Using GIS in Sustainable Urban Planning Evaluation of Educational Services in Basilia City

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Abstract

The study presents an applied model of how GIS technology can be used to analyze spatial information and highlight the spatial relationships between them, as the research relied on studying the areas of distribution of educational services in the city of Basilia as one of the cities located in the Syrian capital, Damascus, and then the research extracts the spatial relationships and the nature of the distribution of educational services within the region and identifying the service areas and access distances for each category and comparing them with the approved standards. GIS technology is a good tool for this type of applied studies, where maps can be entered, spatial classifications and distribution of services and the use of Spatial Analyst tools and Spatial Statistics tools in modeling information and analysis, highlighting the relationship in the spread of these services within the region, assessing the pattern of spread and identifying the places that lack those services, and then developing recommendations aimed at sustainable urban planning.

Keywords: GIS; Sustainable Urban Planning; Educational services

1. Introduction

In the ever-evolving landscape of urbanization, the imperative to practice sustainable urban planning arises to meet the needs of current generations without compromising the ability of future generations to meet their own, and the synergy between technological advancements and project management methodologies has become paramount [1]. Within this context, the Architectural, Engineering, and Construction (AEC) industry is considered as the primary driver of global development [2]. it plays a pivotal role, shaping our cities and economies. Two transformative technologies Geographic Information Systems (GIS) and Building Information Modeling (BIM) have emerged as catalysts for change.

1.1 Beyond Traditional Methods

The AEC industry, like other industries, benefits from Information and Communication Technology (ICT) [3]. The crucial need for innovative, sophisticated, and complex projects in the AEC industry, with detailed specifications, renders conventional approaches inadequate, performance and productivity [4]. Shifting away from conventional methods towards sustainable and eco-friendly approaches is essential [5].

1.2 BIM: Global Trends and Local Context

BIM is considered an innovative way of addressing the many problems that arise in the design, construction, and maintenance of buildings [6].

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Developed countries have acknowledged the advantages of BIM and view it as the future standard for the AEC industry [7]. However, developing countries are still in the nascent phase of investigating BIM and seeking effective practical strategies for its adoption [7]. Where BIM usage in these regions remains at level 0 or level 1, and the gap between levels 1 and 3 continues to widen [8].

Syrian AEC projects are currently at BIM Maturity Level 0, indicating that there is minimal implementation of BIM in these projects, in addition to that, there is a scarcity of research related to BIM in the AEC industry in Syria, and awareness about BIM remains very low [9].

1.3 GIS: Enhanced Accessible Data by Mapping the Urban

GIS provides a comprehensive view of urban dynamics. By integrating layers of information ranging from land use patterns and transportation networks to environmental factors planners gain insights that transcend traditional approaches. The ability to visualize data spatially empowers decision-makers to create more informed, efficient, and sustainable urban environments.

1.4 Syria's Urgency for Sustainable Urban Planning

During the 11 years of war, Syria has suffered tens of thousands of lives lost [10] and millions have been displaced and forced to migrate. This context underscores the urgency of sustainable urban planning, as cities strive to rebuild and create resilient environments for their inhabitants. The scars of conflict demand thoughtful reconstruction, where GIS and BIM play pivotal roles in shaping a brighter future. And what is worth to mention, the rehabilitation of public facilities has become one of the most frequently discussed initiatives among humanitarian organizations involved in post-war recovery efforts [10].

1.5 The Power of Synergy: GIS-BIM Integration

The integration of BIM and GIS is transforming the fields of design and spatial data analysis. This synergy enhances visualization [11], supports data-driven decision-making, and simplifies processes. BIM provides a digital description of the building process, while GIS captures, manages, and analyzes spatially georeferenced data. Together, they empower smart cities by combining realistic modeling, precise location information, and holistic insights for sustainable urban development. The joint use of BIM and GIS is a current trend in 3D city modeling, bridging the gap between design and spatial data.

2. Related Work

2.1 Overview

Since its inception in the 1970s, GIS has been instrumental in urban infrastructure planning and development [12]. It facilitates the analysis of collected data, making it easier to implement various proposals [13]. GIS applications play a crucial role in smart urban development by addressing necessary issues and presenting them to individuals [14]

Spatial approaches and GIS technologies are extensively utilized to analyze the distribution of accessible urban green spaces [15]. Key research areas include identifying regions with inadequate accessibility [16], social disparities affecting ethnic minorities with restricted access to green spaces [17] [18] [19], and the correlation between the availability and accessibility of green spaces and health outcomes [20] [21]. Recently, the modeling of accessibility to green spaces has significantly advanced, thanks to improved GIS capabilities (notably the development of GIS network analysis tools like ArcGIS Network Analyst) and the enhanced computational power of personal computers. Moving beyond simple radius-buffering methods that assess the number of facilities and the proportion of the population within a defined area [22] [23], recent studies have incorporated urban landscape features or socio-economic data with more sophisticated distance evaluation techniques [19] [24].

2.2 The Use of GIS in Urban Planning

GIS has become more accessible to urban planners and is now a crucial tool in urban planning for both developed and developing nations. GIS is one of several formalized, computer-based information systems that can integrate data from various sources to provide the necessary information for effective decision-making in urban planning [25]. Urban planning also employs various information systems, such as decision support systems (DSS), database management systems (DBMS), and expert systems. GIS functions as both a database and a versatile toolset for urban planning (Figure 1) [26]

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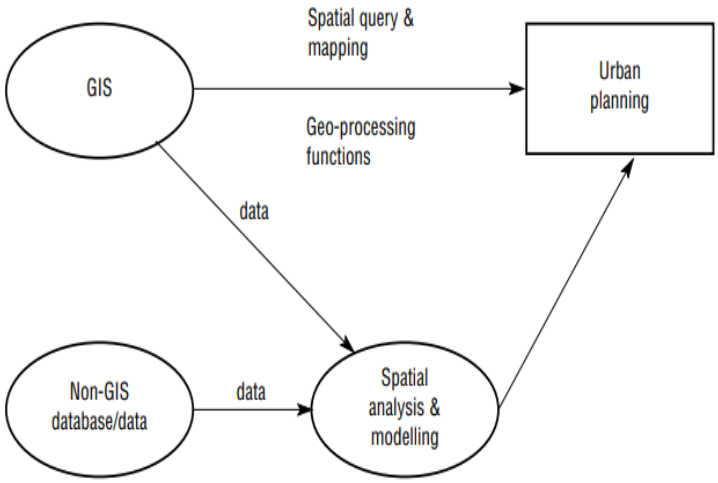

Figure 1. GIS and urban planning

2.3 The Use of GIS in Different Functions and Stages in Urban Planning

The use of the data management, spatial analysis, visualisation and modelling components of GIS varies according to different functions of urban planning (Figure 2(a)). Data management, visualisation, and spatial analysis are used more in the routine work of urban planning. Spatial modelling is used more in strategic planning. General administration employs mainly data management and visualisation. Finally, development control uses the visualisation and spatial analysis functions of GIS most. The routine tasks of general administration and development control in urban planning includes [27]:

- Management of land use records
- Thematic mapping
- planning application processing
- Building control application processing;
- Land use management
- Land availability and development monitoring
- Industrial, commercial, and retail floor space recording
- Recreational and countryside facility planning
- Environmental impact assessment
- contaminated and derelict land registers
- Land use/transport strategic planning
- Public facilities and shops catchment area and accessibility analysis
- Social area and deprivation analysis

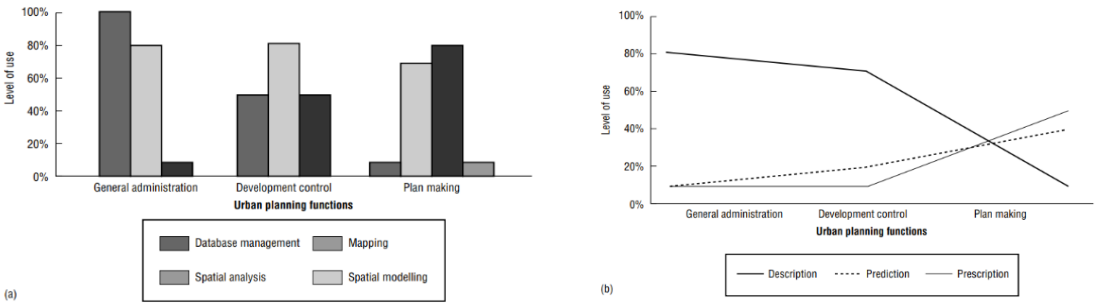

Figure 2. (a) Use of GIS functions in urban planning; and (b) their importance for description, prediction, and prescription functions in three types of urban planning activity

3. Research Methodology

This research adopted the spatial analysis technique to study the features of the phenomenon and identify its patterns, as well as the descriptive approach to study and analyze the study data for the purposes of presentation and evaluation.

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A set of methodological tools have been employed, especially geographic information systems techniques, field surveys, and the use of region-specific plans and maps.

Analysis of the scope of service zoning: It is the spatial boundaries covered by the service from the population benefiting from that service, and its theoretical form is that its center is the service and its perimeter is the maximum distance between the service and the population served.

Mean Center tool: It is used to determine the geographic center of a group of point features. The Mean Center is calculated by calculating the geographic center of the individual points and then calculating the geographic center of the group as a whole. This concept is used in many applications, such as locating urban centers, locating neighborhood centers, or locating emergency safety centers

Study area

● The Basilia City Residential Towers project is located within the second area 102 of the Southern Planning Project, and includes the following real estate areas (Mezzeh - Kafar Sousse - Qanawat Basateen - Daraya - Qadam)

● The Basilia City Towers area is considered one of the largest regulatory areas in Syria, as its area reaches 900 hectares, equivalent to 9 million square metres, and includes approximately 4,000 properties.

● The population is about 255,000 people

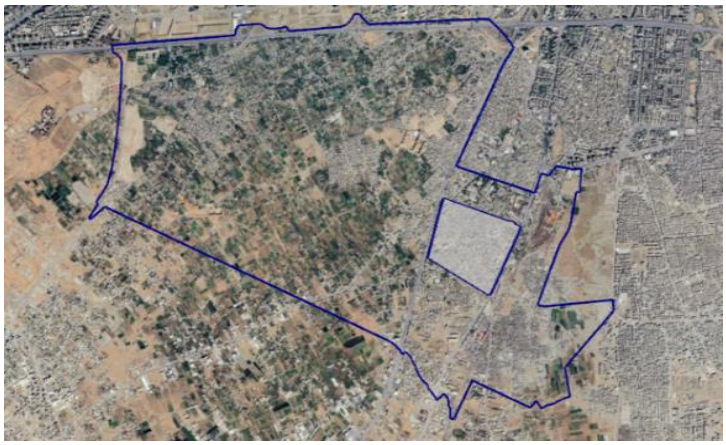

Figure 3. The borders of the Basilia City

Table 1: Standards of Educational institutions that must be provided in residential organizational units

Residential Units Type	**Category**	**Average**	**The number of students**
Residential group	Kindergarten	- 12 m2 per student	- 4% of the total population
Basic unit	the basic education	- 12 m2 per student	- 22% of the total population
neighborhood	General secondary education	- 16 m2 per student - 3 m2 per person of the total population	- 4% of the total population
Residential sector	Vocational education	- 16 m2 per student - 0.6 m2 per person of the total population	-determined according to the privacy of the gathering
The entire city or urban area	Higher education & specialized institutes	-	-determined according to the privacy of the gathering

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Table 2: Distance standards

Category	**Access Distance walking of foot (m)**
Kindergarten	500 >
the basic education	1000 – 500
secondary education	1500 – 1000

4. Results discussion

● The results of the spatial analysis using the ArcGIS program for educational service sites in the city of Basilia revealed a random and irregular distribution within the region in general. There is a discrepancy in the distribution of educational services, as there is a concentration of kindergarten services in the southeastern region.

Note that the scope of educational service provision has been represented so that the center of the circle is the educational service and the radius is the approved standard for ease of access (kindergarten up to 500 m Figure 4- basic education up to 1000 m Figure 5).

Figure 4. Scope of Service for Kindergartens

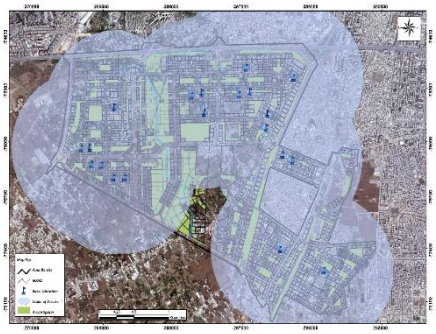

Figure 5. Scope of Service for Basic Education

● Geographical distribution measurements showed that the Mean Center for the distribution of kindergarten services is located slightly in the southeast direction (Figure 6), while for basic education, the spatial Mean is located in the middle of the region (Figure 7).

Figure 6. Mean Center for Kindergartens

Figure 7. Mean Center for Basic Education

● The results of the spatial analysis also showed that there is an overlap in the service scopes of educational services, and this is evident in the figure (8), where a convergence is observed between the locations of educational services, whether kindergarten or basic education, but in the last one, it appears more clearly as it is shown in figure (9).

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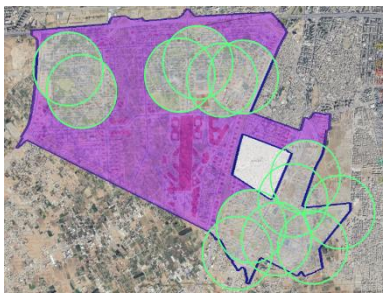

Figure 8. The green circles represent the scope of service for kindergartens

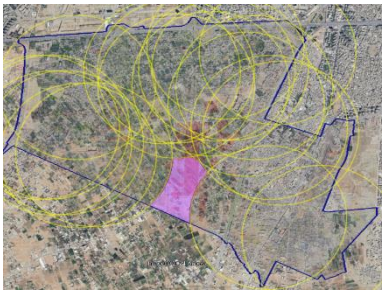

Figure 9. The yellow circles represent the scope of service for basic education

● Despite the overlap in the service scopes of these services, it is also noted that there are areas outside the scope and this is clearly evident in kindergarten services, where the area of the areas outside the scope of service is almost equal to the area of the areas within the scope of service. As for basic education, the area of the area is outside the scope of service. It is a small area compared to the area of the serviced area. ((The areas covered in purple represent the areas outside the service scope in both figures 8-9))

5. Conclusion

The study highlighted the role of geographic information systems in being a decision-supporting tool through advanced spatial analysis techniques as well as spatial query mechanisms and with different tools and conditions

- Recommendations:

✓ Taking into account the approved standards in planning before starting to build new educational services

✓ Consider choosing appropriate locations for schools when starting the planning process to build new educational services

✓ Create a comprehensive and accurate database about schools and the number of students and update it constantly, which can benefit planners in the future.

✓ Providing a sufficient number of buildings to comply with the approved spatial and spatial standards

✓ Reconsidering the distribution of kindergarten and basic education services in the city of Basilia

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