Evaluation GIS management for smart city Case Study :Elbieda City, Libya

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ABSTRACT – The GIS system's availability has made studying the spatial distribution of urban cities easier and less expensive.
GIS technology generally aids in smart city planning and obtaining solutions for problems and questions, This is accomplished integrating, managing, analyzing and displaying all kinds of related information spatially.
Additionally, This system and its observations can be used to developing plans to access to green energy. This paper explains how GIS can assist in the planning, development and management of some of the principles of energy for smart cities.
this paper analyzes the possibility of using green energy in the city of Elbieda using satellite images (Google Earth) and the Arc GIS technology and georeferencing on the areas of buildings, roads, and green areas.
In order to determine the amount of solar energy
By calculating the surface areas of buildings that can be used to receive solar radiation.
The paper concluded that GIS technology helps to plan cities more intelligently by visualizing the built-up areas and centralizing all relevant data in one place. This helps and cost effective manner supply of power in addition, smart urban planning.

Keywords: overall planning ; Spatial Analysis ; satellite imagery; solar energy ; green energy.

1. INTRODUCTION

Where are things? can be answered using a geographic information system (GIS), a type of digital mapping technology. GIS can offer more thorough justifications for why things exist. Where should everything be fundamentally? GIS enables us to display, explore, analyze, and interpret data so that we can understand relationships, patterns, and trends.

Managing, analyzing, and producing spatial data for cities on the surface of the planet using a set of components known as a geographic information system (GIS). The surface can yield significant outcomes.

Smart cities are those that offer basic infrastructure, offer its residents a good quality of life, and use "Smart" Solutions to address infrastructure-related issues. [1] solar panel roof Some of the "Smart" Solutions include photovoltaic systems, water harvesting at the home level, and green roofing.

Automated and semi-automated methods to extract area available for rooftop solar PV panel installation can aid in this process [2]A reduction process started through selecting a reduction factor of 0.3 reported in literature (Saha, 2016). [3] Using the reduction factor, area available for solar panel installation is obtained . Through local area development and smart technology, a smart city aims to provide smart services for its residents, enhancing their quality of life, enhancing their efficiency, increasing their economic productivity, improving the functioning of cities, and improving the environment and social interactions (Jain 2016).[4], [5]

1.1 GIS

Since geographic position is a key component of many activities, policies, strategies, and plans, all GIS definitions acknowledge the distinctiveness of spatial data. In light of these definitions Ducker (1979) defined GIS as " a special case of information systems where the database consists of observations on spatially distributed features, activities or events, which are definable in space as points, lines, or areas. [6] A geographic information system manipulates data about these points, lines, and areas to retrieve data for ad hoc quires and analysis".

Smart utilities, smart energy, smart infrastructure, smart communities, smart societies, smart buildings, smart care, smart security, public safety, smart traffic management, smart waste disposal, and smart public services are some of the essential elements of any smart city. Every element of a smart city is integrated via GIS, from conceptualization and planning through development and maintenance (Esri, Arc India News 2015). [7]

Urban areas have never had enough open space, so infrastructure can be built on top of buildings. For instance, solar photovoltaic (PV) systems can be built on the roofs of residential, commercial, or industrial buildings. The electricity produced by such systems can either be used for self-consumption or completely fed into the grid

Large-scale solar energy projects have become more prevalent, in both private and public constructions. This process can be aided by automated and semi-automatic techniques to extract available space for installing rooftop solar PV panels (Saha et. al., 2016) [8]

The energy from solar is becoming gradually a great solution for energy for our planet, where it is nonpolluting, and an infinite and free source. Modeling solar energy using GIS data is helping to generate more design elements from the GIS existing sets of data. In a Geographical Information System (GIS), which offers a variety of applications for geographical analysis, automatically demarcated objects can also be updated and merged with other theme data. According to Mathieu et al. (2007), [9] a trustworthy tool that can automatically extract geometric data from any item could help with the mapping of areas with different socioeconomic statuses and private gardens in metropolitan settings (Stow et. al., 2007. [10]

Using parametric modeling software, Lobrocco et al. (2016) examined the solar accessibility of Norwegian residential homes. Rhinoceros (McNeel Robert and Associates, 2015), a Windows-based NURBS modeler, and Grasshopper (Davidson, 2013) .[11] have been utilized to manipulate the geometric parameters (such as building height, façade exposure and orientation, and distance between the investigated structures). The Nordic environment's urban roof area hasn't yet been extracted using a remote sensing technology, nevertheless.

As the idea of "Smart Cities" gains traction in academia, business, and government, academics and professionals have proposed a wide range of technologies and applications using in situ and mobile sensors; however, the use of GIS/Remote Sensing (RS) techniques on satellite images is still surprisingly underutilized. Smart city applications often deal with concerns related to energy use, mobility, and occasionally public health (mainly to do with air and water quality).

GIS is a tool for storing, processing, analyzing, and visualizing spatial data so that users may make informed decisions. According to Dueker (1979), "GIS is an information systems where the database consists of observation on spatially distributed features, activities or events, which are definable in space as points, lines, or areas. A geographic information system manipulates data about these points, lines, areas to retrieve data for ad hoc quires and analysis"

where another database is made up of observations of objects that can be defined as points, lines, or regions in space and are spatially distributed. Vector, raster, and attribute data are all parts of a GIS.

Jacqueline Tyrwhitt provided the first thorough description of manual map overlay in a 1950 planning. In Design with Nature, Ian McHarg also employed opaque overlays that were blacked out to choose sites. Then, in the 1960s, numerous new types of geographic data and mapping software emerged.

The hottest trends right now include geo apps, geo forms, and web mapping. Urban populations have the chance to readily exchange maps and information with all stakeholders thanks to web mapping.

Geodesign, a crucial framework for smart cities, has been introduced by Esri. The design framework and enabling technology offered by Geodesign include Geo Planner, City Engine, and Geo Event Processor.

Planning our space is For thorough city planning, sustainable land management, and local area planning, geospatial foundation layers including State/District/City Boundaries, transportation, land

uses, ecology, species biology, elevation, soils, and water are important.
GIS is capable of analyzing land use, transportation routes, levels of pollution, demographics, risk assessments, and responding to any type of calamity in a community.

1.2 Solar energy

Solar energy has long been seen as a clean, environmentally friendly way to provide an energy footprint that is sustainable. Topographic data and 3D building models are the foundational data for solar planning and modeling using GIS. For instance, buildings receiving different hours of sunshine have quite diverse energy consumption patterns in cold seasons in high and intermediate latitude zones, Since cities have always lacked open space, roof area of buildings can be used to provide
infrastructure. For example, solar Photovoltaic (PV) Systems can be installed on rooftops of residential, commercial or
industrial premises and the electricity generated from such systems could either be entirely fed into the grid or used for
self consumption
Based on urban DEMs, Morello et al. [12] developed a procedure for estimating the distribution of solar energy over the iso-solar surfaces of buildings. Urban planners can directly use the findings. A methodology was developed and put into use by Yasumoto et al. [13]to examine how different social groups' access to sunlight varies with respect to time and location. The 'Libyan Renewable Energy Authority' has estimated that the average solar sunlight hours are approximately "3200" hours/year and that the average solar radiation is 6 kWh/m2/day (Faisal Abdussalam 2022). [14] Over the past few years, there has been a steady increase in energy consumption. Libya now has the highest per capita electricity consumption rate in Africa, which ranges from 4.60 to 2.65 kW per hour. [15] Therefore, renewable energy could provide a good complement for meeting peak loads; and this, in turn, may be a reasonable reason to encourage Libya's government to invest in solar projects (Yahya et al., 2020). [16] These results indicate that Libya receives a huge amount of solar energy that can be used to generate electricity. [17]

Improving the reasonable design of the urban landscape, boosting quality living circumstances, fostering social fairness, reducing waste discharge, and preserving the integrity of the natural environment are shared tenets of smart urban design and sustainable growth. Given these elements, it is essential to construct a virtual geographic setting using geographical data.
Finally, preparing our space GIS is capable of evaluating land use, transportation routes, pollution levels, demographics, risk assessments, and responding to any form of disaster in a community for full city planning and sustainable land management.

1.3 The importance of GIS in building cities :

1.3.1 Smart Cities and GIS Applications :

It is all the processes and programs that contribute to building and transforming into smart cities, such as communications and imaging programs, remote sensing programs, engineering programs used in city planning and GPS devices, whether they are programs for collecting or processing information and data, monitoring them, or interconnecting programs such as communication and the Internet. This also requires an effective system. Facilities and Buildings Management A plan to transform the existing city into a smart city.
smart cities are designed, developed, implemented, and managed at their core using GIS as an enabling technology. Real-time data can be provided to the GIS by modern technology like various sensors and high-speed networks for improved management of smart cities, green spaces, trees, and other land uses Whether they are green-area or built-area.

1.3.2 The function and impact of GIS in the planning of smart cities:

GIS technology generally aids in wiser city planning. GIS creates interactive maps that are simple to understand even for persons without significant technological abilities by evaluating data from sensors and imagery from satellites, balloons, and even drones. Moreover, the whole of the program can be directly obtained on a smart phone. Indeed, GIS may help cities become more intelligent in terms of both technology and location. The Geographic Information System (GIS) services give local governments the resources they need to create smarter communities and provide better community services. Your city can provide better end-to-end solutions that make it a more inclusive, sustainable, and prosperous place to live with empowered collaboration and timely information exchange.

1.3.3 Planning and spatial analysis ?

The use of GIS involves collecting and organizing information to represent it in the form of data for different patterns
and analysis of fixed patterns.
In the analysis of residential built-out, GIS can be quite useful. This forecasts the number of housing units that will be built in underdeveloped areas. The location and size of new water, sewage, and electricity distribution supplies as well as water and sewage treatment facilities can be planned by water, sewerage, and power companies using this information. Designing more livable communities and improving the built environment are two goals of urban development. Vision, involvement in the community, and collaboration across a variety of areas and sectors are essential factors for success.
Our goal is to gain a deeper understanding of how cities and urban environments function while also contributing to the creation of better policy and development frameworks for the creation and administration of urban settlements.

2. CASE STUDY

The current study was carried out on the city of bieda, which is one of the largest cities in Libya ,City of Elbieda is chosen as the case study location (Figure 1) . the study Area contains buildings with different typology and orientation.
to receive enough sunshine from the test site's residential buildings' roofs.
The city of El bieda in Libya is considered one of the major cities, which is witnessing a turbulent increase in the population and urban census, followed by an increase in demand for the availability of needs and energy, as there have been several major problems facing the city, including the availability of green areas and water, problems with energy supply, and the continuous provision of electricity to solve other problems.

Figure [1] Location of case study site in Libya.

3. aim of the study

this paper proposes an method to quantify the total roof area of El bieda City. The presented quantification will further help to estimate the potential of smart solutions.
This paper explains how GIS can assist in the planning, development and management of some of the principles of energy for smart cities.
this paper analyzes the possibility of using green energy in the city of El bieda using satellite images (Google Earth) and the Arc Gis technology and georeferencing on the areas of buildings, roads, and green areas.
Where spatial analysis is important to use along Continuity of development of the smart city.

4. problem statement

Since open space is not available in cities, infrastructure can be installed on building roofs.
Rooftop solar PV is one of the main renewable energy sources, and as such, it is becoming increasingly important in the planning of smart cities. By lowering the time needed for assessment and calculation of solar energy potential through rooftop solar PV at any geographical scale, the proposed and explored approach for rooftop extraction, given in this study, would aid in Smart City initiatives.
Urban areas have never had enough open space, so infrastructure can be built on top of buildings. For instance, solar photovoltaic (PV) systems can be built on the roofs of residential, commercial, or industrial buildings. The electricity produced by such systems can either be used for self-consumption or completely fed into the grid.

5. methodology

Through case studies, this paper specifically focuses on three GIS applications, including open space, roadways, and building area mapping.

The Spatial Statistics Access point Analysis tool in Arc GIS was used to analyze them. This paper, compares the extract urban roof area using gis for Elbieda city .besides reducing fuel consumption on the city greatly Depending on the steps that follow:

5.1- A satellite image of the El bieda City and the zoning within the city was taken as an example for the study using Google Earth showing in figure2 El bieda's population has seen slow growth in recent years. Between 2018 and 2020, the population grew by only 2.5%.There are 270,000people living in El bieda city.

The city, which includes the area under study, has a total area of 12,593,397 square meters. and the construction pattern extends from west to east with a width from north to south of 3412 meters and length from east to west of 6851 meters.

Figure (2) Satellite image of El- bieda taken by Google Earth

5.2- Locate the city of Al-Bayda on the global browser UTM.

The satellite image of the city is converted to a file format with a kml extension to deal with it with the GIS program and use the engineering reference for these images in the global system (WGS1984) and then project the map onto the system slice (UTM) as the city of El bieda is located on slice No. 34 north, which is considered a classification in the slices (Zone 34S) figure2.

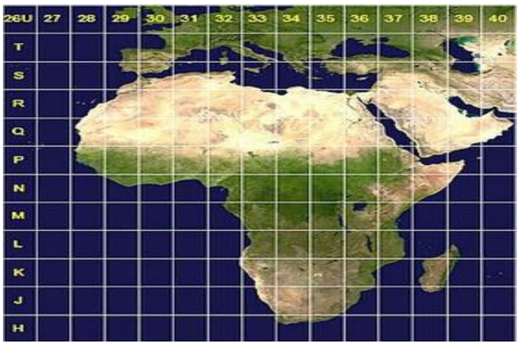
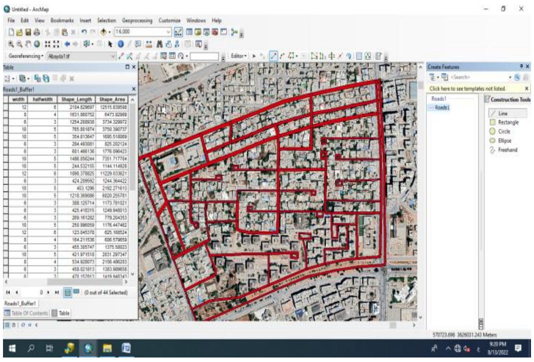
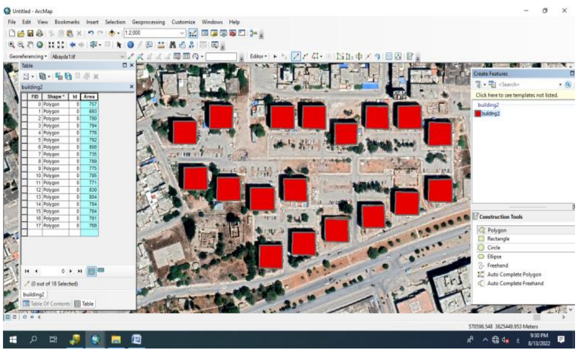


Figure (3) shows the location of the city of El bieda on the UTM map.

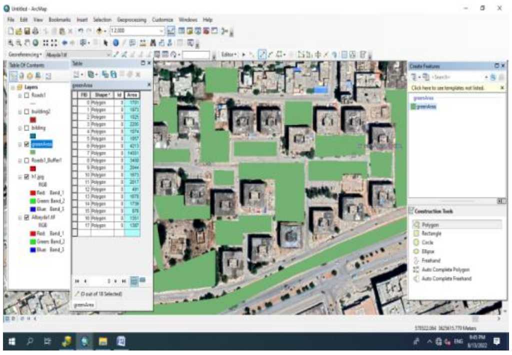
5.3- After entering the image into the GIS program and processing it using Arc Map and Arc Toolbox, To verify the area of the studied area and then classify it, into three areas, namely: Building Roof area; road area; landscaping(green areas) see figure (4),(5),(6).



Figure(4) showing the Building Roof using GIS



Figure(5) the road network using GIS



Figure(6) showing green areas using GIS

5.4.EVALUATION OF SMART SOLUTIONS' POTENTIAL

5.4.1-Calculating Rooftop PV's Potential for Solar Energy:

Beginning with the GIS-generated Digital Surface Model, which included image objects named "Building Roof Layer, Green Areas Layer, and Road Area Layer: are integrated and categorized under the new class,"

The overall area for Elbieda city is 1259 hectare look at Figure 7. the extraction of urban roofs began it is building roofs are estimated as distinct polygons.

The total roof area of the city's buildings is first computed after the area's land use for Elbieda City has been determined, As shown in table 1. Then, in order to create space for solar PV applications, a reduction factor of 0.3 is applied to this area.

On the other hand, the 0.3 reduction factor was developed based on a review of the literature.

Therefore, the total roof area (ARoof) multiplied by the reduction factor creates the available roof area for a photovoltaic system, as shown below.

The total area of the roofs of the buildings for PV

= 0.3 * Roofing Area

= (0.3) * 9193200 = 2757960 sqm.

The available roof area of the Evaluation Area is determined, and then the potential energy output per day is calculated as follows:

E = Imd *e * APV

Where "Imd" is the mean daily global insulation on a horizontal plane 6 kWh/m2/day and "e" denotes the module efficiency which is taken as 15% (according to The leading PV producers offer this as their minimum module efficiency.), "APV" is the roof area that can be used for PV installation, The potential energy output for the Test Area is computed using the equation,The product potential energy of the test area is calculated and compared with the demand. ,Table 2 provides specifics about the computation.

Steps to calculate the number of solar panels and the required area After adding coefficients to account for the efficiency of the solar panels used, the number of solar panels required to cover the daily consumption of buildings from lighting and operating electrical appliances is calculated. After this, the areas that need to be installed on the roof are determined, and the remaining area is calculated as green spaces or to store water.

Table 1land uses for the city of El- bieda

DESCREPTION	Percentage area By master plan	Area by master plan (hr)	Percentage area By GIS	Area by GIS (hr)
the residential uses covered by the plan 45%-65%	%60	755.60	%73	919.32
Percentage of road coverage from the plan	%13	163.71	%12	151.12
Other uses	%27	340.02	%15	188.90
Total area (hr)	1259			

Table 2 Potential and daily consumption of energy per capita in the test area

The total area of the roofs of the buildings for PV (sqm)	Potential daily solar energy output in (kWh) for the test area	Potential daily energy output per capita the test area (kwh/day)	The Test Area's per-capita energy consumption (kwh/day)
2757960	2482164	9.19	4.60

Table 2 shows that rooftop solar PV can supply the Test Area with three times its daily energy needs. In addition, once it has satisfied its own needs, it may be able to contribute to the grid's electrical supply.

5.4.2 Green roofing

Smart buildings should be permeable to air, water, and shade and shouldn't promote the development of urban heat islands. Instead, they should seek to build air-cooling reservoirs. Green roofs, or rooftop vegetation, can be built on any sort of roof, taking into account factors like as roof material, slope, and sunlight, among other things. the GIS can be used to address the smart city indicators.

5.4.3 Water collection at the household level and green roofing

Most Libya Cities suffer from acute water shortage and one of the reasons is water loss caused from leakage occurring during the transportation of water from the source to the end user. here the Installing a rain water harvesting system at the building level can be a solution to the issue. This can be computed using the GIS . It results in calculating consumption based on each building's user count and lowering energy consumption during pumping operations. GIS can be used to plan storm water harvesting schemes at both a city level Harvesting storm water reduces pumping costs, GIS can be very helpful in Identifying areas suitable for storm water harvesting ,for Smart Cities by analyzing land cover, land use and topography.

Controlling the flow of water Libya is one of the driest countries on the planet.

The only criteria for allocating water should be its social and economic significance. Because of this, it should be appropriately distributed to the domestic sector as a top priority, then to the industrial sector in order to meet their needs, and lastly to the agricultural sector.

Roofs equipped with solar panels or photovoltaic modules, or other "green" technologies, may also be referred to as having a "green" roof. Other names for green roofs include vegetated roofs, living roofs, eco-roofs, and green roofs.

Also Because they increase insulation and decrease heat transmission through the roof, green roofs can save energy expenses.

6.Conclusion and discussion :

You may create a smart city that is sustainable and eco-friendly by setting strategic goals based on the city's infrastructure and database capabilities.

GIS is thus a crucial tool for transforming urban regions into Smart Urban Communities. this information is used to quantify and contrast the potential for producing solar energy through rooftop PV with the existing demand. Additionally, it is predicted that there is a chance for green roofs and rooftops to collect rainwater, which will improve water supply and quality of air.

GIS can get to and oversee a lot of spatial information.

- The potential for "smart solutions" in certain cities has to be evaluated. The time needed to complete the aforementioned activities would be decreased by the proposed and well investigated rooftop extraction method, which is discussed in this work.

It is evident that making spatial decisions is a very complex process, and the majority of spatial choice problems are difficult to solve.

When comparing GIS with other expert systems Spatial decision making requires large volumes of spatial data. Expert systems lack spatial data handling capabilities such as buffering and overlay which are unique and important to spatial analysis Which explains the importance of using geographic information systems

GIS is used throughout the life cycle of a smart city, from site selection and design to visualization, building, and maintenance. Because it scales across any area, including a single asset like a building and a nearly global context including all facets of smart city planning and development, GIS is the ideal tool.

A geographic information system can be used to precisely replicate a project, location, or important issue. GIS may help a facility be more sustainable by using less water and energy, finding better ways to get rid of waste, and reducing its carbon impact. GIS can help, for instance, by maintaining data on both inside and outside of structures, allowing for the differentiation of the environmental impact.

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