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A Spatial Analyze Approach for Determining the Best Possible Locations of Police Stations in Azaz

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Abstract

In the context of sustainable urban planning, identifying an optimal land use location plays a crucial role in effectively managing land distribution. Therefore, a comprehensive evaluation of various factors influencing the choice is necessary to determine the most suitable site. This paper aims to identify an appropriate location for a police station in Azaz City using Geographic Information Systems (GIS). A novel approach is proposed by integrating service area analysis and multi-criteria analysis to minimize emergency response time. The evaluation process focuses on travel time from the existing police station within the study area. Three critical zones were generated using network analysis, each representing coverage within a one-minute travel time. These critical zones were ranked and assigned weights based on their proximity to high-crime areas and travel time from other essential facilities. The facilities were categorized into three groups, namely education, health, and tourism services. A suitability map was created to determine the priority of alternative locations, and the highly suitable area was overlaid with an aerial photograph to assess land availability. Finally, facility location-allocation techniques were utilized to select the optimal site for establishing a police station. This approach offers valuable insights for governmental bodies and urban planners seeking to make informed decisions regarding site selection.

Keywords

Geographic Information System GIS, Spatial Analysis, Police Station, Safety and Security, Land Use.

1. Introduction

Selecting the best location for something new is crucial in sustainable urban planning. To assess site suitability, data from various sources and complex analyses are integrated (El Baroudy 2016). One common approach is Multi-Criteria Decision Analysis (MCDA) (Elsheikh 2016) (Chakraborty 2013), which considers different methods and processes for decision-making in fields like mathematics, management, planning, and economics (Guarini 2018). When choosing a site for a police station, factors like proximity to other police stations, main roads, and crime-prone areas are considered (Hasan Rahmani 2015). Visualizing crime hotspots and existing police stations helps identify suitable locations for a new police station (Kim 2012). However, many emergency location selections are made using simple analysis, focusing on the geographical distribution of police stations and service area gaps (M. M. Ahmed 2013). The ranking is a simple method but lacks a mathematical foundation. To address this, Saaty proposed the pairwise comparison method within the Analytic Hierarchy Process (AHP) (Saaty. 2008). AHP has been used in GIS-based emergency site suitability procedures (H. S. Mirzahossein 2020). Buffer analysis in GIS cannot accurately determine reachable travel times. Integrating service area analysis and multi-criteria analysis provides a better solution by considering a range of perspectives rather than a single approach, increasing the study's certainty.

When searching for a suitable location for a new police station, several objectives must be considered, such as reducing response time, minimizing costs, and maximizing coverage (Şen 2011). Geographic Information Systems (GIS) is a valuable tool for handling large amounts of spatial information (Hamadouche 2014). In emergency situations, quick access to critical areas is crucial. Therefore, the chosen location should prioritize travel time. Using GIS, we can map service areas based on travel time from existing police stations. This involves combining service area analysis and Multi-Criteria Analysis (MCA) to improve decision-making for optimal planning of the new police station's location.

The effective and strategic placement of police stations plays a crucial role in maintaining law and order in urban areas. The location of police stations can significantly impact response times, accessibility, and overall effectiveness in combating crime and ensuring public safety. In the context of Azaz city, a rapidly growing urban center with unique geographic and demographic characteristics, the optimal location of a police station is of paramount importance.

The United Nations Human Settlements Program (UN-Habitat) has developed widely recognized methodologies for urban planning and development, including the assessment of police station locations. UN-Habitat's approach takes into consideration various spatial factors, such as crime patterns, population density, and transportation infrastructure, to identify optimal locations for police stations in urban areas. In addition, ArcGIS, a popular geographic information system (GIS) software, offers powerful spatial analysis capabilities that can be leveraged to analyze and visualize spatial data for identifying suitable police station locations.

This study aims to utilize UN-Habitat methodology, in conjunction with ArcGIS spatial map analysis, to identify the best location for a police station in Azaz city. By applying a data-driven and evidence-based approach, this research seeks to provide valuable insights for urban planners, policymakers, and law enforcement agencies to make informed decisions on the optimal location of a police station in Azaz city.

The specific objectives of this study are to:

1. Collect and analyze relevant data, including crime rates, population density, transportation infrastructure, and other spatial factors.
2. Utilize UN-Habitat methodology and ArcGIS spatial map analysis to identify potential locations for a police station in Azaz city.
3. Evaluate and compare the potential locations based on defined criteria.
4. Make recommendations for the best location of a police station in Azaz city, supported by evidence-based justifications.

The findings of this research are expected to contribute to the body of knowledge on optimal police station location analysis and provide practical insights for urban planning and law enforcement strategies in Azaz city.

2. Methodology

The methodology utilized in this research comprises two main parts. In the first part, critical zones were delineated around the existing police stations using network analysis. These zones represented areas that could be reached within one minute of travel time and were considered crucial for police coverage. Within these critical zones, demand points were identified, including facilities related to education, health, and tourism services.

In the second part of the methodology, a ranking multi-criteria decision-making analysis method was employed to identify areas within the critical zones that were at higher risk for crime or required increased police presence. This analysis facilitated the generation of a suitability map highlighting areas with higher crime susceptibility. The highly suitable areas were then overlaid with aerial photographs to assess the availability of land for potential police station locations, providing a comprehensive assessment of the physical feasibility of establishing new police stations.".

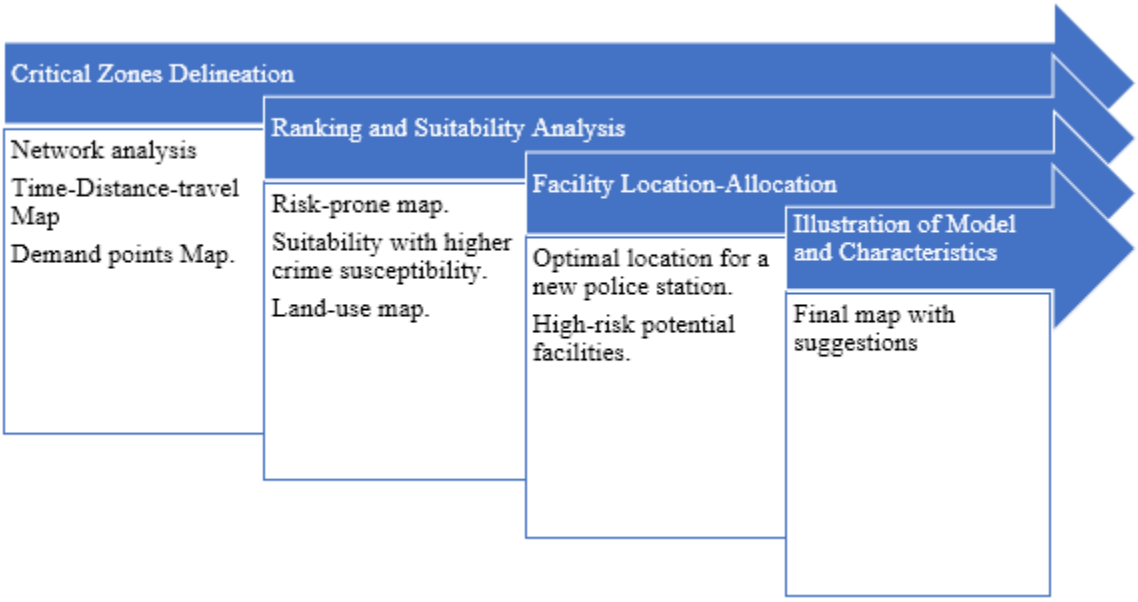

Figure 1. Methodology Workflow

To identify the best location for a new police station, facility location-allocation techniques were used (Figure 1). This process involved considering factors such as accessibility, risk-prone areas, and land availability to select the optimal location for the new police station. Finally, the model and its characteristics were illustrated to provide a comprehensive understanding of the methodology employed in this research.

It's important to note that the specific tools and techniques used in the methodology may vary depending on the software or technology employed in the research, such as ArcGIS or other GIS software.

2.1. Current case study area

Azaz is a city in northwest Syria, roughly 20 miles (32 kilometres) north-northwest of Aleppo. (Figure 2)
According to the Syria Central Bureau of Statistics (CBS), Azaz had a population of 31,623 in the 2004 census. (CBS 2004). As of 2015, its inhabitants were almost entirely Sunni Muslims, mostly Arabs but also some Kurds and Turkmen (CBS, 2004).

It is close to a Syria–Turkey border crossing, which enters Turkey at Öncüpınar, south of the city of Kilis. It is the capital of the Syrian Interim Government (Warontherocks 2017).

The population of Azaz city has been experiencing significant growth as a result of internal displacement caused by individuals seeking employment opportunities and improved living conditions, while also fleeing from the devastating impacts of war.

As immigration and population growth continue to occur, the demand for police services in Azaz city has increased significantly, placing immense pressure on the existing police resources.

The city of Azaz was chosen as the study area, with the analysis focused on the extension of the study area and its networks. Within the study area, there is currently one existing police station, as shown in (Figure 3).

2.2. GIS Data

The road network data used in this study was obtained from satellite images (Google Earth) after geo-referencing using four control points collected by the Urban Research Center (URC) team in Azaz. GPS coordinates of the existing police stations were also collected. Data related to health, education, and public services layers, as well as attribute data of the road networks, were obtained from URC's Azaz City Profile (URC 2016).

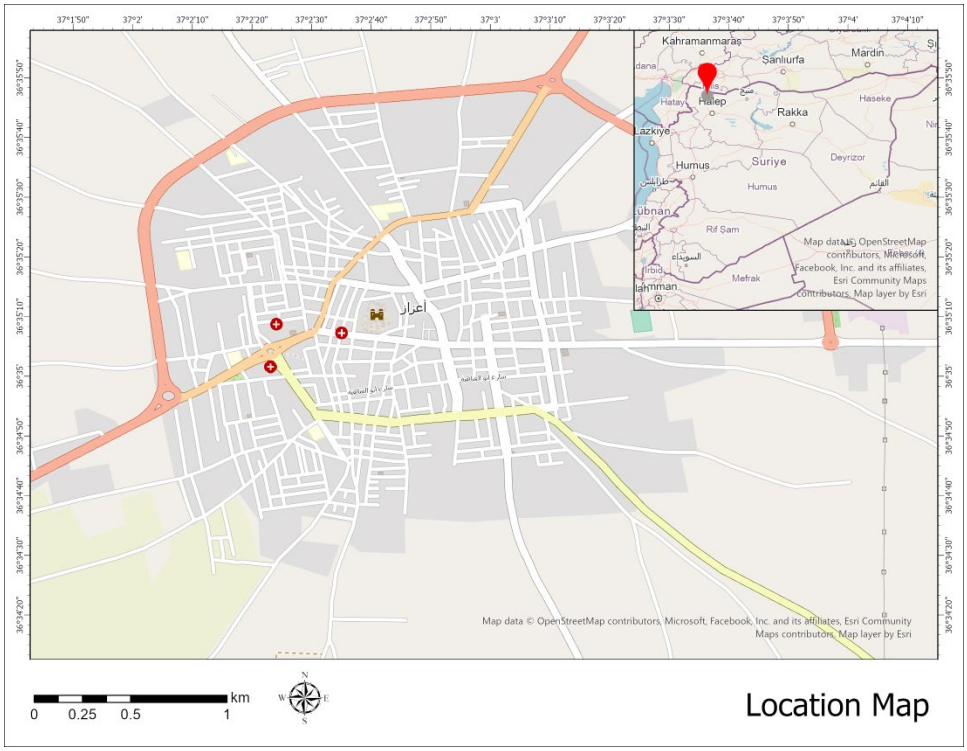

Figure 2. Azaz City

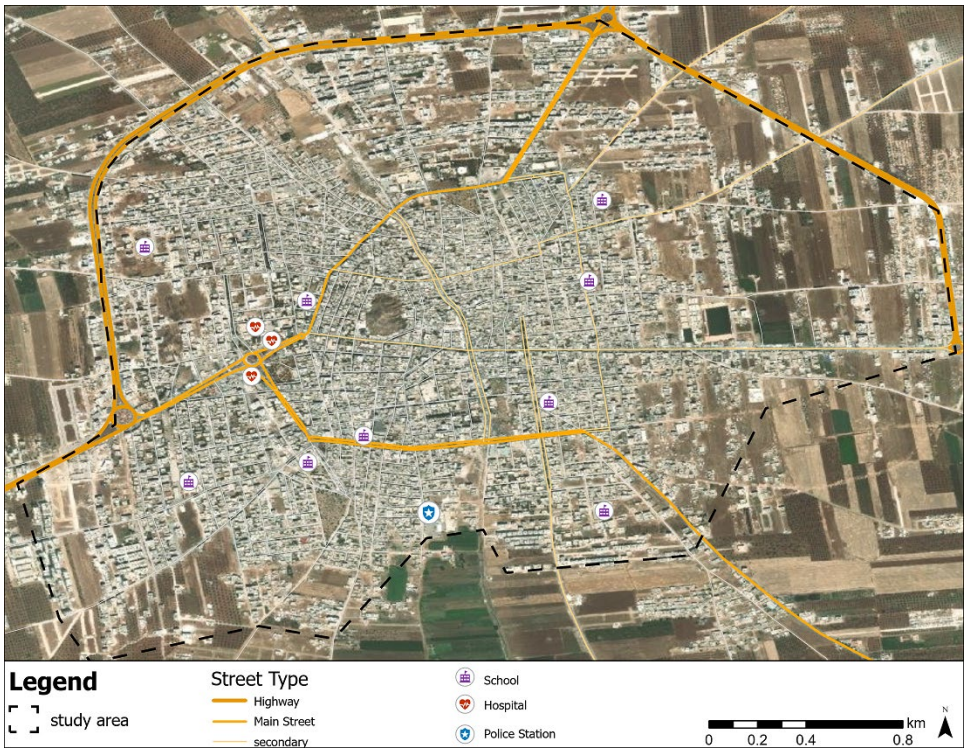

Figure 3. Azaz Street Network and land use

2.3. Network analysis

Network analysis is a powerful tool that can effectively model real-world network conditions. It can be utilized to analyze various problems such as vehicle routing, closest facility, and service area, by incorporating data on roadways and cost attributes (Ahmed (2017), Mar (2019), Hetamsaria (2019) and Elsheikh (2016)). In emergency situations, rapid access to critical areas is crucial for saving lives and minimizing damage. The response time between the location of police services and the incident can be measured in seconds. Maps play a significant role during emergencies as they help in understanding the extent of the impact, coordinating response efforts, and conducting search and rescue operations (Balasubramani 2016). Therefore, the initial evaluation in this study will be based on travel time using network analysis. GIS can be leveraged to calculate accessibility in terms of travel time and assess it against specific criteria (Comber 2009).

In this study, a network dataset was generated, which included important parameters such as distance (in meters), speed (in km/h), road direction, road name, and road type. Arrival and return times were calculated in minutes based on the speed and distance. Topology analysis was conducted to ensure model validation and connectivity relationships. Subsequently, the network dataset was utilized to identify three critical zones surrounding the police stations, where each zone represented an area reachable within one minute of travel time using the service area application (as shown in Figure 4).

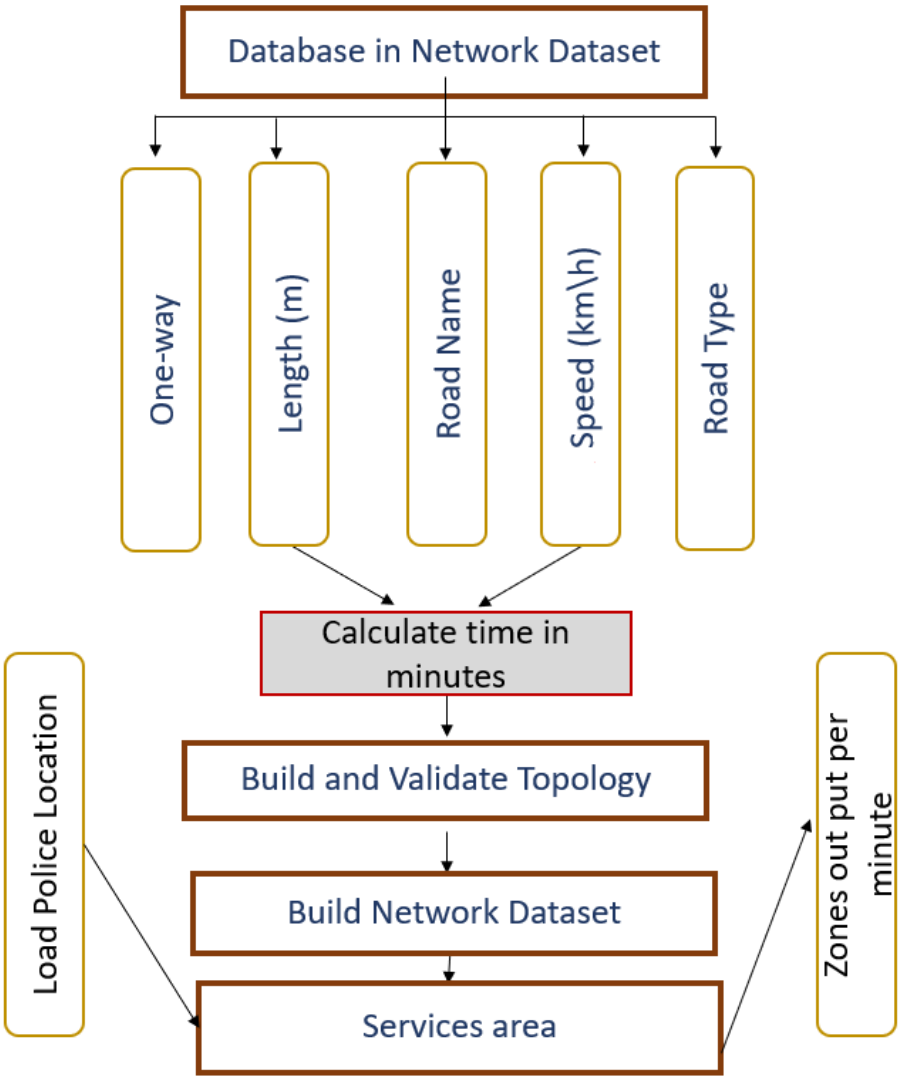

Figure 4. Network Analysis Workflow

3. Results and Discussion

Previous studies have commonly used buffer zones from a specific point to create service areas (H. S. Mirzahossein 2020) (Soltani 2011). However, in this study, service analysis was conducted using four parameters. Firstly, time was chosen as a cost attribute to determine accessibility. Secondly, a one-way attribute was incorporated to account for vehicles that must follow one-way streets, treated as restrictions. Thirdly, default service areas were set with a break of three, and the extent of each service area was calculated based on a one-minute travel time from the police station. Finally, service areas were generated by accumulating impedance in either the direction away from or towards the police station (as illustrated in Figure 5). This approach takes into account travel time, road network restrictions, and impedance accumulation to create more accurate and realistic service areas for analysis.

Service Area Analysis in this study was conducted based on distance and time, which illustrates how accessibility varies with impedance. Emergency response time is crucial and depends on factors such as the condition of the emergency response vehicle and potential obstructions along the road network (Nicoară 2014). Quick arrival of police officers at the scene allows for timely arrest of suspects, gathering witness testimonies, and preventing destruction or contamination of physical evidence (Vidal 2015). Rapid response time, typically defined as less than five minutes, is considered an effective tool for crime detection by police forces (Bratton 2009) (Karn 2013). In this study, all service areas were overlapped to identify non-service areas where travel time of 5 minutes was deemed insufficient to reach a location. These areas were designated as 'critical zones' for further evaluation.

Based on the map data, it is observed that only 64% of the total area is covered by police stations within a 5-minute travel distance (equivalent to more than 2000 meters). This indicates that 46% of the study area is not adequately served by police stations, particularly in the Blue Area. As a result, it is necessary to establish at least one additional police station to cover the unserved areas.

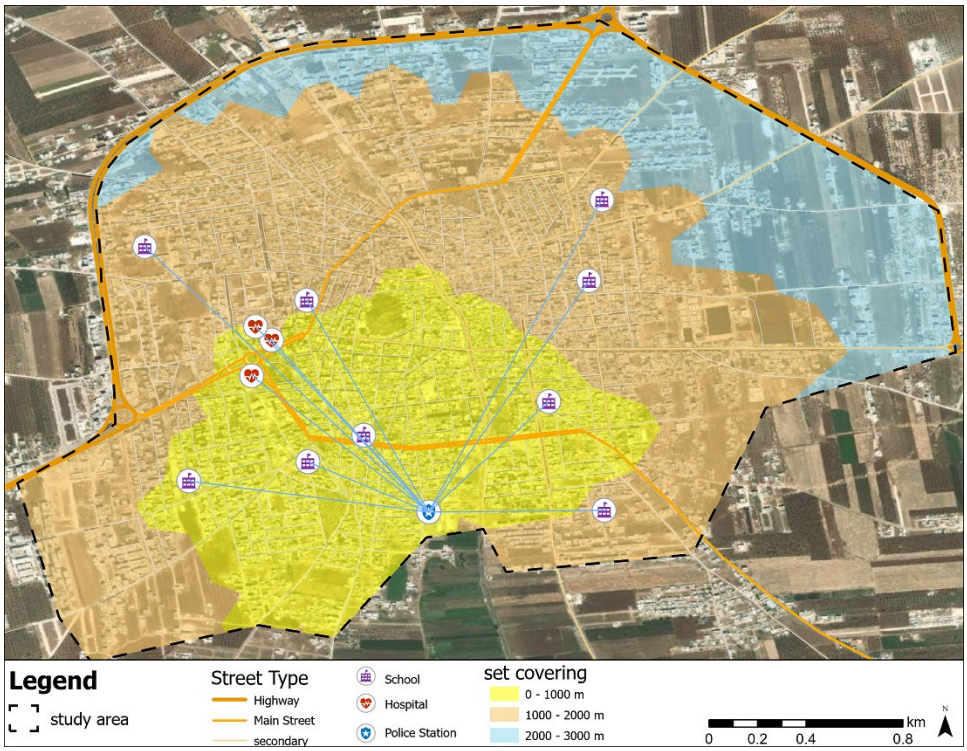

Figure 5. Service Area zones based on travel time from a police station

Land use planning is a valuable method for managing and regulating the allocation of land, taking into account the risk characteristics of different locations (Nguyen 2017). This process involves assessing the requirements of a proposed facility against the likelihood of crime-prone areas. Currently, there is a trend of increased crime hotspots

near public areas (Yang 2019). The facilities located in critical zones were identified and categorized into three classes: education, health, and tourism services, as illustrated in (Figure 5).

The ranking method was used to assess each criterion by assigning a preference order as determined by the decision maker. The factors were ranked using inverse ranking, where 1 represented the least important and 3 represented the most important factor. Areas that were farthest from a particular facility received a low potential rank of 1. The critical zones that were reachable within a 10-minute (more than 2000m) timeframe were ranked as the most important with a rank value of 3. After reclassifying and ranking all layers, a composite map was generated to identify risk-prone areas, which were categorized into three classes (as shown in Figure 5). Class 3, represented by the color blue, was identified as the highest-risk area and the most suitable site for locating a new police station.

4. Suggestion to Improve the Service

Based on the creation of a suitability map to prioritize alternative locations, overlaying aerial photographs to assess land availability, and conducting location-allocation analysis, the recommended location for a new police station is the northern side of Azaz (as shown in Figure 6). This suggested location should be in close proximity to the main road that connects the surrounding highway, ensuring good coverage for the northern side of the city. It is also crucial to take into account the anticipated city expansion over the next 10 years when considering the placement of the new police station.

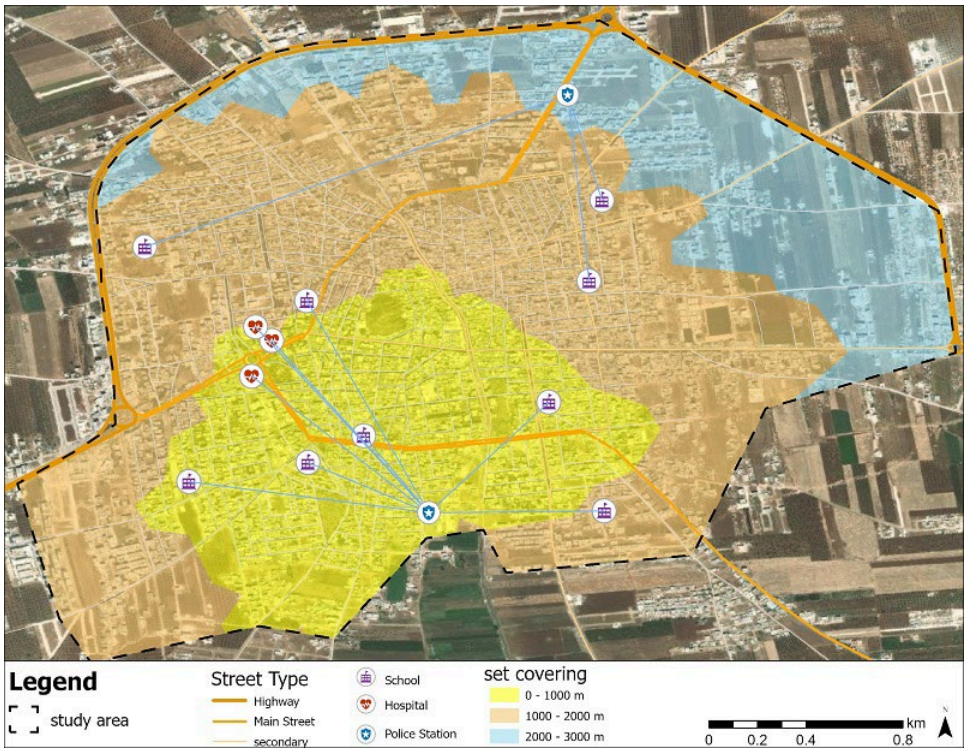

Figure 6. Finding the best location by Location-Allocation Analysis

5. Conclusion

The Risk-prone map can serve as a valuable tool for planners, insurers, and emergency services in selecting optimal sites for new police stations. The study highlights the role of Geographic Information Systems (GIS) in decision-making and optimal planning, emphasizing the importance of considering travel time and distance from facilities, as well as hotspot trends of crime to improve service delivery and increase safety. By integrating service areas in network analysis and multi-criteria analysis, the study provides a clear understanding of high-risk zones where minimizing response time is crucial. These high-risk zones are identified as suitable areas for candidate locations. Location-allocation analysis is then applied to choose the best location among the candidate facilities, considering cost and

demand allocation. This approach offers optimal solutions for government or planners in making informed decisions for site selection.

For future studies, it is recommended to consider crime information and its spatial distribution as effective factors in site selection. The implemented Network Analysis can be extended to cover the entire area around Azaz, including suburbs, to provide a more comprehensive understanding of the road network and potential site locations for police stations.

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Biographies

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