A simple platform for registering comprehensive information of a new donor. Users can enter the donor's ID, name, age, blood type, donation date, medical background, number of donations, and contribution amount. The donor record in the database is securely populated with donor's information, by clicking the save button, assuring thorough and well-organized record keeping.

The interface also features a handy delete option that may be used to get rid of a donor's data if necessary .With the aid of this capability, users may effectively manage the donor database and handle any necessary adjustments or changes.

The New Donor interface makes sure that the process of gathering and maintaining donor data is smooth and organized ,which improves the system's overall efficacy and structure.

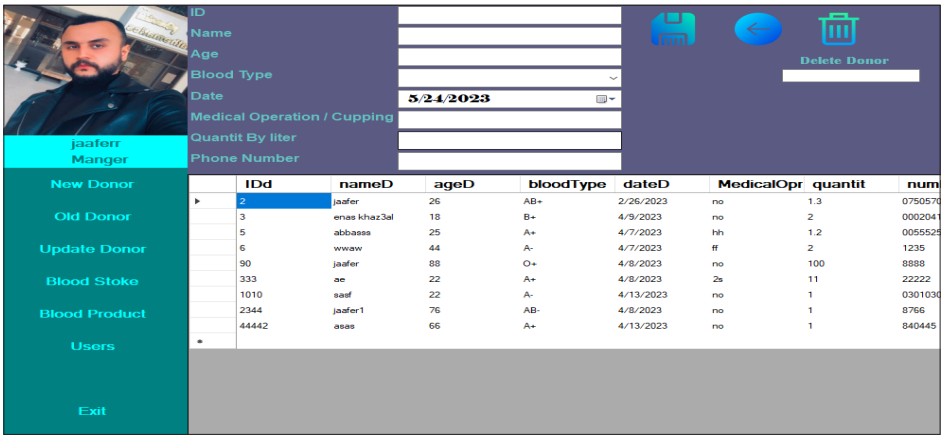

Figure (4) Home Interface

4. Old Donation Interface-6 :Month Donation Interval

Donors can make repeated donations through the gift interface as long as it has been longer than six months since their last gift .To maintain ethical and secure blood donation procedures ,the system strictly enforces this requirement.

Figure (5) Old Donor Interface

1-Donor Data Modification Interface: Users can alter donor data using this interface in the event of mistakes or adjustments to certain criteria. Information about donors may be updated and edited by users with ease to maintain correctness and completeness, as shown in Figure (6).

Figure (6) Update Donor Interface

2-Blood Stock Interface: The Blood Stock interface shows the quantities that are currently available for each blood type. It provides real-time data regarding blood stock levels by retrieving this information from the database's "BloodStorage" table, as shown in Figure (7).

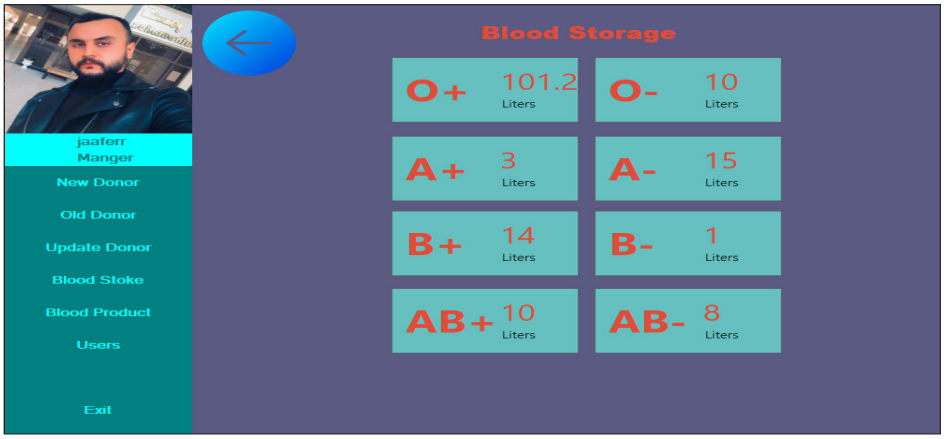

Figure (7) Blood Stoke Interface

3-Blood Withdrawal Interface: Users can extract blood from the storage using this interface. The technology automatically lowers the stock for that blood group in the storage when a set amount is taken out of a certain blood group, as shown in Figure (8).

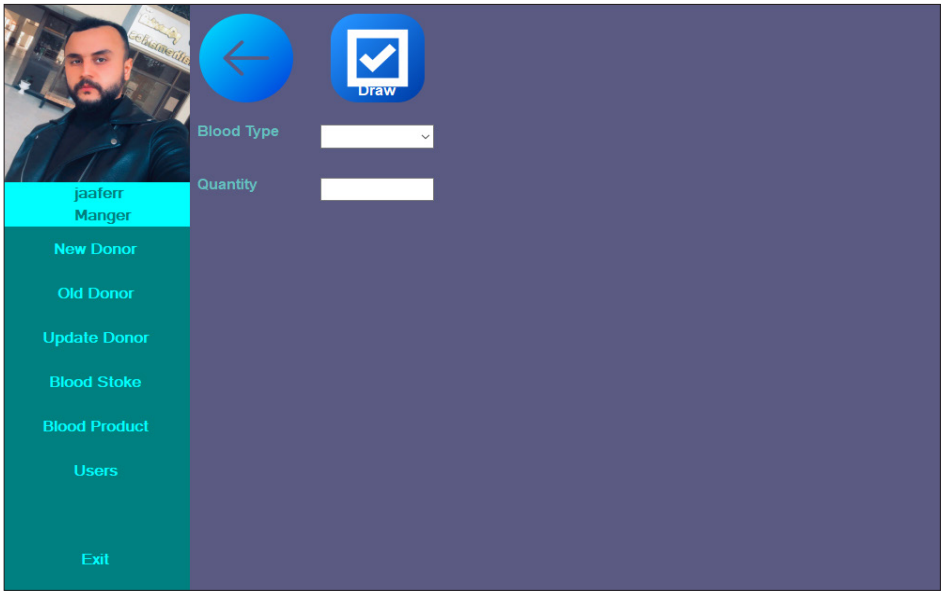

Figure (8) Blood Product Interface

4-User Management Interface: Users can add new users to the program using this interface so they can utilize the application. Users with the necessary authority can effectively manage user accounts, as shown in Figure (9).

Figure (9) Users Interface

5-User Data Update Sub-Window: Users can edit a user's data by clicking the update button in the user interface, which causes a pop-up sub-window to appear. The "users" table in the database is queried for user data using the distinct ID number, making user data maintenance simple, as shown in Figure (10).

Figure (10) Update Users Interface

5-Conclusion and Future Work

The problems with the current blood bank systems were effectively resolved by the blood donor data management system. Donors may quickly register, change their information, and check their gift history with a user-friendly interface. The system imposed a minimum donation interval of 6 months for donor safety and used group-based donation tracking to assure precise blood supply levels. The inventory control module improved the management of the blood supply, increasing the effectiveness of blood bank operations. In future work the blood donor data management system has chances to be expanded and improved in a number of areas going future, including the advanced data analytics and machine learning approaches may be used to improve blood supply chain management by providing useful insights into donor behavior, blood consumption trends, and inventory predictions .Mobile application by creating a mobile application ,donors will be able to easily access the system ,get alerts ,and remain involved in the blood donation procedure .Integration with health systems connecting the system to electronic health records and hospital information systems can give users a complete picture of patient data and transfusion requirements .Security enhancements continuously improving security measures ,such as encryption and multi-factor authentication, will safeguard donor data and protect against unauthorized access. Collaboration and data sharing establishing collaborations with other blood banks and healthcare institutions for data sharing can improve blood supply availability and overall system efficiency .The blood donor data management system may continue to develop by taking these factors into account in further work ,giving blood banks and healthcare facilities even more effective and dependable support.

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Equip Ziyarte Al-Arba'een service points with clean energy through solar radiation Using remote sensing techniques: a case study along the path from northern Baghdad to the holy Karbala

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Abstract

Millions head on foot every Hijri year in the month of Safar from various provinces of Iraq, as well as pilgrims from different countries of the world to commemorate the day of Zeyart AL-Arbaeen of Imam Hussein, as millions head towards the Holy Karbala. During the course of the visit, a large number of organizations or stations (processions) are erected on both sides of the visitors' path to provide service to pilgrims. In this study, we will highlight the possibility of providing electric energy using renewable energy to these bodies on the side of the Baghdad-Karbala road. Photovoltaic cells are one of the most important and most common renewable energy sources, especially in sites with high solar radiation such as Iraq. To determine the best sites location for the installation of solar cell stations using sensing applications and geographic information systems through the analysis of satellite images (Sentinel 2 and ALOS PALSAR) to calculate a set of necessary criteria to determine the best location as well as using the hierarchical analysis process to determine the best location for the installation of photovoltaic cells in addition to estimate the rate of energy produced by photovoltaic cells using simulation in MATLAB

The results of this research provide valuable insights into the possibility of providing Husseini Camps (processions) with clean energy along the Baghdad - Karbala road by taking advantage of solar radiation. This study provides a comprehensive and effective approach to ensure sustainable energy supply for the processions and the results can guide decision-making and development of energy infrastructure in the future and work on similar initiatives in other regions

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Keywords: Zeyart AL-Arbaeen; Remote Sensing; Multi Criteria Decision Making; GIS; AHP; Pv Array; Simulink

1. Introduction

Zeyart AL-Arbaeen represents the largest religious gathering in the world, according to the World Health Organization, and the public health of mass gatherings, which marks the 40th day after the martyrdom of Imam Hussein (peace be upon him), the third Imam of the Shia [1]. Imam Hussein, the son of Imam Ali, the grandson of the Prophet Muhammad, who is the third Imam of the twelve Shia imams, Imam Hussein was martyred in a battle that took place in the Karbala region of Iraq, which was called (the Battle of Karbala), which took place between Imam Hussein and 72 of his companions with the Umayyad State on the 10th of Muharram (the first month of the Hijri year) in the year 61 Ah (68 AD) [2]. About 20 million pilgrims are heading to Holy Karbala from various Islamic countries to commemorate the Zeyart AL-Arbaeen anniversary two weeks before the Arbaeen, millions of pilgrims begin their journey on foot from various regions of Iraq (mostly from Central and southern Iraq) to the city of Karbala, where the Holy Shrines are located [3]. The camps (processions) are set up on the pilgrims ' road towards Holy Karbala by donors from various religious communities to provide services to pilgrims, including free food and drink, as well as a place for pilgrims to sleep and rest, and to provide them with the necessary health supplies and aid. These camps need electric power sources to continue providing comfortable services for pilgrims[4]

Electricity can be provided using renewable energy, especially that fossil fuels face a problem of depletion of their resources, in addition to the climatic effects that accompany the use of fossil fuels, so renewable energy is the best alternative because sources are flowing, renewable and not stored. Solar energy is one of the best renewable energy sources, especially in Iraq due to the intensity of solar radiation[5], Photovoltaic stations convert solar energy into electrical energy, which is characterized by being less expensive and does not affect the environment, as well as these stations can be developed and increase energy production by adding photovoltaic panels and also characterized by easy connection with the energy transmission network and easy maintenance [6]. The most suitable sites for the installation of photovoltaic plants are determined based on a set of criteria such as solar radiation, slope, type of ground cover and others, to decide the best location the analytical hierarchy process (AHP) was used depending on the criteria [7].

Remote sensing techniques and geographic information systems (GIS) were used to calculate the parameters through satellite images (Sentinel 2 and ALOS PALSAR) and analyze them using the ArcGIS software. For optimum site selection studies, a combination of GIS and AHP used[8].

To calculate the amount of energy produced by photovoltaic plants based on the amount of solar radiation, a simulation model of a photovoltaic plant system was designed using MATLAB software

The study in this research focuses on the provision of electrical

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energy using renewable energy, determining the appropriate locations for the installation of photovoltaic stations and calculating the amount of energy produced, which feeds the camps (processions) installed on the road north of Baghdad-Karbala

2. Literature review

The most suitable sites for the installation of solar photovoltaic power plants in Azerbaijan have been identified through a comprehensive assessment of the meteorological and environmental parameters of the potential areas Using an analytical hierarchical process method based on a multi-criteria decision-making technique for large-scale solar energy projects In this study (N. S. Imamverdiyev 2021), By converting the digital elevation model's data using the geographic information system's "Area solar radiation" tool, the solar radiation values for study area were calculated. The site suitability index was calculated using the ArcGIS weighted overlay tool, and it was found that 1.17% (1016.8 km2) of the country had the best locations for solar PV system installation[9].

B. Halder In 2022, Remote sensing and Geographic information system Technologies were used in this study to determine the possible location selection of solar power plants in Kolkata, India, as well as the sequencing and multi-criteria decision-making process was used to calculate the weights. A total of 1438.15 km2 (32.43%) of the total area was calculated as highly suitable for solar power plants[10].

In2021The main goal of this article is to identify and evaluate the

best locations around Tunisia for constructing massive solar PV power facilities. For this reason, we use geographic information systems (GIS) and multi-criteria decision-making analysis (MCDM) to analyze the land suitability of the research area. The results showed that the most practical places covered 1571 km2 and accounted for 1.11% of the total surface area. Additionally, it was noted that the administrative regions of Tataouine, Gabès, Gafsa, and Kassérine have demonstrated the greatest potential for solar PV system construction-friendly sites. Additionally, it was calculated that the annual solar energy yield would be close to 328 TWh. Consequently, it was determined that the accepted model was a highly helpful [11].

The suitability of Moroccan land for hosting solar power plants was studied using the combination of the Geographic Information System (GIS) and the Analytical Hierarchy Process (AHP) by (Meryem Taoufik in 2021), the results presented that 53.88% of the occupation area have high suitability land for solar plant[12].

In 2021, a study to select the optimum site for solar energy farms in Iraq, In order to determine if land is suitable for the construction of solar farms, this study combines the Geographic Information System (GIS) with Analytic Hierarchy Process, one of the multi-criteria decision-making methodologies. The findings indicated that 19% of the research area would make excellent locations for solar farms. The majority of the eligible areas were acquired by the southern, southeastern, and a few western regions. Additionally, this method is easily adaptable to include various criteria and weights to help planners choose the best

places for solar farms[13].

Experimental measurements were made to study the characteristics of voltages-current and power-and current for two types of photovoltaic cell model. Using MATLAB, a solar cell simulation model was created with variable solar radiation values and values for Energy, current and voltage were obtained for each of the solar radiation values[14].

3. Study area

The Baghdad-Babylon-Karbala Road is a major route that links Baghdad to the central and southern governorates. It is also significant for religious tourism to Karbala and Najaf, for its commercial significance in that owners of heavy and medium load vehicles frequently use it to transport goods between the governorates, and for the industrial businesses that are located next to the road, such as the Alexandrian automobile industry and the mechanical company[15]. The length of the road (139.683 Km), which starts from the north of Baghdad (from a city called Rashidieh) and passes through the province of Babylon, to reaches the Holy Shrines in Karbala. The route of the road for pilgrims was selected by the Iraqi security forces for the purpose of providing protection and securing the way for pilgrims towards Karbala. Camps (processions) are erected on the side of the specified road for the purpose of providing free services to pilgrims[16].

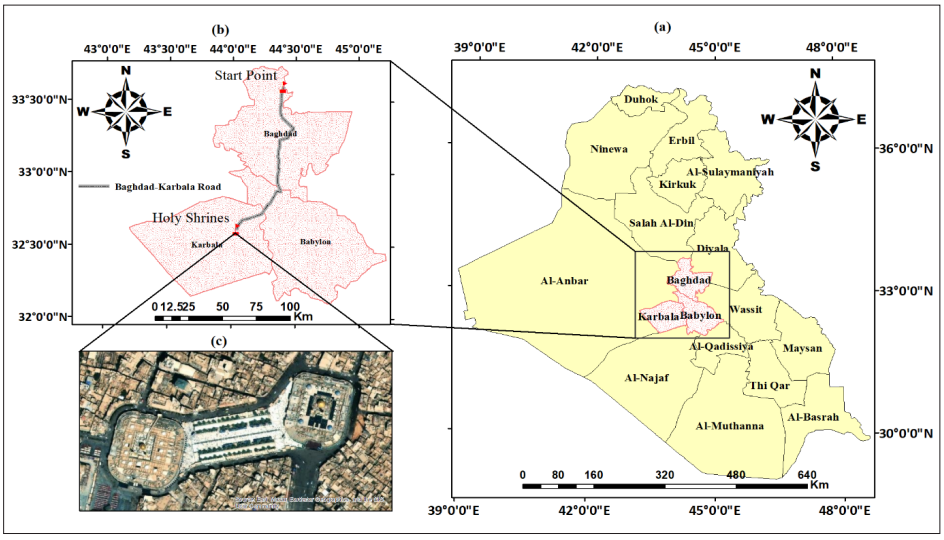

Figure 1. (a) Study area location, (b) Baghdad-Karbala Road, (c) Holy Shrines

4.Methodology

4.1. Criteria selection

The selection of criteria is the most important step in the process of assessing the suitability of the site for the installation of photovoltaic solar cells, the table (1) shows the criteria that were used in previous studies that analyzed the suitability of the site for the installation of photovoltaic solar cells[17]. In this research, seven criteria were selected to analyze the suitability of the study area (Solar radiation, Slope, Aspects, Elevation, Land cover, Proximate from highway and proximate from Power transmission lines).

Table 1.The criteria adopted in previous studies to analyze the site suitability of photovoltaic system [17].

References	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Uyan			✓			✓	✓	✓	✓	
Watson and Hudson			✓	✓		✓			✓	
Aly et al.	✓					✓	✓	✓		✓
Al Garni and Awasthi	✓	✓	✓	✓		✓		✓		
Yushchenko et al.	✓					✓	✓	✓		
Tahri et al.	✓	✓	✓			✓	✓		✓	
Merrouni et al.	✓		✓			✓	✓	✓		✓
Asakereh et al.			✓	✓	✓		✓	✓	✓	
Noorollahi et al.	✓	✓	✓		✓	✓	✓	✓	✓	
Suh and Brownson	✓	✓	✓				✓	✓	✓	
Sánchez-Lozano et al.	✓	✓	✓			✓	✓	✓		

C1: Solar radiation, C2: temperature, C3: Slope, C4: Aspect, C5: Elevation, C6: distance from a residential area, C7: distance from a road, C8: distance from a power line, C9: land use, C10: waterbody.

4.2. Data acquisition and Software

Two types of data were used in this research: (raster data and vector data). The raster data represents multispectral images taken from the Sentinel 2 satellite with a resolution of 20m in (2022-8-21) from (https://scihub.copernicus.eu), 5 scenes were used to cover the study area, in addition to the digital elevation models (DEM) provided by the ALOS PALSAR satellite, which represent the elevation of the area with an accuracy of 12.5 m in (2007-6-21) from (https://asf.alaska.edu), 6 scenes obtained to represent the study area. Vector data is represented by the data of the road network and the power transmission network as shapefile. Table2 show the data reference and properties.

Table: 2.Data references and properties

Reference	Data type	Band	Sensing time	Resolution (m)
Sentinel-2 Instrument: MSI	Raster	8.3.2	2022-8-21	20
ALOS PALSAR	Raster	L-band	2007-6-21	12.5
Open street map	Shapefile		Up-to-date	
World Bank Data Catalog	Shapefile	×	Up-to-date	×

These data were processed using the program ArcGIS from ESRI, which contains many tools suitable for analyzing the criteria to determine the land suitability. A set of processors is performed on raster data, the geometric correction of the satellite images was performed using GIS 10.5 to convert them to geospatial coordinates of UTM, also o get rid of No Data value and extract the study area from the overall scenes

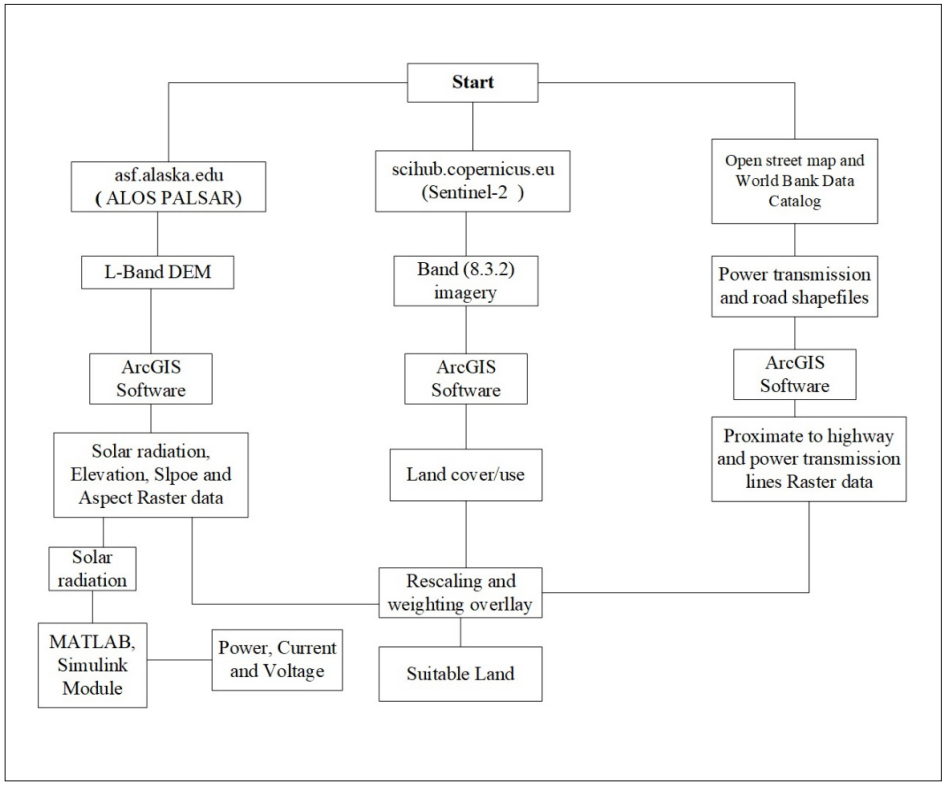

Figure 2.Methodology flowchart for Land suitability of solar cell site selection

4.3. Criteria calculation

- **Solar radiation:** The incoming solar radiation at the surface in the 0.2–4.0 m wavelength range on a specific surface area is referred to as the solar irradiance, which is typically stated in W/m2 (Watts per square meter). There are two types of solar radiation: diffuse (diffuse irradiance) and direct (direct irradiance), both of which are received from the direction of the sun. Since the atmosphere scatters it, diffuse radiation is emitted in all directions. [18] , by using (Area solar radiation) in ArcGIS which using the Digital Elevation Model (DEM) as input data, set the (Area solar radiation) tool at specific day (2022-8-21)

- **Elevation, Slope and Aspect:** The DEM represent the altitude of the area, the value Z in DEM represent the Elevation value from the sea in meter. Where the highlands received solar radiation greater than lowlands. The slope, which is measured in degrees and ranges from zero (flat) to 90 (vertical), represents the elevation change associated with a change in horizontal position, its indicate the steepness of the landscape. Aspect is yet another important terrain feature that is commonly retrieved from digital elevation data. The aspect indicates a downward slope. The direction is frequently expressed using an azimuth angle[19]. The surface analysis tools used DEM raster data to calculate Slope and Aspect[20].

- **Proximate to highway and power transmission lines:** Because of the enhanced distribution efficiency across the study region due to distance from highway, the potential locations for solar power plants were most affected by the distance from highway criterion. Roads were frequently utilized by researchers to define the solar power plant area, also, proximate to power transmission lines is an important criterion for facilitating the transfer of energy produced by solar cells and connecting it with the distribution network, Five buffer zones were created for roads and power lines zones based on the actual circumstances and the literature assessment [21]. The multi-buffer tool in ArcGIS enables us to draw a set of areas with certain areas surrounding the lines, in this study, Baghdad-Babylon-Karbala Road represent the main highway.

- **Land cover/use:** One of the most common uses of remote sensing is the classification of land cover and use. Different methods are used to extract data about the various categories of Land Cover from optical imagery (Sentinel-2) using the pixel values, the process of classifying pixels under user supervision is referred to as supervised classification. The user defines the numerous spectral signatures or pixel values that may be connected to the particular class[22].

Depending Criteria raster data values rating into five categories (value 1 mean unsuitable categories and 5 mean most suitable categories), because of the land suitability was analyzed by comparison. The table (2) show the criteria rating depending of previous studies [23-26].

Table:3.Criteria values Rating

C1	C2	C3	C4	C5	C6	C7	Value Rate
5150-5340	3<	S	Barren land	0.5	0-5	97.9-156	5
5110-5140	3-5	SE, SW	Rangeland	1.0	5-8	70.6-97.8	4
5050-5100	5-7	E, W	Crops	1.5	8-10	44.6-70.5	3
4940-5040	7-9	N, NE,NW	Deciduous forest	2	10-12	27.8-44.5	2
2530-4930	9>	Flat	Water/ Build area / Evergreen forest	2>	12>	-2-27.2	1

C1: Solar radiation, C2: Slope, C3: Aspect, C4: land use, C5: Proximate to highway, C6: Proximate to power transmission lines, C7: Elevation

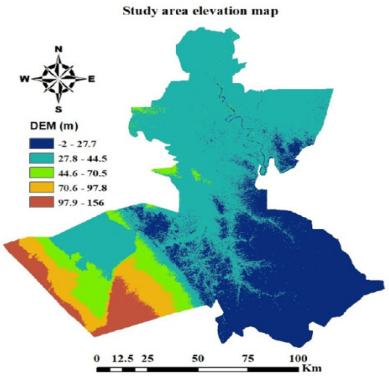

Figure 4. Elevation map

4.3.

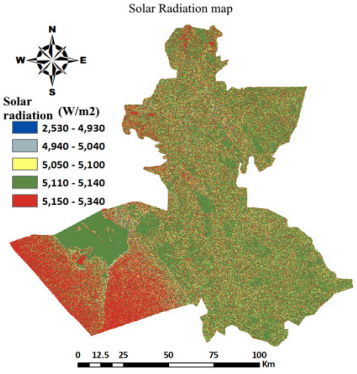

Figure 3. Solar radiation map

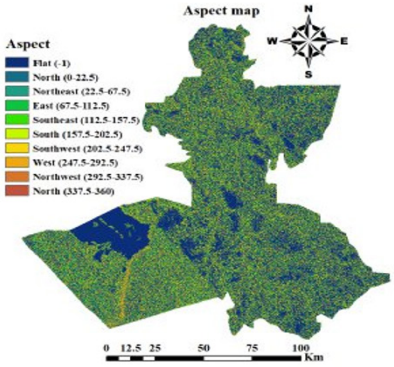

Figure 5. Aspect map

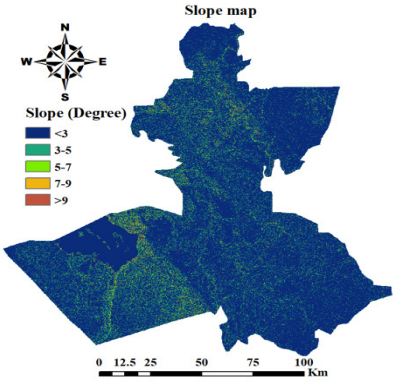

Figure 6. Slope map

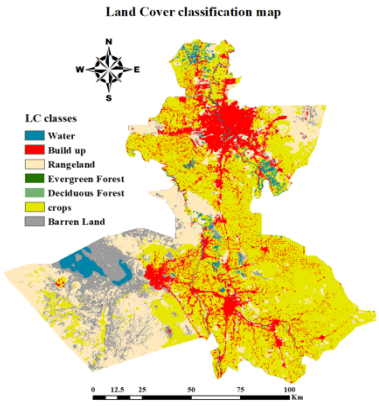

Figure 7. Land Cover/ Use map

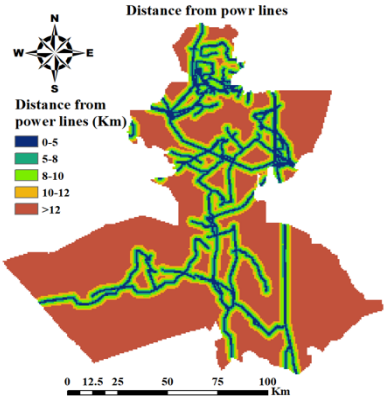

Figure 8. Proximate to Power transmission lines

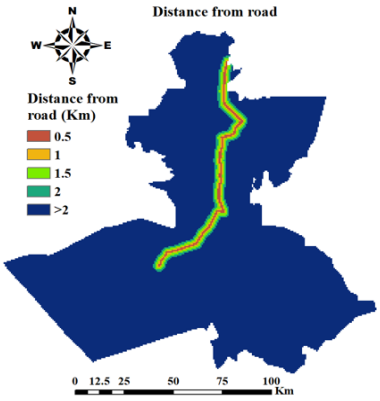

Figure 9. Proximate to Baghdad-Babylon-Karbala road

4.4. Weighting Criteria

Saaty created the AHP approach, which has been applied to decision-making, particularly when weighting numerous variables. It offers the benefit of reducing pairwise comparisons of difficult judgments. This approach is also a crucial tool for ensuring choice consistency and minimizing decision analysis bias [27]. The creation of a pairwise comparison matrix (A), if the number of criteria is n, then the A=n×n, as shown in equation (1)

$$A = \begin{bmatrix} 1 & p & q \\ 1/p & 1 & r \\ 1/q & 1/r & 1 \end{bmatrix} \quad (1)$$

Using a numerical scale from 1 to 9, each component of M shows the relative weight of the two criteria as determined by experts [28]. As shown in table 4.

Table:4. Pairwise Comparison scale[28, 29]

Importance Degree	Definition	Description
1	Equally preferred	Both the activities have equal contributions towards achieving the objective
3	Moderately preferred	One of the activities is slightly favored over the other.
5	Strongly preferred	One of the activities is strongly favored over the other.
7	Very strongly preferred	One of the activities is very strongly favored over the other
9	Extremely preferred	One of the activities is favored over the other of the highest possible degree
2,4,6,8	Intermediate values	Between the degrees of importance

The elements of the column must be divided by the sum of the elements of the same column to determine the weight of each criterion, Hence, normalizing A.

The AHP method enables us to calculate the consistency of a weight by using the following equation (2)

$$CI = \frac{\lambda max - n}{n-1} \qquad (2)$$

Where:

CI= the consistency index

λmax = is the comparison matrix's biggest eigenvalue.

By comparing the consistency index value (CI) with the consistency index of a random-like matrix (RI), the consistency ratio (CR) was determined as shown in equation 3

$$CR = \frac{CI}{RI} \qquad (3)$$

A matrix that has had the judgments entered randomly is called a random matrix. It is therefore very inconsistent. Saaty delivers RI values that have been broadly estimated depending on the sizes of various criteria. Recalculating the pair comparison values would be necessary if CR ≤10% [30] , as shown in table below

Table:5.Random Consistency Index[30]

Number of Criteria	1	2	3	4	5	6	7
RI	0	0	0.58	0.90	1.12	1.24	1.32

4.5. Solar PV cell modeling

Solar PV cells are the fundamental building block of a solar PV array or panel; to obtain the necessary voltage and current levels, they are coupled in series and parallel. A PV cell is a semiconductor with a p-n junction that produces electricity when exposed to light. The PV cell mathematical model can be used for simulation to show how voltage, current, and power behave under various operating situations. Fig. 1 displays a simplified equivalent PV cell circuit with five parameters.

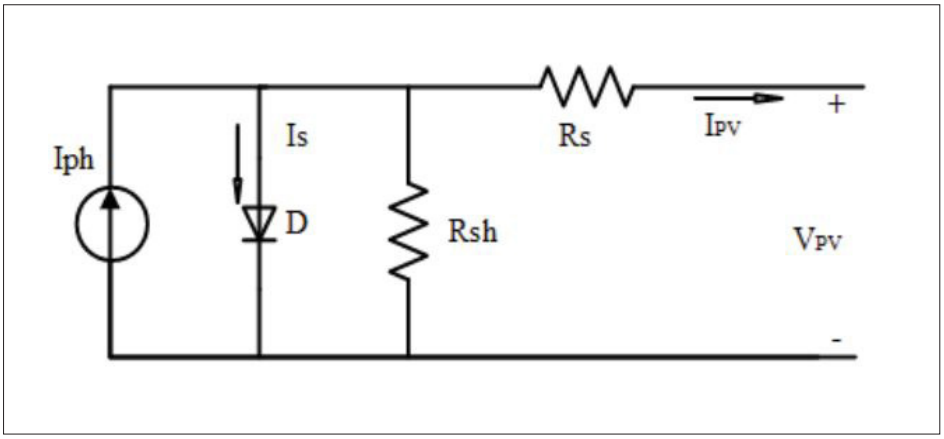

Figure:10 PV cell Equivalent circuit

Cell photocurrent (Iph), exponential diode (D), and shunt resistance (Rsh) are linked in parallel and in series, respectively, with series resistance (Rs). The PV cell's current and voltage are expressed as Ipv and Vpv, respectively [31].

The 200W PV array system and PV panel designed using MATLAB Simulink[32], as shown in figure (11)

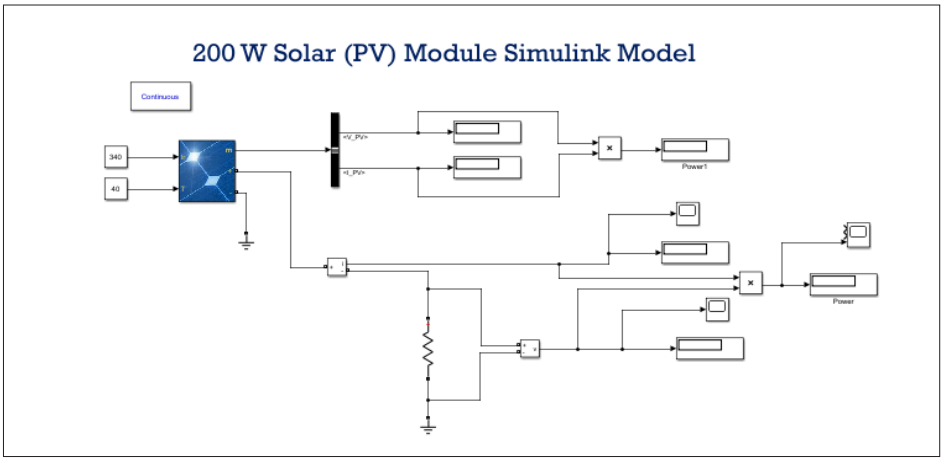

Figure 11. MATLAB Simulink model of Solar Cell

Table:6. PV panel parameters[32]

PARAMETER	RATED VALUE
Rated Power(Pmp)	200W
Voltage at Maximum Power(Vmp)	26.4V
Current at Maximum Power(Imp)	7.58A
Open Circuit Voltage(Voc)	32.9V
ShortCircuit Current (Isc)	8.21A
TotalNumberofcellsinSeries(Ns)	55
Total Number of cells inParallel (Np)	1

5. Results and Discussion

According to Table (6). AHP results indicate that the Solar radiation factor has the most weight (35.428%), Slope (23.993%), Elevation (15.865%), Aspect (10.362%), proximate to power transmission lines (6.756%), proximate to highway (4.477%) and Land Cover/Use (3.17%). The pairwise comparison results for this investigation were acceptable because the CR was 2.5%, and the values were thought to be stable.

Table 6. Pairwise comparison, weight for each criteria and consistency ratio (CR).

Criteria	C1	C2	C3	C4	C5	C6	C7	Weight	CR
C1	1	2	4	7	6	5	3	35.428	0.025
C2	0.5	1	3	6	5	4	2	23.993	
C3	0.25	0.333	1	4	3	2	0.5	10.362	
C4	0.143	0.167	0.25	1	0.5	0.333	0.2	3.17	
C5	0.167	0.2	0.333	2	1	0.5	0.25	4.477	
C6	0.2	0.25	0.5	3	2	1	0.333	6.756	
C7	0.333	0.5	2	5	4	3	1	15.865	

The rating raster data for each Criteria and its weights used as input data in Weighted Overlay tool table (weighted Overlay its ArcGIS software tool) to create a Map for Land suitability for study area as shown if figure 10, The appropriate map is classified into 5 categories (Unsuitable, Low suitability, Moderate suitability, Suitable and Most suitable)

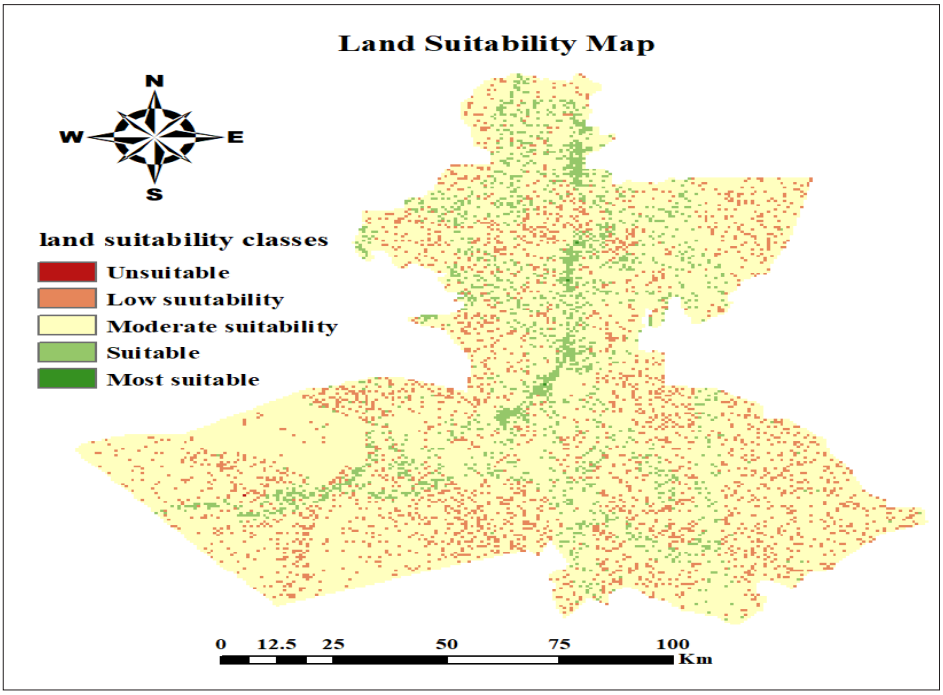

Figure 12. Map classification of suitable lands for the installation of solar photovoltaic power plants

The results showed that the Moderate suitability areas represent (82.3%) of the total area, Low suitability areas (10.6%), Suitable areas (7%), Most suitable areas (0.01%) and the Unsuitable areas (0.003%). The table (7) shows the geometric information of land suitability classes

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Table 7. Area and percentage of land suitability categories

Categories	Area (Km^2)	Percentage %
Unsuitable	0.5329	0.003
Low suitability	1632.273	10.62
Moderate suitability	12663.84	82.36
Suitable	1078.59	7.01
Most suitable	1.5987	0.01
Total area	15376.82972	100

After determining the appropriate sites for the installation of solar power stations, the appropriate sites near the Pilgrims ' Road (The Baghdad-Babylon-Karbala) were identified in order to facilitate the process of transferring the electrical energy produced from the solar power stations that will be installed on the specified sites to the camps (processions) located on both sides of the Pilgrims' Road (The Baghdad-Babylon-Karbala). The results showed the existence of nine sites at different sites as shown in the figure (11)

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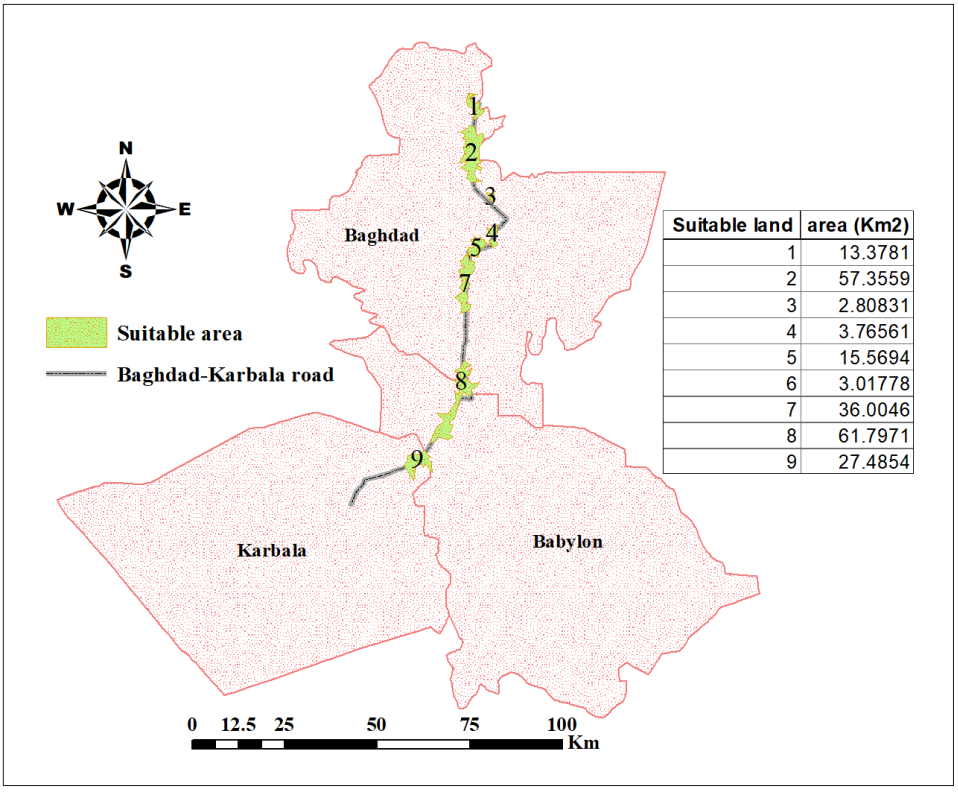

Suitable land	area (Km2)
1	13.3781
2	57.3559
3	2.80831
4	3.76561
5	15.5694
6	3.01778
7	36.0046
8	61.7971
9	27.4854

Figure: 13.Suitable land close to The Baghdad-Babylon-Karbala road

The amount of solar radiation depends on the length of the day. The daytime period for the study area averages 13 hours during August month, the sun rises at 5.30 am and sets at 18.40 pm. The value of solar radiation during this period for the sites indicated in the figure (13) was calculated using ArcGIS (Point Solar Radiation tool). The results showed that the values of solar radiation during the same period of time for these sites were close due to the convergence of the height values of the study area.

Finally. A simulation of the PV array system model shown in the figure (11) was performed with the values of solar radiation and the average temperature of the sites (40C°, https://power.larc.nasa.gov/) using MATLAB Simulink, the values of both energy, current and voltage were obtained as shown in the two figures (14,15)

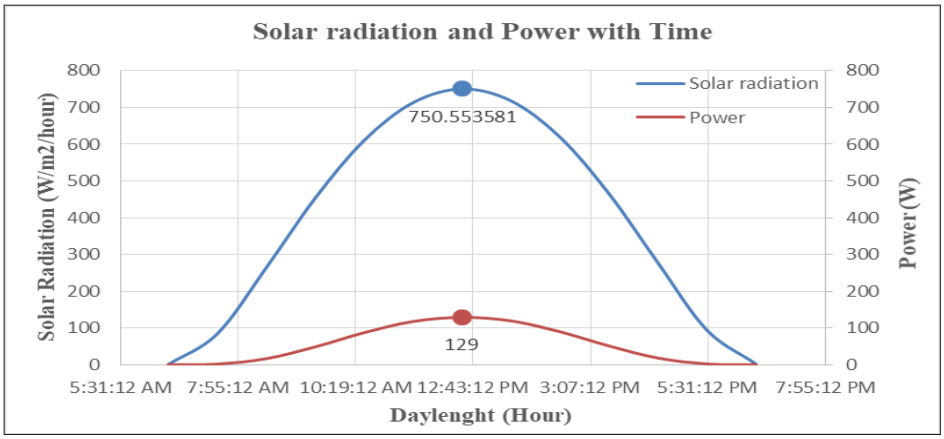

Figure 14. Solar radiation and Power with Time for single PB panel

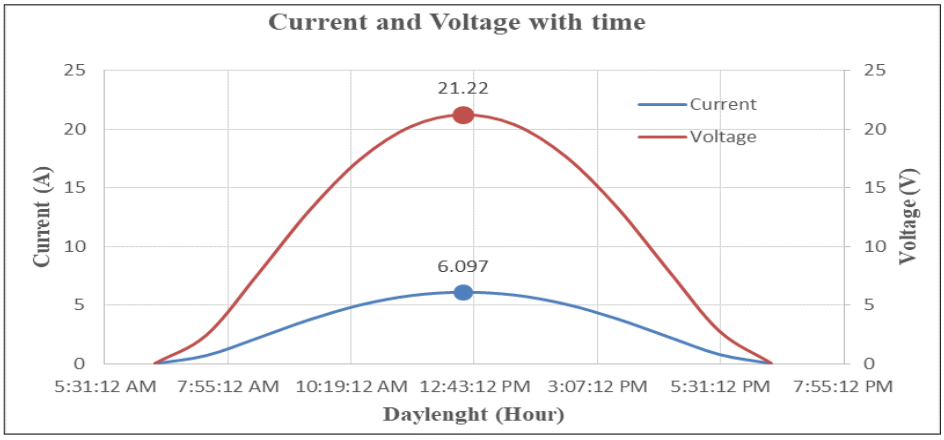

Figure 15. Current and Voltage with time for single PV panel

The values of Power, Voltage and Current increase with the increase in the value of solar radiation, where the maximum Power values were recorded (129W), maximum Current (6.97A) and maximum Voltage (21.22V) for single PV panel.

The standard size of PV panel about 25 square feet (2.3 m2) [33], so many PV panels can be added due to the vast areas of the selected sites to increase the amount of electric energy output that feeds the camps (processions) along the Baghdad-Babylon-Karbala highway.

6. Conclusion

Solar radiation is the most important criterion for determining the suitability of sites for the installation of photovoltaic solar cells

The study area is exposed to a high amount of solar radiation during the long daylight period in the summer, so solar panels are the best ways to obtain renewable energy

The values of seasonal radiation reach their highest levels during the afternoon, so the pilgrims of the forty should not walk during this period in order to avoid exposure to solar radiation

The specifications of solar panels can be changed by specialists for the purpose of obtaining higher efficiency and greater electrical energy

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