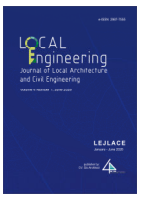
Available *online* at: https://journal.gioarchitect.co.id/index.php/localengineering/issue/current

Local Engineering

Journal of Local Architecture and Civil Engineering

| Doi: 10.59810/localengineering | ISSN (Online) 2987-7555 |



Architecture – Research Article

Google Maps API as a Tool for Detecting Urban Density Levels

A Case Study of Kupang City

Donatus Ara Kian, Ridwan Sanjaya, V. G. Sri Rejeki

Program Studi Doktor Arsitektur, Konsentrasi Arsitektur Digital, Universitas Katolik Soegijapranata, Semarang, Indonesia

ARTICLE INFORMATION

Received: November 11, 2025
Revised: December 20, 2025
Available online: June 01, 2026

KEYWORDS

Google Maps API, smart city, spatial analysis, traffic, urban density

CORRESPONDENCE

Donatus Ara Kian

E-mail: donarakian@unwira.ac.id

A B S T R A C T

The development of geospatial technology has enabled more efficient analyses of urban density. Google Maps API provides location data, traffic information, and user activity patterns that can be utilized to detect density levels in urban areas. This study aims to explore the potential of the Google Maps API as a tool for identifying urban density by integrating traffic data (Traffic Layer), business location datasets, and user movement patterns. The findings indicate that data obtained from the Google Maps API can be used to map high-density zones in both real-time and historical contexts. These insights have significant implications for urban planning, congestion mitigation, and smart city development.

INTRODUCTION

The growth of cities in Indonesia, particularly in the eastern region such as Kupang City, has shown increasingly complex dynamics in line with rising population figures, urbanization, and socio-economic activities. As the capital of East Nusa Tenggara Province, Kupang City faces significant pressure on urban space due to the expansion of residential areas, increasing transportation activities, and infrastructure development that is not always accompanied by adaptive and data-driven spatial planning.

One of the primary challenges in regional and urban planning is the ability to understand and accurately map urban density in a real-time and sustainable manner. Information regarding density levels is essential for spatial management, transportation planning, disaster risk management, and public service provision.

In the current digital era, the Google Maps API has emerged as a technology-based tool capable of providing spatial data and real-time traffic information. Google Maps API offers various services such as the Traffic Layer, Distance Matrix API, and Places API, which can be utilized to analyze mobility patterns and potential density levels within urban areas. By leveraging these APIs, urban planners can obtain more dynamic and up-to-date insights into density patterns as well as spatial changes occurring in Kupang City.

Therefore, the utilization of the Google Maps API as a tool for detecting urban density levels is expected to contribute to the development of a more responsive, data-driven, and efficient urban planning approach particularly within the context of eastern Indonesian regions that continue to face limitations in conventional spatial data collection systems.

Problem formulation

Based on the aforementioned background, the problem formulations in this study are as follows:

1. How can the utilization of the Google Maps API assist in detecting urban density levels in Kupang City?
2. To what extent are the data obtained from the Google Maps API accurate and relevant in reflecting actual conditions in the field?
3. What challenges and limitations arise in the application of the Google Maps API for urban planning purposes in eastern Indonesian regions?

Research objectives

The objectives of this study are to:

1. To analyze the potential of the Google Maps API as a tool for detecting and mapping urban density in Kupang City.
2. To evaluate the effectiveness and limitations of using Google Maps API data within the context of regional and urban planning.
3. To develop an applicative approach for utilizing the Google Maps API to support data-driven spatial planning processes.

Research benefits

a. Theoretical Benefits

- To enrich the body of literature in the field of information technology applications for regional and urban planning, particularly in spatial data–based density analysis.
- To offer a new approach to urban density mapping through non-conventional methods.

b. Practical Benefits

- To provide practical guidance for urban planners, local governments, and other stakeholders in utilizing the Google Maps API.
- To establish a framework that can be adopted by other regions especially in eastern Indonesia in applying similar approaches to urban planning.

Scope and limitations

This study focuses on the use of data from the Google Maps API to analyze density levels within the administrative area of Kupang City. The research does not include the development of software or specialized applications; rather, it centers on the utilization of available data and its integration into spatial analysis for urban planning purposes. Data validation is conducted through comparison with secondary data obtained from local government sources and through limited field observations.

Literature review

Concept of urban density

Urban density is one of the key indicators in regional and urban planning studies. In general, density can be categorized into several types, including:

- Population Density: the number of inhabitants per unit area.
- Building Density: the number or total floor area of buildings within a given area.
- Activity Density: the intensity of human activities in a particular location, which may be measured through traffic flows, visitation frequency, or the use of public spaces.

High density without proper planning may lead to various issues such as congestion, environmental degradation, and a decline in overall quality of life.

Conventional approaches to measuring density

To date, urban density measurement in Indonesia has largely relied on conventional methods such as:

- Population census
- Household surveys
- Manual field observation
- Low-resolution satellite imagery

Although these methods are fairly accurate at a macro scale, they possess limitations including lengthy data collection periods, high costs, and the absence of real-time information. These constraints hinder rapid decision-making, especially in rapidly developing cities such as Kupang.

Information technology and spatial data in urban planning

Advancements in information technology have created new opportunities for the collection and analysis of spatial data. Geographic Information Systems (GIS) and big data have increasingly been integrated into regional and urban planning processes.

Sources of non-conventional spatial data that are now widely utilized include:

- GPS and mobile device data
- Location-based social media data
- Open-source spatial datasets such as OpenStreetMap
- Mapping service APIs such as the Google Maps API

By leveraging real-time and crowdsourced data, urban planners can better understand patterns of activity and urban density in a more responsive and dynamic manner.

Google Maps API: concepts and components

The Google Maps API is a set of application programming interfaces provided by Google that enables access to maps, location information, and interactive traffic data.

Several key components relevant to detecting urban density include:

- Google Maps Traffic Layer: Provides real-time traffic information, which can be used to analyze congestion levels and vehicular density.
- Google Maps Distance Matrix API: Calculates travel time and distance between locations, offering data that may be analyzed to understand mobility levels and travel speeds as indicators of density.
- Google Places API: Provides information about places and the activities occurring within specific locations, including place popularity, which may serve as an indicator of human activity density.
- Geocoding API and Maps JavaScript API: Used to display maps, locations, and spatial data within a geographic information system framework.

https://doi.org/10.59810/lejlace.v4i1.231

The Google Maps API offers advantages in real-time data availability, global coverage, and ease of integration with various web- and mobile-based systems.

Related studies

Several previous studies have demonstrated the relevance and effectiveness of using the Google Maps API in spatial and urban density analyses:

- Santoso (2020) utilized Google Maps Traffic to analyze congestion patterns in Surabaya as an indicator of transportation density.
- Larasati & Putra (2021) combined Google Places API data with satellite imagery to assess commercial activity density in Bali's tourism areas.
- Widianto et al. (2022) used the Distance Matrix API to model the spatial accessibility of public services in Jakarta.

However, research specifically examining the application of the Google Maps API in eastern Indonesian cities such as Kupang remains limited. Thus, this study offers an important contribution by expanding the geographical and practical scope of such technological applications.

Theoretical framework

This research is grounded in several theoretical perspectives:

- Theory of Spatial Interaction (Ullman, 1954): This theory posits that spatial interaction between two places is influenced by mass (size), distance, and friction. The Google Maps API enables dynamic measurement of these elements.
- Smart City Framework: The utilization of information technology, including real-time monitoring systems, forms part of the smart city pillars supporting efficiency and sustainability in urban planning.
- Geographic Information System (GIS): Serving as the primary framework for managing and analyzing spatial data, GIS is strengthened in this study through integration with data from the Google Maps API.

METHODS

Research approach

This study employs a quantitative approach using descriptive-analytical methods, in which spatial and non-spatial data obtained through the Google Maps API are analyzed to understand patterns of urban density. The use of real-time data enables dynamic analysis of community activities within urban spaces.

Additionally, a Geographic Information System (GIS)-based approach is used to visualize and analyze spatial density patterns across the study area.

Research location and period

The research was conducted within the administrative area of Kupang City, East Nusa Tenggara, covering six main districts: Alak, Maulafa, Oebobo, Kota Lama, Kota Raja, and Kelapa Lima.

The research period spans from January to June 2025, consisting of the following stages:

- Data collection (API and secondary data)
- Spatial processing and analysis
- Limited field validation

Types and sources of data

a) Primary Data

- Traffic and congestion information from the Google Maps Traffic Layer (real-time and time-series)
- Travel time and distance data from the Distance Matrix API
- Location and place popularity data from the Google Places API
- Limited field observations for validation

b) Secondary Data

- Administrative maps of Kupang City from Bappeda or the Department of Public Works
- Population data from the Central Bureau of Statistics (BPS) of Kupang City
- Regional Spatial Plan (RTRW) and other urban planning documents

Data collection techniques

Data collection was conducted using the following methods:

- API Programming: Accessing and extracting data through HTTP requests to the Google Maps API using Python or JavaScript.
- Time Sampling: Collecting data at fixed time intervals (e.g., every 30 minutes) on weekdays and weekends to compare density variations.
- Field Observation: Conducted at strategic points in Kupang City to compare digital data with actual on-site conditions.

Data analysis techniques

The obtained data were analyzed through the following steps:

1. Data Cleaning and Pre-processing
   - Filtering irrelevant or outlier data from API responses
   - Converting JSON formats into CSV or shapefiles
2. Spatial Visualization using GIS
   - Using software such as QGIS to map density points through hotspot analysis
   - Overlaying Google Maps API data with administrative maps
3. Temporal Analysis
   - Comparing density levels at different times (morning, afternoon, evening, weekends)
   - Developing charts of daily density fluctuations
4. Density Level Classification
   - Categorizing city zones into low, medium, and high-density areas
   - Determining criteria based on traffic speed, place popularity, and visitation intensity
5. Data Validation
   - Comparing model outputs with field observations and official data (e.g., BPS)

Tools and software

The tools and software used in this research include:

- Google Maps API Console (for obtaining API keys)

- Python/Jupyter Notebook (for data retrieval and analysis)
- QGIS (for spatial mapping and analysis)
- Excel/Google Sheets (for data management)
- Google Cloud Platform (if required for large-scale data handling)

Research validity and reliability

To ensure data validity:

- Google Maps API data are compared with secondary data from government agencies.
- Spatial validity is tested through ground-truthing at several high-density locations.

Reliability is tested by:

- Repeated data collection to assess consistency.
- Cross-check antar sumber (misalnya: Google Maps vs data RT/RW) Cross-checking across different data sources (e.g., Google Maps vs. neighborhood-level data).

Research ethics

This study does not collect personal or sensitive information. All data used are aggregated and publicly accessible. API access is conducted following the policies and limitations set by Google Developers.

RESULTS AND DISCUSSION

Overview of the study area

Kupang City is located in the western part of Timor Island and serves as the administrative, economic, and service center of East Nusa Tenggara Province. With an area of approximately 180 km² and a population of over 450,000, Kupang has been experiencing rapid urbanization, particularly along the El Tari Road corridor, Piet A. Tallo Road, and the Kelapa Lima area.

Urban density in Kupang is unevenly distributed, with high concentrations of activity occurring in the central business district (CBD), educational areas, commercial centers, and transportation terminals. These conditions justify the selection of Kupang City as the study location.

Results of Google Maps API utilization

Traffic Data (Traffic Layer API)

Through the collection of traffic data over a one-month period (September 2025), information regarding congestion intensity during peak hours (07:00–09:00 and 16:30–18:30 WITA) was obtained. The findings indicate:

- The most congested corridors: El Tari Road, Veteran Road, and Timor Raya Road.
- Average vehicle speed drops to below 10 km/h during peak periods.
- Weekdays show significantly higher congestion compared to weekends, particularly around office and marketplace zones.

The data were visualized using heatmaps in QGIS, highlighting red zones as areas with high transportation density.

Place and activity data (Google Places API)

From approximately 1,200 mapped locations in Kupang City, the popularity and visitation data indicate:

- The busiest locations include Hypermart Bundaran PU, Lippo Plaza Kupang, and the University of Nusa Cendana.
- Places of worship and schools show peak visitation at specific times (morning/evening).
- These high-activity areas serve as indicators of human activity density.

Mobility and Distance Analysis (Distance Matrix API)

Analysis was conducted between key nodes such as the airport, port, commercial districts, and residential areas. The results show:

- Travel time increases significantly during peak hours.
- Inter-district mobility is concentrated between Oebobo, Kota Raja, and Kelapa Lima.

Classification of Urban Density Zones in Kupang City

Based on the integration of the three datasets obtained from the APIs, a classification of urban density zones was conducted:

Zone	Location	Characteristics	Density
Zone 1	El Tari Street, Kota Lama	Office and educational centers	High
Zone 2	Kelapa Lima	High-density residential areas with port access	Medium
Zone 3	Maulafa, Alak	Medium- to low-density residential areas	Low

The zoning map was generated using QGIS and overlaid with the Regional Spatial Plan (RTRW) to assess conformity with designated land-use allocations.

Discussion of findings

Potential of Google Maps API in Density Detection

The findings indicate that the Google Maps API is effective as a supporting tool for:

- Identifying high-density zones in real-time
- Detecting vehicle and human movement
- Mapping the spatial distribution of urban activities

Strengths:

- Availability of real-time and historical data
- Easy accessibility, particularly for cities lacking primary datasets
- Compatibility and integration with GIS platforms

Validation and Comparison with Official Data

The API data were compared with:

- Vehicle volume data from the Kupang City Transportation Agency;
- Population data from the Central Bureau of Statistics (BPS);
- Field observation results.

https://doi.org/10.59810/lejlace.v4i1.231

A positive correlation was found between high-density points indicated by API data and official congestion reports from the Transportation Agency. However, discrepancies were observed in areas with limited Google Maps coverage (e.g., narrow alleys or informal settlements).

Limitations and Challenges
- Limited data availability in peripheral or unindexed areas;
- Signal quality and internet connectivity may affect accuracy;
- Dependence on crowdsourced data (not official sensor-based measurements).

Nevertheless, for cities like Kupang that lack real-time spatial data systems, this technology proves highly beneficial as an alternative analytical tool for planning purposes.

Planning Implications

Based on the results, several planning implications emerge:
- Recommendations for spatial adjustments based on density zones;
- Regulation of operating hours and routes of public transportation in high-density corridors;
- Integration of API-based technology into a continuous urban monitoring system (urban dashboard).

CONCLUSION

Based on the findings of this study, several key conclusions can be drawn: (1) The Google Maps API is an effective tool for detecting urban density levels in real-time, particularly through the use of the Traffic Layer, Distance Matrix API, and Places API. The resulting data provide both spatial and temporal insights into patterns of activity, mobility, and congestion within urban areas; (2) In Kupang City, the use of the Google Maps API successfully identified several high-density zones such as El Tari Street, commercial centers, and major urban corridors. The density maps produced were consistent with field observations and official datasets from relevant agencies; (3) The main strengths of the Google Maps API include real-time data availability, broad spatial coverage, and ease of integration with geographic information systems. However, limitations remain, including incomplete coverage in peripheral areas, reliance on crowdsourced data, and variable data quality depending on connectivity; (4) The use of the Google Maps API provides significant contributions to regional and urban planning processes, particularly in areas without well-developed spatial data systems. The API can serve as a foundational element in the development of information technology–based urban monitoring systems; (5) Overall, this study demonstrates that the Google Maps API holds substantial potential as a tool for detecting and analyzing urban density levels, and it can serve as an integral component in advancing data-driven, adaptive, and smart urban planning practices.

Recommendations

1.For the Local Government of Kupang City:
- Consider integrating the Google Maps API into urban planning and monitoring systems, particularly to support transportation policies, land-use planning, and congestion management.
- Strengthen collaboration with technology providers and spatial data institutions to enhance the city's geographic information systems.

2. For Planners and Researchers:
- Combine API-based data with conventional data sources (e.g., surveys and censuses) to improve accuracy and analytical depth.
- Future studies should explore predictive density models using machine learning with Google Maps API as a primary input.

3. For Technology Development:
- Establish standards and guidelines for the use of APIs in regional and urban planning to ensure structured and ethical data utilization.

4. For Other Regions in Indonesia:
- The approach used in Kupang City may be replicated and adapted to other cities, especially medium-sized urban areas that lack digital density monitoring systems.

REFERENSI

BPS Kota Kupang. (2024). *Kota Kupang dalam Angka 2024*. Badan Pusat Statistik.

Google Developers. (2025). *Google Maps Platform Documentation*. Diakses dari https://developers.google.com/maps

Larasati, R. & Putra, D. (2021). Pemanfaatan API Google Places untuk Analisis Aktivitas Pariwisata di Bali. *Jurnal Pariwisata Digital*, 3(2), 25–39.

Pemerintah Kota Kupang. (2023). *Rencana Tata Ruang Wilayah Kota Kupang 2023–2043*.

Santoso, A. (2020). Analisis Kemacetan di Kota Surabaya Menggunakan Google Traffic. *Jurnal Teknologi dan Transportasi*, 12(1), 45–58.

Ullman, E. (1954). Geography as Spatial Interaction. *The Professional Geographer*, 6(1), 3–9.

Widianto, H., Setiawan, B., & Kartika, M. (2022). Model Keterjangkauan Pelayanan Publik di Jakarta Menggunakan Google Maps API. *Jurnal Sistem Informasi Geospasial*, 5(1), 18–27.

This page is intentionally left blank

https://doi.org/10.59810/lejlace.v4i1.231