Cal Poly Pomona

CIS 3350 – Geographic Information Systems
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Group 5 – GIS Term Project

Identifying Gaps in Emergency Service Coverage

A GIS-Based Spatial Analysis of Fire Station and Hospital Accessibility in Pomona, CA

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1. Introduction:

Emergency response times are a critical determinant of the efficiency and effectiveness of public safety services. Quick and efficient responses to medical emergencies, medical crises, or violent incidents, fire incidents, and natural disasters can mean the difference between life and death. When response times are delayed, it can lead to increased casualties, greater property loss, and long-term negative impacts on affected communities. Thus, optimizing the locations of emergency service facilities, such as fire stations and hospitals, in locations that allow for the fastest possible response times. Cities like Pomona, California, face unique challenges in emergency response planning. In these regions, emergency response times often exceed the recommended standards due to traffic congestion, inefficient road networks, and the geographical placement of fire stations and hospitals.

This project does not focus on simulating response times or proposing new facility locations. Instead, it aims to use Geographic Information Systems (GIS) to identify areas that are underserved by existing emergency services. GIS tools allow for the visualization and analysis of population density, existing emergency service locations, and crime data to highlight underserved areas. The results aim to support data-driven decision-making for future EMS resource allocation and infrastructure planning.

1.2 Existing Problem & Facts

Emergency response times can vary significantly depending on the region, and in many cases, they exceed the National Fire Protection Association (NFPA) recommended standard of five minutes in urban settings. Multiple factors contribute to these delays, including population density, road network inefficiencies, and the geographic placement of emergency facilities. In Pomona, a densely populated city in Los Angeles County, certain neighborhoods remain underserved due to their distance from existing fire stations and hospitals, leading to prolonged response times.

One of the primary concerns in Pomona is the uneven distribution of emergency service facilities. While central areas may have better access to hospitals and fire stations, the eastern and southern neighborhoods often experience longer response times due to a lack of nearby emergency facilities. Additionally, densely populated residential areas, such as those around Mission Boulevard and Garey Avenue, face logistical challenges in emergency service deployment, as narrow streets and high traffic congestion can impede ambulance and fire truck movement.

Another significant factor contributing to delays in emergency response is traffic congestion. Major highways such as I-10, SR-57, and SR-71, which pass through Pomona, often experience heavy traffic during peak hours. Delays caused by congestion can prevent emergency vehicles from reaching their destinations in a timely manner. The city's road infrastructure, designed to support high volumes of traffic, does not always provide the most efficient routes for emergency responders, especially when alternative roads are limited or unavailable.

To improve emergency response times in Pomona, it is necessary to conduct a comprehensive spatial analysis of high-risk areas, road networks, and population density to identify the most suitable locations for new fire stations and hospitals. Utilizing Geographic Information Systems (GIS) along with real-time traffic data, city planners can design a more efficient emergency service network that minimizes delays, improves accessibility, and strengthens overall public safety for the community.

Research Objective & Question

Research Question: Where are the spatial gaps in fire station and hospital accessibility in Pomona, CA?

Objective: This study aims to identify areas in Pomona that are underserved by emergency service facilities based on their distance to the nearest fire station and hospitals, by analyzing their distance from these facilities in relation to population density. Through the use of GIS technology to map and evaluate these coverage gaps, we can support future decisions related to emergency planning and public safety

resource allocation. Additionally, by incorporating demographic and crime-related data, the study provides a comprehensive view of where public safety vulnerabilities are most concentrated. The results of the GIS-based from this spatial analysis will support future decision-making related to emergency preparedness, infrastructure planning, and equitable distribution of resources—ultimately enhancing safety and resilience across the city.

2. Literature Review

The first article is about a GIS-enabled smartphone application. The article discusses the critical role of GIS and how the software assisted field workers and decision-makers in more efficiently restoring electricity infrastructure in the disaster-affected region. The app contained all relevant information and details about each village and electrical substation. “It allowed the field teams to report the day’s progress by answering about a dozen simple questions” (Sharma, 2020). “The app helped in bridging key information gaps between the field team planners and the civic administration” (Sharma,2020). After collecting data from field workers, GIS maps were created utilizing app data. These maps used a dot density format, with green dots showing places where power had been restored and red dots indicating areas where it had not. One aspect of this study that could be applied to our project is the use of GIS in data collection and visualization. Geographic Information Systems (GIS) tools like ArcGIS can help show areas that require the most emergency services, whether due to population density, infrastructural concerns, or danger zones, ensuring that resources are prioritized where they are most needed.

The next article highlights the effect of the "golden time" on the efficiency of responses. “This study aims to analyze the operation of fire emergency dispatch, understand the impact of golden time on fire emergency dispatch, and identify factors and improvement measures for effective fire emergency dispatch within prime time” (Park,2024). The concept of "golden time" is the most crucial thing to

remember after an emergency happens. As the article emphasizes the necessity of reducing response times, we can implement this principle in our work by ensuring that emergency service stations, such as fire stations, are strategically located to reduce the time it takes responders to arrive on the scene. We can utilize GIS technologies to examine our area of interest and discover the best locations for emergency services with respect to high-risk zones. GIS can assist us ensure that emergency responders can get to these regions quickly, reducing the "golden time" and increasing results. It is also vital, as stated in the article, to identify key components influencing response times such as road networks, traffic patterns, and access locations.

The third article explained how GIS might be used to identify and prioritize regions for investment in risk reduction measures, particularly in urban areas. “GIS spatial statistics technique is introduced to investigate global regional risk pattern as well as identify local risk hot spots in spatial scale, and scenario planning paradigm is used to explore the dynamically changing regional risk pattern and risk hot spots in temporal scale due to risk reduction”(Zhao,2020). We could implement this strategy in our project by using GIS technologies to identify locations with the highest exposure to emergencies and prioritizing emergency service deployment. For example, in Pomona, our emphasis area, GIS can help identify places most vulnerable to natural disasters and neighborhoods with insufficient emergency services. Using a spatial prioritizing strategy, we may recommend strategically locating fire stations, medical facilities, and other emergency services in high-risk locations.

The last article emphasizes the need to assess disaster recovery efforts in order to enhance future responses. This can be applied to our project by utilizing GIS to evaluate how successfully emergency services responded after a crisis and find areas for improvement. For example, we can utilize GIS tools to assess emergency response timings and coverage. By monitoring response times and comparing them to highly populated regions or high-risk zones, we may determine whether emergency stations are positioned optimally and make recommendations for station placement or resource allocation.

3. Proposed Methodology and Dataset

This study uses Geographic Information Systems (GIS) to analyze the accessibility of emergency services in Pomona, California. The primary purpose is to identify underserved areas where emergency aid is too far away or where the demand for services is overly high. Instead of offering new locations for fire stations or hospitals, the study focuses on identifying gaps in current coverage to inform future planning.

3.1 Critical Variables

What are the critical variables for this study?

The study incorporates the following key variables:

Population Density – Helps identify neighborhoods where more people may be affected by limited emergency service access.

- **Source:** U.S. Census Bureau and ESRI Business Analyst Online
- **Data Type:** Raster (gridded density) and Vector (census tracts).

Existing Fire Stations & Hospitals – Determines current emergency service coverage.

- **Source:** Pomona Utilities GIS Portal, Los Angeles GeoHub
- **Data Type:** Vector (point features).

Road Network – Evaluates accessibility and emergency vehicle routes.

- **Source:** OpenStreetMap, ArcGIS Living Atlas
- **Data Type:** Vector (line features).

3.2 Area of Interest

What is the focus area of this study?

The study focuses on Pomona, California, a city with varying population densities, emergency response times, and infrastructure. This study aims to identify areas in Pomona that are underserved by emergency service facilities, specifically fire stations and hospitals, by examining their geographic distance from these critical infrastructure points in relation to population density

3.3 Geographic Unit of Analysis

What geographic unit will be used?

The study will use Census Tracts and City Boundaries to analyze emergency service accessibility at a localized level while ensuring compatibility with demographic and zoning data.

3.4 How GIS Will Be Used to Answer Research Questions

What are the most suitable locations for new fire stations to ensure efficient emergency response times?

- **Datasets & Variables Used:**
    - **Existing Fire Stations (Point)** – Locations of current emergency services.
    - **Population Density (Raster & Vector, Census Tracts)** – Identifies areas needing additional emergency coverage.
- **ArcGIS Tools Used:**
    - **Service Area Analysis (Network Analyst)** – Identifies coverage gaps based on existing facilities.

- **Drive-Time Analysis** – Estimates emergency response reach within 5, 10, and 15-minute intervals.
- **Weighted Overlay (Raster Analysis)** – Prioritizes sites based on population density and drive time

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Where are the largest coverage gaps in emergency services?

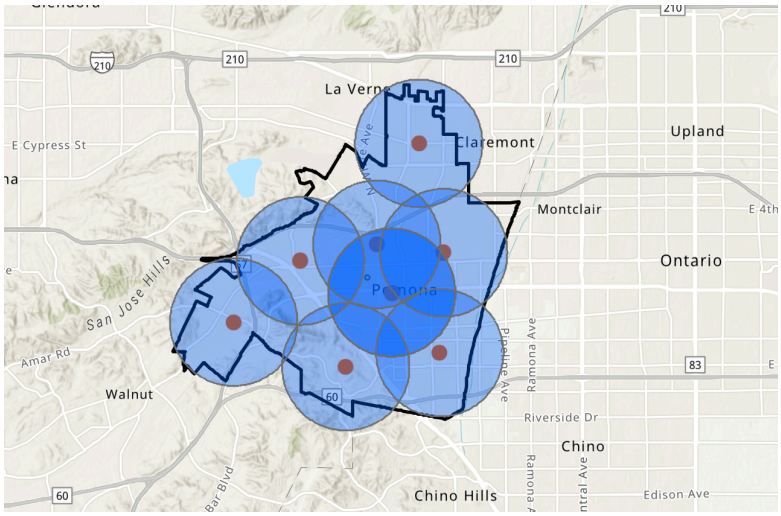
- **Datasets & Variables Used:**
  - **Existing Fire Stations (Vector, Point)** – Identifies current service locations.
  - **Population Density (Raster & Vector, Census Tracts)** – Highlights underserved areas.
- **ArcGIS Tools Used:**
  - **Buffer Analysis** – Maps coverage gaps based on fire station/hospital locations.
  - **Zonal Statistics** – Identifies high-population areas outside coverage zones.

How long does it take emergency vehicles to reach high-population areas?

- **Datasets & Variables Used:**
  - **Emergency Response Time (Raster, Heatmap)** – Evaluates response efficiency.
  - **Population Density (Raster & Vector, Census Tracts)** – Assesses impact on high-density areas.
- **ArcGIS Tools Used:**
  - **Closest Facility Tool (Network Analyst)** – Measures actual response times.
  - **Time-Series Analysis (ArcGIS Insights)** – Analyzes variations in response times throughout the day.
  - **ArcGIS Business Analyst**

3. Analysis

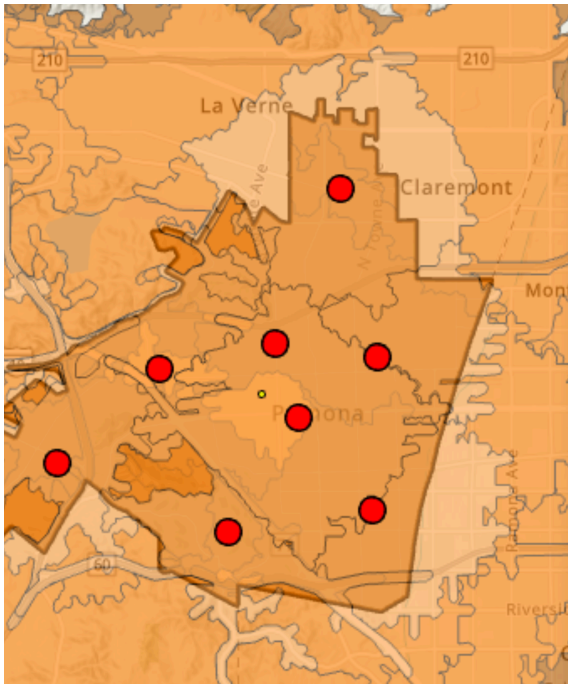
Initial Distance Buffer Analysis



The map illustrates an initial spatial analysis using 1.5-mile radius buffer zones around existing fire stations, marked by red dots.

Each blue circle represents a straight-line distance (Euclidean buffer) from a station, providing a general sense of potential service coverage. However, this approach does not factor in critical real-world elements such as road networks, traffic conditions, or travel speeds. This buffer analysis was used as an early-stage screening tool to identify potential gaps in service coverage. These findings were informed and were further refined by a subsequent drive-time analysis for more accurate accessibility assessments.

Drive Time Analysis: 5, 10, 15 Minutes



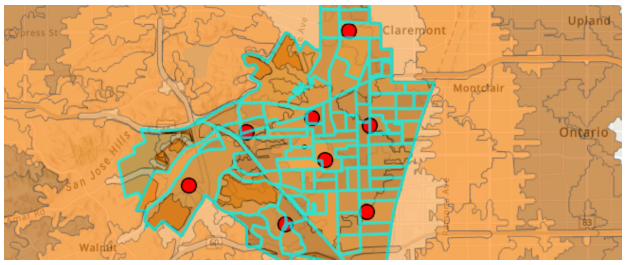
This map presents a drive-time accessibility analysis for fire station coverage in Pomona, CA. Red dots mark the locations of existing fire stations, and the shaded zones represent areas reachable within:

- 5 minutes (light orange)
- 10 minutes (medium orange)
- 15 minutes (dark orange)

This method provides a more realistic estimate of emergency response times by accounting for road networks and driving conditions. The results indicate strong coverage across central and southern Pomona. However, limited access is evident in the northern and northeastern regions, which fall outside the 15-minute response range. These underserved zones may benefit from the

strategic placement of new fire stations to improve response times and ensure equitable coverage citywide.

Population and Service Gap



This map combines 2024 population density data (blue grid) with drive-time emergency response coverage (orange shading) and existing fire station locations (red dots).

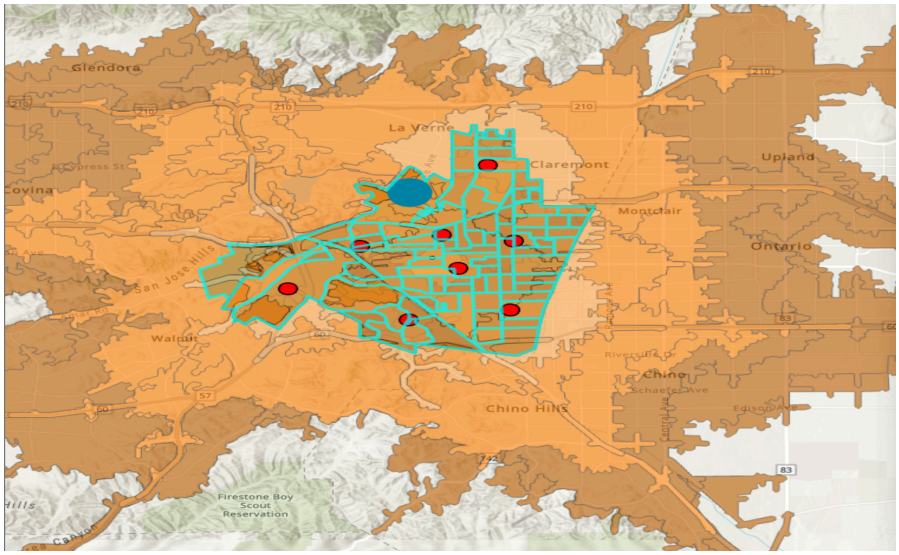
- Blue grid cells represent populated areas, with denser clusters indicating higher residential concentrations.

- Orange zones depict 5-, 10-, and 15-minute drive-time areas from current fire stations, with darker shades indicating longer response times.

- Gaps emerge where densely populated grid cells lie outside of the 15-minute drive-time zones, signaling underserved communities.

Notably, parts of northern and northwestern Pomona show both high population density and insufficient coverage. These areas should be prioritized for the placement of a new fire station to enhance emergency response efficiency and equity.

5. Recommendations



The blue marker on the map under the "Recommended Fire Station Location" section represents the planned location of a new fire station in Pomona. This location was chosen based on numerous important spatial factors:

- It is located in a densely populated neighborhood, as shown by demographic grid analysis.
- The facility is outside of the 15-minute drive-time zone of existing fire stations, indicating a large service coverage gap.
- There are no nearby emergency facilities, indicating that the area is underserved and needs improved access to emergency services.

This strategic location is intended to improve emergency response coverage in northern Pomona and provide more equitable access to life-saving services throughout the city.

6. Conclusion

In conclusion, optimizing emergency response times is crucial for enhancing public safety and reducing the negative impacts of delayed responses to medical emergencies, fires, and natural disasters. This study highlights the significant challenges faced by cities within California, such as in this case, Pomona, where factors such as uneven distribution of emergency facilities contribute to prolonged response times. Through comprehensive Geographic Information Systems (GIS) and spatial analysis techniques this research aims to identify problematic areas and propose strategic locations for new fire stations and hospitals.

By interacting with population density and current emergency stations, GIS systems can offer us specific insights to improve emergency service accessibility. The literature review goes over the importance of technology in disaster response planning, demonstrating how GIS can enhance decision making, optimize resource allocation, and minimize response times within the critical “golden time” window.

This spatial analysis utilizing GIS reveals major gaps in fire station accessibility throughout Pomona, particularly in highly populated regions outside the 15-minute emergency response range. The study identified underserved communities and an appropriate location for a new fire station by using drive-time modeling as well as demographic data and spatial overlay techniques. Acting on this advice would improve emergency response speed, increase public safety, and provide higher-quality service coverage across the city. Furthermore, the methodology provides a scalable model for emergency infrastructure planning in other metropolitan environments.

References

Cristian, A. (2024). Post-Disaster Recovery and Environmental Monitoring Using GIS and GeoAI: Building Damage Assessment Insights from McDonough County.

Park, H. S., Kwon, S. A., & Azam, M. (2024). A study on GIS-based spatial analysis of emergency response for disaster management: Focusing on Seoul. *Heliyon*, *10*(7), e28669-. https://doi.org/10.1016/j.heliyon.2024.e28669

Sharma, S. K., Misra, S. K., & Singh, J. B. (2020). The role of GIS-enabled mobile applications in disaster management: A case analysis of cyclone Gaja in India. *International Journal of Information Management*, *51*, 102030–102036. https://doi.org/10.1016/j.ijinfomgt.2019.10.015

Zhao, M., Sun, Z., & Zeng, Y. (2020). Exploring urban risk reduction strategy based on spatial statistics and scenario planning. *Journal of Cleaner Production*, *264*, 121668-. https://doi.org/10.1016/j.jclepro.2020.121668