# A New Approach to Enhance Smart City Applications Through Integrating GIS & BIM Technology

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**Abstract**

The research deals with the study and analysis of smart cities, the requirements for their establishment, and the role of Building Information Modeling (BIM) in building sustainable, energy-efficient smart cities. The primary objective is to put a smart city transformation methodology and apply it on Lattakia city as a case study, using Building Information Modeling (BIM). We proposed new tools in an integrated methodology to transform from ordinary to smart city, and implemented basics of its objects, including GIS/BIM technologies integration, insuring both sustainable and energy saving vision at general planning designs. Implementing the chosen methodology steps at an organized area in Syria – Lattakia City, starting with building an accurate geodatabase, then, obtaining Sun Shadow Frequency analysis, which shows that December contains the highest shade values, with cumulative coverage rate 79.84%, while June instead contain the lowest shade value, reaching only 33.84%. But in general, most of the area has shade coverage that does not exceed 15% most of the day, therefore no need to make an adjustment to the distribution of building blocks. After that, in order to secure the energy needed for the study Area, analyzing the Land Surface Temperature (LST) done using the ArcGIS Pro® software, and locating a renewable energy station site (solar plant). On the other hand, analyzing a residential building energy through annual PV analysis has been done, by using Revit® software through Insight™ extension, with two cases: first one, building without changing building material, while second one done after changing building material to save solar energy inside and rising roof slope up to 10%, and we achieve valuable energy savings by applying this modification to building material. And finally, introducing the infrastructure underground network, that serving transformation to smart city.

**Keywords:** Smart Sustainable City; Sustainable Urban Planning; Building Information Modeling (BIM); Geographic Information System (GIS); Land Surface Temperature (LST)

## 1. Introduction

Cities are home to more than half of the world's population, and they are major centres of economic activities. In 2019, about 55.72% of the world's population resided in cities [1], and this percentage is expected to reach 68% by 2050 [2].

Rapid urbanization makes cities more vulnerable to a series of challenges related to growth, competitiveness, performance and livelihoods, including potential pressures on services and infrastructure. Moreover, unplanned or poorly managed urban development, coupled with unexpected shocks and stresses, may ultimately lead to a series of challenges and severe pressures on urban systems, creating long-term stresses on essential components and services. That's why the Architecture, Engineering, and Constructing (AEC) industry is the most important part of development in all countries [3,4,7,12].



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Hence the need to plan Smart Sustainable Cities, which provide an intelligent vision to meet the challenges posed by growing modern cities, by integrating physical systems and information and communications technology, and providing an appropriate and participatory sustainable environment for urban residents [3,15].

A smart city is a community that practices information and communications technology to enhance the level of community services and people's health. It can be broadly defined as regional systems with creative levels that combine knowledge-based activities and institutions to develop education and creativity, and digital spaces that develop interaction and communication, in order to increase the ability to solve problems in the city [5,15].

The smart city concept takes into account the involvement of citizens in the sustainable use of resources, social capital and improved relationships, which ensures quality performance and development. The term “smart” refers to the intelligent system consisting of Building Information Modelling / BIM, communications and Cyber-physical systems / CPS.

Building Information Modelling (BIM) is a technology that can represent information-rich 3D models to help all stakeholders plan, design, build, operate and manage facilities in a timely, cost-effective manner. It is deemed as an environment that effectively combine all liabilities through different times to get an innovative design. It can provide a reference database that supports decision-making at all stages of the project and mitigates risks and conflicts. In addition, buildings that support this technology in smart cities are always technologically integrated with Internet of Things devices and other infrastructure such as transportation, municipal facilities, and smart networks, and due to the benefits of BIM, developed countries like France, Denmark, and the United Kingdom are requiring all major and public projects to be designed using various levels of BIM [6,8,13,16].

Supporting the aforementioned reference database with spatial information and data provided by Geographic Information Systems (GIS) enables more comprehensive spatial analyses of the vital field in smart cities. GIS contributes significantly to improving government services in smart cities. These systems provide accurate and updated information about the various geographical locations and areas in the city. Using this information, local governments can improve city planning and organize public services such as transportation, sanitation, electricity, and water more efficiently. Moreover, GIS can be used to develop smart applications that make it easier for citizens to access government services faster and easier [9,10].

Smart city development aspires to new heights and leads to energy efficiency, comfort and sustainability by integrating intelligence and construction industry practices, including smart construction and planning [11,14,17].

The research problems can be summarized by the following research questions:

• What are the most appropriate planning strategies necessary to make the transition to a smart, sustainable city, especially with our case study at Lattakia city in Syria?

• How to benefit from Building Information Technology (BIM) to meet the conditions for smart cities sustainable designing and planning?

• What is the importance of using Geographic Information Systems (GIS) and Building Information Technology (BIM) to achieve optimal urban planning in smart sustainable cities?

The main goal is to determine the necessary planning strategy to transform an ordinary city into a smart sustainable one, taking a part from Lattakia city as a practical case study, by studying the current situation of a residential area, and re-modeling it according to the principles of smart city design, taking advantage of Using:

I. (Revit®) for 3D modeling, in addition to analyzing the energy of buildings and studying their optimal orientation to achieve sustainability standards.

II. (ArcGIS Pro®) for spatial analysis especially Solar Power Analysis.

## 2. Literature review

Achieving sustainable smart city design requires multiple parameters, especially power resources issues, and that requires analysis for both internal (building energy) and external (power source for city) energy. This leading first to study the current method to construct and design smart cities, and



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second to investigate the probable technologies that helps to implement sustainable smart cities, such as BIM technology, GIS, and their integration if possible.

On current methods for implementing smart cities or transforming, (Alavibelmana & Fazekas, 2018) tried to find out how the current understanding and application of smart city concept affect the urban planning practices and urban policy making [18], this objective pursued by examining Malmo city as case study, by analyzing the policy and strategy documents in planning, and smart city projects. This study revealed that in the first place, the smart city concept needs an interdisciplinary dialogue to be translated inclusively into the integrated strategies and initiatives. To achieve this, it is required that different perspectives and stakeholders are involved in defining a holistic and strategies model and plan based on the city's demands and integrated into urban planning strategies, and an integrated framework defined under which it can be possible to evaluate the contribution of smart city projects in different sustainability goals.

(Elsheikh, Alzamili, Al-zayadi, & Alboo-hassan, 2021) comes up with important details regarding the integration between GIS and BIM. And have also learned about its positive and the most important advantages that can provide complementarity between two of the most important technologies currently available in the urban planning field. In simple terms, the possibility of the overall vision that could obtain from this integration leads to achieve promising urban planning techniques for the present and future of any region, which gives high flexibility and huge potential for professionals in this field. In the future, old buildings in downtowns will have to be demolished or modernized more frequently to enable cities to cope with population growth and urbanization. Construction sites are a source of noise and dirt, and create major traffic problems that impede mobility. Therefore, construction will have to be done more quickly. That requires better data on the building site as a basis for more efficient planning and building and all these features can be offered by the integration of GIS and BIM [19].

Continuing with BIM technology in cities modeling, (Kolbe & Donaubauer, 2021) refers that Digital models of the built environment provide detailed information on the physical urban reality. Semantic 3D city modeling as well as Building Information Modeling both address not only the representation of spatial and graphical aspects of urban entities, but especially focus on their thematic structuring and decomposition into meaningful objects. However, semantic 3D city modeling and BIM are following different modeling paradigms to achieve that goal. While the former is especially tailored to create descriptive models of the existing urban reality, BIM is tailored to create prescriptive models telling how reality should become. The different approaches are originating from different disciplines, that is, geomatics and AEC, and are supporting the typical applications within their disciplines very well. There is an increasing demand to combine the two representations, though, and a number of different approaches were explained in the chapter. Also, examples for use cases that require combinations of semantic 3D city models and BIM were given. In general, semantic urban models are key for a wide range of urban applications in a multitude of domains, including all kinds of simulations [20]. In conclusion, it is important to point out that the achievable and manageable data quality of urban models is not only limited by the data collection processes (and thus by sensors and the subsequent interpretation of sensed data), but also from the employed standards concerning the data modeling frameworks and data exchange capabilities. Data loss may occur between two parties or systems, if the data exchange standard is not capable of preserving the original content, structure, and logic of a dataset. Files like City Geography Markup Language (CityGML) and Industry Foundation Class STEP (IFC) are the most important open standards for semantic 3D modeling of the built environment.

Otherwise on sustainable analysis derived from (BIM) programs, (Omran & Wassouf, 2022) says Energy is one of the most important issues that attract the attention of the whole world, although interest in it is still very limited. This, in turn, is reflected in the increase in energy consumption. This increase comes primarily in residential and industrial buildings by opening windows and doors. The walls of buildings with poor insulation also cause energy loss, so the process of evaluating the efficiency and quality of internal spaces is an important step from which the process of developing these spaces and upgrading them to reach sustainable models in terms of environmental, economic



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and social terms. The research aims to study the distribution modes of residential exchanges and their reflection on energy for a residential suburb consisting of twenty blocks in Tartous Governorate, through the development of a software tool using the Dynamo, which is one of the methods of visual programming, which is one of the latest tools currently used in BIM technology with the use of the Python programming language This tool studies the formed shadows and their effect on the neighboring buildings every hour of the year in order to know the area of the facades that are exposed to the lovely winter sun, which in turn improves the thermal comfort of users, in addition to studying the heating and air conditioning loads for the current situation of orientation and comparing them with the loads after guiding the building at different angles In order to reduce consumption and benefit from solar radiation sources by Revit, which is classified among the most important BIM software, in addition to proposing a tool to achieve the building envelope at the design stage, since most of the energy leaking that increases the heat load is due to the external walls, floors adjacent to the soil, ceilings and windows in order to achieve the design requirements of the Syrian thermal insulation code using Dynamo and the Python language in order to reach sustainable, energy-saving buildings that benefit from sunlight and reduce the consumption of fossil energy [21].

While (Yousef & Surkn, 2023) conduct that Building Information Modeling (BIM) can assist complex building performance analysis to ensure a sustainable building design [22]. The use of Building Information Modeling (BIM) provides multiple means to increase and improve the quality of interior design and architecture projects at the level of design, implementation, facility management, maintenance and operation, and contributes to the accurate preparation and control of schedules, bills of quantities and specifications, and to reduce the total costs of the project. Hence the basic research problem is that there has not been much interest regarding the impact of BIM on achieving sustainability in large projects. Hence, the importance of this research that it aims at supporting sustainable design and construction by evaluating the use of BIM technology in the fields of interior design, architecture and building engineering. The results were:

- BIM contributes to cost estimation and schedules for all interior design, architecture and other disciplines and coordinates information in one integrated model.
- The use of BIM technology reduces costs associated with traditional energy, by providing information necessary for sustainable design, analysis, and certification routinely as a by-product of the standard design process.
- Building Information Modeling technology provides the opportunity to achieve many benefits in all stages of project design, interior and exterior design, building and implementation operations, and the post-occupancy phase of the building.
- Linking the construction model to energy analysis tools allows to evaluate energy use during the early design stages, and this is not possible using traditional two-dimensional tools, which require separate energy analysis at the end of the design process, thus reducing the chances of early adjustments that can improve energy performance in the building.
- Building information modeling systems and levels have developed significantly in all components of their systems in parallel to developments in the field of electronics, communications and information, which has made them appear to be highly appropriate to facilitate dealing with interior design projects as well through the application of sustainability standards.
- The use of BIM applications can greatly facilitate complex operations in sustainable design such as analyzing natural lighting, the movement of the sun around and inside the building, calculating the amount and intensity of lighting, as well as solar energy and automating work that requires effort.

Under the title of Saving Energy Efforts in Building Energy Analysis, (Ismail, Jdeed, & Zaarour, 2022) represent pre-cooling technology using a solar photovoltaic energy system where the increasing in air-conditioning demand during summer results in a rise in the amount of electrical energy consumed from the electric network, as well as an increase in electricity bills. Air conditioners are operated in governmental facilities during official working hours, at the time of the peak demand for electricity, when electric costs are the highest. In order to shift the cooling demand out of the peak period into a lower electric cost period, reducing the energy consumption of the building and the value of the electricity bills, this study was conducted on the technology of pre-cooling using solar



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photovoltaic energy system. The results showed that applying the Photovoltaic (PV) pre-cooling system led to a significant decrease in the cooling demand during critical hours, and reduces the daily consumption of the electric power from the electric system, as the demand was decreased from 85 kWh to 21,250 kWh. Besides, the value of the electricity bills was decreased by 83%. Pre-cooling lowered the PV system capacity that was needed to operate the building's air conditioning equipment by 50%. A reduction of 42.5 kg of $CO_2$ emissions per day could be achieved using PV-pre-cooling system [23]. The results are encouraging to apply pre-cooling by using solar energy system due to the reduction in the electrical energy demand from the power system, in addition to the reduction in electricity bills. Besides, there was a reduction in the capacity of the PV system that was required for cooling. Moreover, the application of the PV system led to a reduction in carbon dioxide emissions released in the atmosphere.

Smart sustainable cities rely on the latest technologies and apply recent knowledge, like BIM technology and other sections of science such as Information and Communication Technology (ICT), (Slaeh, Elhendawi& Darwish, 2024) study the possibility of Integration BIM technology with Lean Practices in order to obtain smart sustainable cities, and they found Correlation analysis establishes significant positive associations between BIM visualisation and practices such as just-in time production, value stream mapping, lean pull systems, work sequencing, standardised work, and continuous improvement. The findings accentuate the pivotal role of BIM in optimising lean practices, offering valuable insights for practitioners seeking to elevate AEC industry performance through strategic integration [24].

As a result, we found those literature review studies discussed subjects like the methods of planning smart cities, and how the concept of smart city could affect its the planning procedures, and these studies also explained multiple ways to process and implement that procedures using BIM technology, and few studies mentioned about using GIS analysis as well. Many studies also assured the importance of using BIM technology to achieve sustainable planning in smart cities, indicating smart building modeling by its material changing or by building orientation.

Checking out studies result totally showed partially processing procedures of using BIM technology and small participation of GIS analysis in planning sustainable smart cities, thus we will suggest a new approach to enhance smart city applications using GIS & BIM technology integration. The proposed approach will combine for the first time spatial analysis from GIS technology, and BIM technology output, neither buildings orientation, material, or energy saving analysis, all that in term of transforming into sustainable smart city planning.

## 3. Research Methodology

Descriptive analytical methodology was used to organize and process research material, practices, and procedures, taking a part of local city in developed country (Lattakia city, Syria) as a case study, depending on analyzing its components, and what previous literature review studies came up with, we suggest a new approach like serial steps, containing concepts of sustainability and smart city perspective. This methodology provides the right tools to determine the optimum steps in sustainable smart cities planning, and to particularly define which technology is preferred to use in each procedure, BIM technology or\and GIS ones.

## 4. Basics of smart cities: Case study (Lattakia city, Syrian Arab Republic)

Sustainable smart cities transformation depending on well-defined steps, including: building a digital urban model, collecting needed data especially remote sensing one, analyzing and interactively visualizing city data, and finally controlling the system. All that in terms of effectiveness of basic informatics and telecommunication structures, and human resources ability to invest and use modern scientific methods such as BIM technology, with priority to obtain a clean and renewable energy source, such as solar power, in order to support suitability at smart cities applications. These criteria were used practically on the following steps and procedures.

After studying related works about implementing smart cities, and how BIM technologies can enhance that development, focusing on four main points that are necessary to reach sustainable smart city transformation, including powerful geodatabase serving smart city analysis, obtaining sustainable site



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selection and sustainable building designing, and finally connecting smart city objects with infrastructure network. This methodology mentioned below applied on ordinary city, located in Lattakia City, one of Syrian Arab Republic governorates, at the Mediterranean Sea east coast.

Implementing a methodology contains four main sections: Re-organize city geodatabase, sustainable site selection, sustainable building enhancing, and finally proposing infrastructure network connecting smart city buildings, figure (1) shows the main points for research methodology.

Starting with available data and maps in Lattakia city council, which represent the input at this processing step, re-organizing and creating a new geodatabase done for study area with use of ArcGIS Pro® software, by digitizing old paper maps, and creating parcels and its master plan layers in a geodatabase, fixing geometric errors that appears after stacking the layers in ArcGIS Pro®, and adding all available attributes such as buildings height, number of floors, planning type to each created zone, type of buildings…etc. After creating a new geodatabase for study area, and visualized it in 3D view using ArcGIS Pro®, and start analysing how much their buildings are well distributed, by analysing two main points: first one is calculating the ratio of Land use for each planning type zone and compare it to local policy standard, and second point is implementing analysis called Sun Shadow Frequency to determine how the buildings are well oriented in study area to benefit as much as possible form sun light and energy.

Sustainable site means to benefit from available renewable energy source -such as solar power- in city location, in order to support the energy cycle and deliver a clean energy needed in the smart city. The reason of choosing solar power as renewable energy source was because it is the most available and reliable energy source. By using analysis called Land surface temperature (LST) in ArcGIS Pro® applied on Landsat 8 Imagery, obtained from United States Geological Survey (USGS) website, the LST analysis output present the study area as a heat colour ramp, so it is easy to select the best site to deploy solar panels in study area location, at the most heat areas spots in the region.

Sustainable buildings refer to analysis about buildings internal energy, and how buildings can benefit from renewable energy sources. When choosing solar power as sustainable energy source, understanding building behaviour of absorbing sun radiation is essential, taking into account building materials, insulation, and reducing overall power consumption. So sustainable building must achieve two main points: First one is to determine the most suitable building materials and insulation in order to reduce building power loss, and second one is to properly benefit from solar power panels to make the building generating some of its power. So we use Revit® to model buildings in 3D and then analysing the buildings energy using Insight extension in Revit® software.

Gathering all results from GIS Analysis (sun shadow frequency analysis, and LST Analysis) and BIM Analysis (Insight output about building energy from Revit®) lead us to un integrated framework enhancing smart sustainable city transformation.



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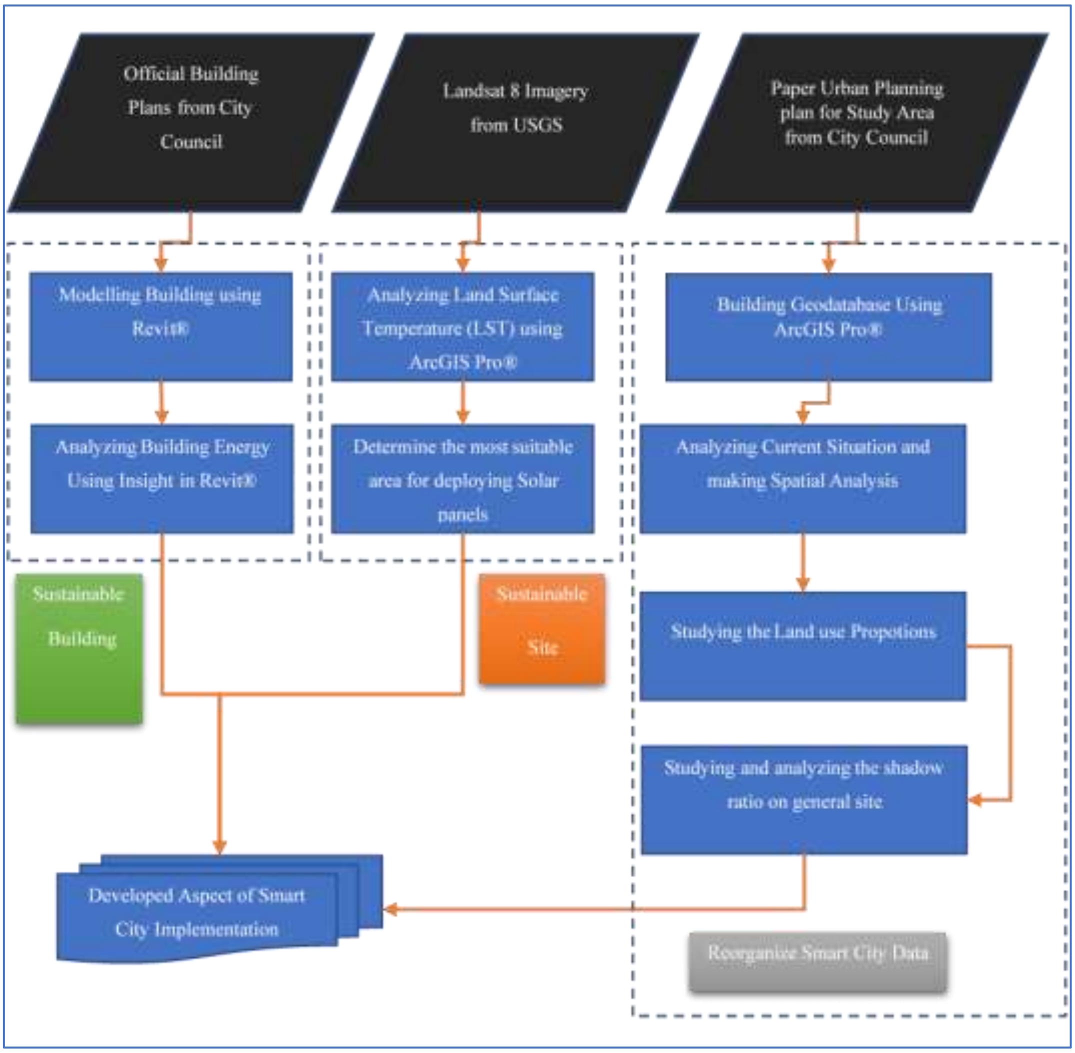


Figure 1: Research Methodology (Proposed of Developing Smart City Implementation)

### 4.1 Building a geodatabase for study area

Using ArcGIS Pro® software, the input data at this step were old planning paper maps, contain the planning types and its properties for each planning zone, and some digital maps for parcels at study area, starting with georeferencing scanned paper maps and digitizing, then stacking resulted layer above parcels digital maps layer, and fixing all geometric errors appears.

After compatibility was made, conflicts and geometric differences were solved, an integrated geodatabase was created for the study area, which will later be the base for 3D modeling, and the input of Shadow Analysis, and Energy Studying. Figure (2) Shows the Layers of designed geodatabase that created in our work. Geodatabase layers including: Zones layer, walking path layer, Residential green strip layer, Residential Commercial Compound layer, Residential layer, Public Construction layer, green Island layer, gardens layer, Educational layer, Commercial Service Center layer, Commercial Compound layer, Administration Health Center layer, Parcel Inside layer, Educational Inside layer, Command Center layer, Roads layer.



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Figure 2: Geodatabase for study area executed in ArcGIS Pro®

### 4.2 Land use Ratio from Analyzing Geodatabase

After creating the geodatabase for the study area, the proportions of land use within the study area can be easily calculated, in order to analyze the current situation regarding the quality of urban planning for the study area, and determine whether these proportions are correct and compatible with local planning policy and standards, and whether they need to be modified. Table (1) Shows the Land Use Ratio obtained from Analyzing geodatabase for Study Area, and it is compatible with planning standards in Syria.

Table 1: Land Use Ratio obtained from Geodatabase Analysis

| Type | Area (Square Meters) | Percentage % |
|---|---|---|
| Administrative | 5014 | 1.2 |
| Walking Path and Yards | 6143 | 1.5 |
| Commercial | 8929 | 2.1 |
| Educational | 32296.3 | 7.7 |
| Roads | 68845.3 | 16.5 |
| Gardens | 88579 | 21.2 |
| Residential | 144284 | 34.6 |

### 4.3 Shadow Frequency Analysis Using ArcGIS Pro®

After applying shadow analysis to the 3D visualization of study area by using ArcGIS Pro®, a 3D conceptual representation of the study area was created, shown in Figure (3), by adding the heights of the blocks drawn within geodatabase, and then applying Sun Shadow Frequency analysis tool on each season of year 2023, on the first of March, June, September, and December, at daily hours starts from 9:00 AM to 17:00 PM, then the sum of each day hours' shadow was calculated, calling it as cumulative coverage. This addition enables us to determine the effectiveness of directing and orienting buildings to gain the largest amount of solar energy during the day throughout the year. Calculating the shadow coverage is simple because the analysis gives back the area of shadow of each time value entered, then calculating the percentage of shadow coverage by dividing that area on the total study area.



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(b) (a)

Figure 3: Shadow Analysis Using ArcGIS Pro®, (a) Conceptual 3D Representation of Study area, (b) Example of Shadow Analysis in 1st March at 13:00 PM.

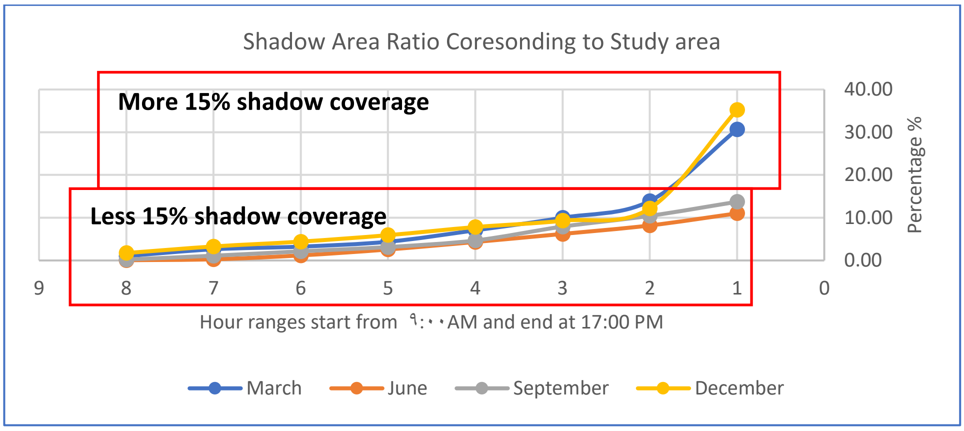


Figure 4: Shadow Analysis Using ArcGIS Pro®

Analysis of the shadow percentage values in the study area shows that the highest shade values are in the month of December with a cumulative coverage rate (sum of hourly shadow percentage) of (79.84%) and the lowest in the month of June with a cumulative coverage rate of (33.84%) from the total area. From Figure (4), it appears most of the area is covered with shadows that do not exceed 15% with time series that processed. Therefore, a greater amount of heat gain can be imagined in the study area, and it indicates that the distribution of buildings and its orientation considered good if the maximum values are excluded for shadows at the beginning of the solar cycle.

### 4.4 Land Surface Temperature Analysis Using ArcGIS Pro®

In order to support the energy source for the sustainable smart city, it is necessary to think towards renewable energies, the most important of which is solar energy, because relying on depleted and polluted energy sources not only affects the surrounding environment, but also affects the economic aspect of the smart city, amid fluctuations in global fuel prices. And indicators of its future effectiveness.

Using land sat 8 satellite image for study area, downloaded from (USGS) website, the input bands were "Band 4, Band 5, Band 10", following procedures mentioned below [25]:

- First the atmospheric radiation values are calculated as follows:

$$L\lambda = Band\ 10 * 0.003342 + 0.1$$

Where $L\lambda$ represent spectral brightness in sensor opening (W/(m$^2$ srμm)).

- Second, using the following equation to convert the atmospheric radiation value to sensor temperature:

$$T_B = \frac{1321.08}{\ln\left(\left(\frac{774.89}{L\lambda}\right) + 1\right)} - 273.15$$

- Third, calculating the Normalized Differenced vegetation index (NDVI) by equation:

$$NDVI = \frac{Float(Band5 - Band4)}{Float(Band5 + Band4)}$$

- Fourth, calculating the vegetation rate by using the following equation:



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$$P_v = 0.004 * NDVI + 0.986$$

Where $P_v$ refers to calculation of vegetation rate.

- Finally, the surface temperature map (LST) is created by applying equation:

$$LST = \frac{T_B}{(1 + \left(0.00115 * \frac{T_B}{1.4388}\right) \ln(P_v))}$$

The use of geographic information systems analysis, including land surface temperature analysis, provides urban planners with a very important addition to the sustainable planning of the smart city, as determining the best places in which the solar energy system can be deployed, so that it achieves the highest degree of productivity. Land Surface Temperature analysis measures the extent of solar brightness over a specific geographical area, and directly gives the best locations for the location of the solar power plant required to be implemented. Figure (5) Shows the most suitable area for deploying solar panels in study area according to LST Analysis, the area chosen because it is reflecting the higher amount of solar radiation (yellow color) and located in un-build up area (western garden border to study area) to deploy solar panel with minimum logistic problems and gain the highest amount of solar power to support smart city activities and residents.

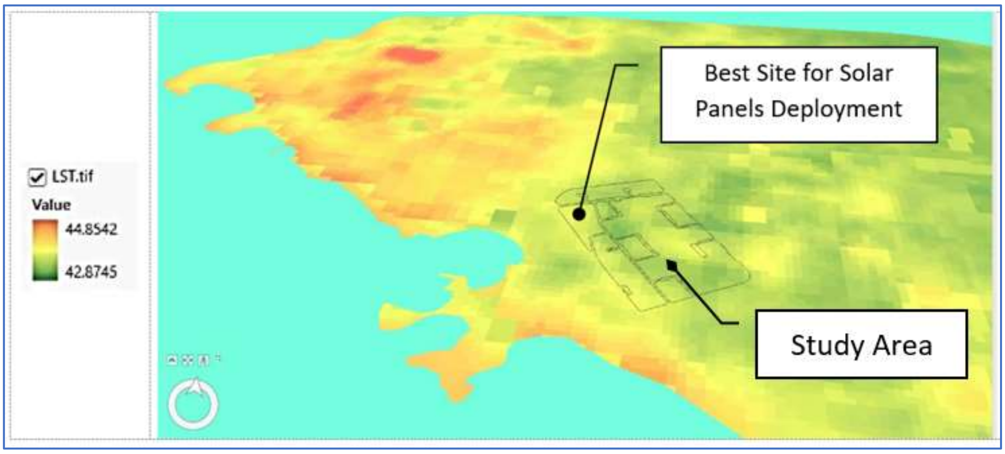


Figure 5: most suitable area for deploying solar panels in study area according to LST Analysis derived from ArcGIS Pro®

### 4.5 Buildings Modeling and sustainability analysis using Revit®

Using Rivet® software, two building types has been modelled, first model existed on the western side from study area, which has a different designing type comparing to surrounding buildings. Figure (6) shows the final modeling done using Revit® for the first model.

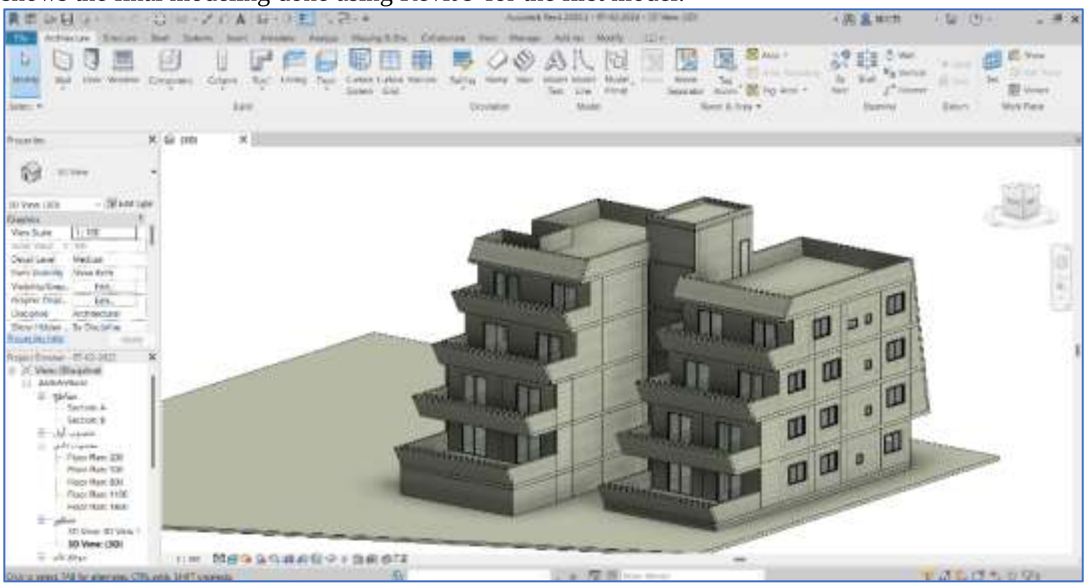

Figure 6: Western side Building style modeling using Revit®



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Second Model was an ordinary Building, and the floor numbers was exactly as designed in official master plan for the study area. Figure (7) shows the final prospect of second building model done by Revit®.

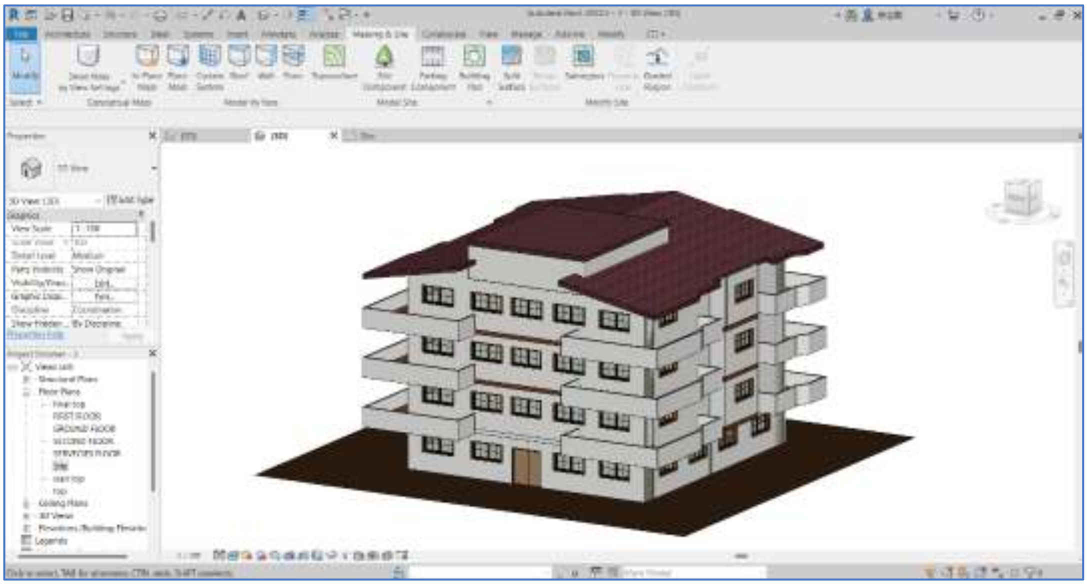

Figure 7: Ordinary Building style modeling using Revit®

And producing side by side the general site 3D model using Revit®, as shown in Figure (8).

Figure 8: General Site Modeling using Revit®.

### 4.5.1 Using Insight™ extension to analyze building energy

By studying the sun radiation effects on building, Insight Extension support sustainability analysis with in Revit®. That determine and lead to more efficient using for the most available clean source of power, the solar power. Earth Affected by sun radiation ten thousand times more than humanity consuming this power. On the other hand, solar power technology can provide heat, cooling, natural lightning, and power source for wide range of applications.

The study implemented in this research called "Annual PV", and because of correct geometric orientation given to buildings models, the analysis was combatable with the default north direction, and analysis repeated twice, first one was made using (cement block) as building material. Otherwise, second analysis was made with different building material (15 cm hollow brick with 10 cm cement block on the southern, eastern and western walls, 15 cm hollow brick with 5 cm air void, and cement oak on the walls Northern).



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Figure (9) shows sun analysis results and PV Energy Production amount before changing building material, while Figure (10) shows the enhanced result of PV Energy Production reached by changing building materials.

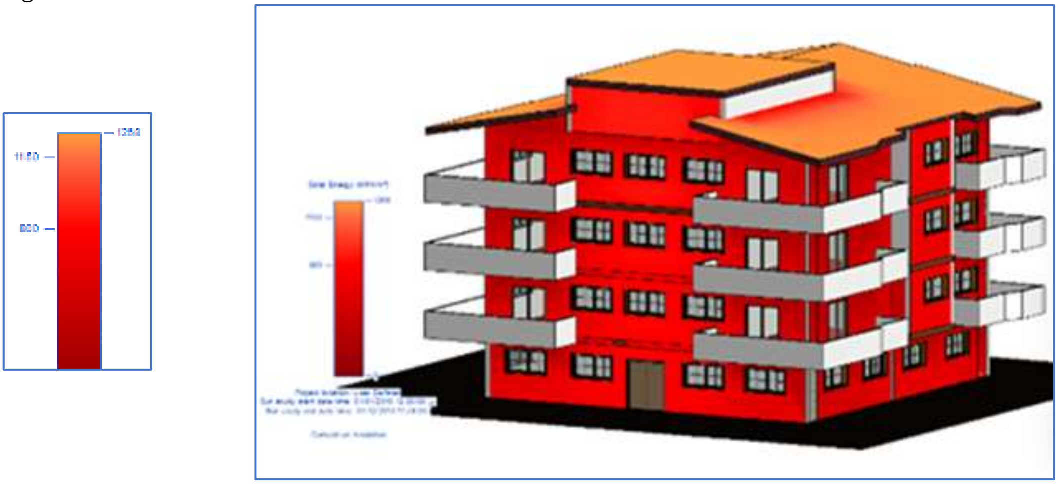

Figure 9: Sun Analysis Results and PV Energy Production for the First Situation (Default building material)


Figure 10: Sun Analysis Results and PV Energy Production for the Second Situation (Changing building material)

### 4.5.2 Insight Analysis results and comparison

By comparing PV Energy Production derived for those models, we can assure that changing building material saves more energy and lead to more sustainable building design. Table (2) led the shed on numeric results done by Insight™ extension using Revit®, note this results was obtained just for modelled building and not for all study area buildings.



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Table 2: PV Annual Analysis results using Revit® Insight (for one building only)

| | Without Changing Building Material Situation (1) | After Changing Building Materials Situation (2) |
|---|---|---|
| ***PV Energy Production (kwh/year)*** | **107346** | **148444** |
| ***Building Energy Offset ($m^2$)*** | **1044** | **1102** |
| ***Energy Savings (Dollar)*** | **2500** | **3500** |

As table (2) refers, the second suggestion for material building enhance the building power savings by (3500 dollar), so depending on this parameter, the second solution is more energy efficient, but it needs more solar panels instead, because first solution needs (1044 $m^2$) only, while second one needs (1102 $m^2$) from solar panels.
More deep analysis for the second solution shows that roof area only can covered by (700 m2) from solar panels, so the suggestion was to convert glass facades and windows into solar panels as well, which mean these objects will be multifunction ones. Figure (11) shows the final overview for smart building modeling derived from Revit®.

Figure 11: Smart Building Model Derived from Revit®

### 4.6 Suggesting Infrastructure Tunnel network in study area project

Final step on applied methodology for sustainable smart city implementation, was to determine the infrastructure tunnels network underneath the city roads, that will serve as junction part for its elements, the road layer was digitized on the step of building and creating study area geodatabase, and it is completely designed according to official planning map derived from Lattakia City Council, figure (12) shows the infrastructure network at study area in 3D perspective, it is compatible with road network, and support sewage pipes, water pipes, drainage pipes, electricity pipes, telecommunication cables, and sensors cables. All this parts connected to each other's by Command Center Building proposed in the research, and this command center relay heavily on the Geodatabase suggested in the research as well.



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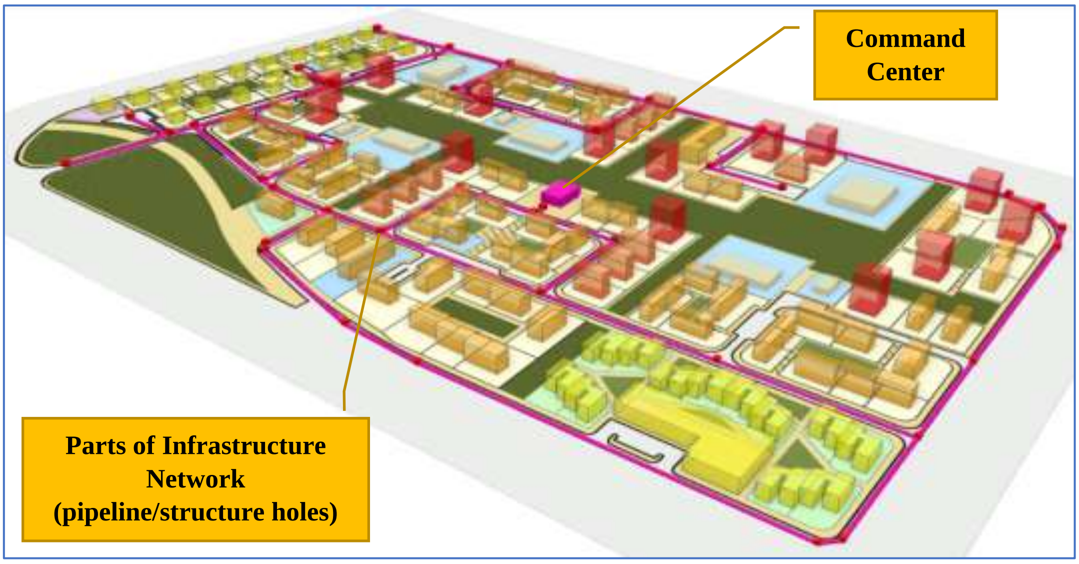


Figure 12: Infrastructure Network under project Location

**6. Conclusion**

In this research, we focused on determining and implementing the most suitable methodology to transform into sustainable smart city, the applied methodology covered four main points: starting with creating an accurate geodatabase for study area, then using GIS technology to investigate the planning standards like land use ratio and building orientation, and introducing sustainable site selection by suggesting a suitable site for solar panels station, finally using BIM technology to insure reaching sustainable building design. And the final results showed:

1- First of all, building an accurate geodatabase is essential part for sustainable city design, because the more information and data derived and analyzed the more efficient smart city resulted, due to the amount of spatial analysis can done using GIS technology, like Sun Shadow Frequency analysis and Land Surface Temperature analysis, which both gives a sustainable direction to overall smart city design.

2- In external energy analysis section, using ArcGIS Pro® software to analyze Sun Shadow Frequency at study area allows us to accurately determine the needs for buildings orientation or not, in our case there was no need for building rotating because most of the area doesn't covered with shadow more than 15% most of the analysis time series.

3- Using also ArcGIS Pro® to suggest renewable clean energy plant location, by calculating and creating Land Surface Temperature map, and proposing the best location to deploy the solar panel in northwestern part from study area.

4- In internal energy savings analysis, Insight™ extension within Revit® software was used to study the building energy (Annual PV), for two situations, first without changing building materials, gaining (107346 kwh/year) in PV Energy Production, leading to (2500 dollar) in total Energy Savings. But after changing the building materials to rise the amount of insulation, and rising roof slope, we enhance the PV Energy Production to (148444 kwh/year), leading to enhance total Energy saving to (3500 dollar).

5- Finally, an infrastructure network was suggested in order to support the sustainable smart city structure.

After reviewing the research results, we recommend to follow the applied methodology in sustainable city implementation, because it balancing the needs for energy in both external and internal side. And encouraging the integration of GIS/BIM technologies because of its advantages in smart cities design. This new approach seems to be valuable and flexible method to ensure reliable transformation toward sustainable smart city planning and support its applications, we highly recommend to use the BIM\GIS integrated approaches that described in our new suggested approach, and studying more basics of sustainable city planning parameters in the future that research doesn't cover yet.

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