



UTM
UNIVERSITI TEKNOLOGI MALAYSIA

FACULTY OF BUILT ENVIRONMENT AND SURVEYING
SEMESTER I, SESSION 2025/2026

ASSIGNMENT 3

SBEG1443 : PRINCIPLES OF GEOGRAPHIC INFORMATION SCIENCE

SECTION EB1

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1.0 Introduction

Universiti Teknologi Malaysia (UTM) is consistently moving towards the implementation of a Smart Campus which will result in digital technology and data-oriented systems being used to enhance university's operational efficiency, safety and sustainability. One of the main obstacles that is usually encountered in a large university such as UTM is the proper management of transportation and parking facilities for students, staff and visitors. As the campus population has been continuously growing, the needs for parking spots also has increased which lead to traffic congestion and improper use of land.

The problems related to parking not only hinder the daily commute but also have contributed to inefficient traffic flow, safety of pedestrians and campus commitment to being environmentally friendly. A thorough strategy that combines spatial analysis, real-data and intelligence in decision-making is needed to solve these kinds of problems. Therefore, Geographic Information Systems (GIS) is the best solution to deal with this issue as it has the capabilities to analyze the spatial patterns, evaluate the land suitability, and support the strategic planning. The aim of this project is to propose a GIS based Smart Parking Planning and Management System for UTM that will lead to a decrease in parking congestion and improvement in overall campus mobility.

2.0 Problem Statement

Parking congestion has been a persistent and major issue at the UTM campus. Most of the parking spots are occupied during peak hours which leads to the inability of the parking area to hold all the cars. This causes most of the drivers to park their vehicles on the roadside and sometimes near the corners. This kind of action adds to the problem of traffic congestion since it makes the road narrower for other vehicles to cross and alters the flow of traffic. Thus, it causes the user to experience a longer time in their journeys as they need to look for a spot to park which results in inefficiency and annoyance.

On top of the traffic difficulties, parking on the roadside also results in serious safety challenges. Vehicles parked close to intersections will block the view of both drivers and pedestrians which creates a blind spot that may lead to an increase of accidents in the campus especially for those who are trying to cross the street. Moreover, some of the drivers end up parking on the grass areas due to the lack of parking spaces. This gradually leads to deterioration of the quality of grass, causes soil compaction and erosion, and may ultimately create the risk of land instability or minor landslides especially in the sloped areas of the campus.

Despite these issues, the parking management at UTM is still lacking a systematic and data-driven methodology. The university currently has not implemented any methods to access the locations that are suitable for the construction of new parking areas and to monitor the parking usage through data collection. Without the spatial analysis, the decisions regarding parking expansion will likely ignore most important aspects such as the soil structure, land use restrictions, road accessibility and environmental settlements.

GIS is an effective tool to support this case scenario since it allows the integration and analysis of numerous spatial datasets alongside land use maps, road networks, lot boundaries and soil characteristics. Furthermore, if parking occupancy sensors or CCTV based monitoring are also considered in future, GIS will be capable of studying the

parking density at various times and places. Thus, it is not only able to pinpoint the spots with maximum demand but also able to find the best options by considering safety and environmental impact for new parking facilities. Through the GIS analysis, UTM gets to implement a smarter, safer and sustainable parking solution that is aligned with the Smart Campus vision.

3.0 Application Objectives

Below are the main objectives of this application in order to handle the parking problem among students, staff and visitors in UTM.

- 1. To evaluate environment suitability for sustainable construction**

Conducting a structural and geotechnical analysis of potential parking sites within UTM. This is to ensure that the soil can support new parking infrastructure without causing land subsidence or erosion in the future, specifically targeting areas that are currently damaged by illegal parking.

- 2. To minimize traffic congestion and roadside hazards**

Designing a strategic parking expansion plan that can eliminate illegal curbside parking. By doing this, it can remove blind spots at junctions and improve the overall flow of traffic and pedestrian safety within the campus.

- 3. To utilize a real-time parking density monitoring system**

Applying an IoT-based system by using CCTV and sensors to track occupancy rates and density. This could give accurate data on peak hour behaviour so that it can reduce the time spent by students and staff to search for available parking.

- 4. To propose data-driven optimal locations for new facilities**

Gathering traffic data and soil analysis to identify the most strategic and high-impact location for new parking lots. This is because, to ensure the built parking is to achieve the demands while maintaining the environment.

4.0 Data Requirements

4.1 Current list of spatial data in UTM

These are datasets that are currently managed by UTM, specifically by Pejabat Harta Bina (PHB) or the Faculty of Built Environment and Surveying (FABU). This dataset is referred from the Data SBEG1443.

1. Building Footprints (Polygon Data)
 - a. 2D/3D models for Academic Buildings (Bgn Akademik), Lecture Halls (Dewan Kuliah), Main Buildings (Bgn Utama/main_building), and Residential Colleges (kolej). It helps to identify high-density destination points and analyze parking demand near "popular" campus structures.
2. Digital Road Network (Line Data)
 - a. Represented by the roads, including attributes like road width and type. This is essential for identifying traffic bottlenecks.
3. Topographic / Contour Data (Height Data)
 - a. Data that shows the steepness of the terrain in UTM Skudai. This data helps to avoid landslide-prone slopes.
4. Land Use / Green Area Maps
 - a. Includes open spaces such as padang (fields) and general Kemudahan (facilities) to differentiate between built-up zones and gazetted green areas for sustainable planning.
5. Utility & Drainage Mapping
 - a. Includes drainage and water features such as kolam (ponds/retention) and Transmission_Line data to locate existing drains and utility corridors, ensuring new parking developments do not cause flash floods in lower areas.

4.2 Additional Datasets

These new datasets are required in order to solve the current problem.

1. Real-Time Parking Occupancy & Density Data (IoT sensor data)

This is non-spatial data. It uses CCTV-based AI detection to track peak-hour occupancy rates. This data allows to calculate the turnover rate of a parking lot and prove when and where the overflow into the roads happens.

2. High-Resolution UAV (Drone) Orthomosaic & Slope Analysis

This is spatial data which uses remote sensing imagery to provide centimeter-level detail to visualize soil erosion and illegal parking scars on grass patches. It also provides an updated "Digital Surface Model" for drainage planning.

3. Traffic Flow & Pedestrian Conflict Point Survey

It is a field survey data (spatial points) which is from manual observation or video analytics to map blind spots and conflict points where illegal parking blocks the line of sight for pedestrians. This spatial data is critical to justify why a certain road must be cleared and where a new lot would be safest.

5.2 Methodology

The development of the UTM Smart Parking and Traffic Management System follows a structured GIS implementation workflow. The methodology is designed to ensure that raw spatial data is systemically converted into actionable intelligence for campus management and is divided into several key phases which includes data acquisition, database development, spatial analysis and output generation. The project will be executed in four distinct phases.

During the first phase, Data Acquisition & Digitization, it involves gathering the core datasets required for the study. It includes obtaining the base map layers such as roads, building and lot boundaries from the university's existing database. Simultaneously, new data will be generated through the deployment of IoT sensors at parking entries and drone aerial surveys to capture current land conditions. Then in the second phase, Data Pre-processing & Management involves cleaning and preparing the datasets as raw data is rarely ready for immediate analysis. Some of the key tasks are georeferencing, which aligns drone imagery with the official campus coordinate system. Then, topology checks which ensure the road network lines are fully connected so that network analysis algorithms can function correctly without error.

Other than that, attribute joining links the non-spatial data to the spatial parking lot polygons using a common ID. Next, during the third phase, Spatial Analysis & Modelling is where GIS algorithms are applied as it is the core processing stage. The system will process the prepared data to identify patterns, measure accessibility and calculate optimal locations. Lastly, in the fourth phase, Output & Visualization is where the final results will be visualized as thematic maps and statistical charts. These outputs will serve as the division-support tools for the university administration. The primary analysis will be conducted using QGIS because of its robust open-source environment, which supports the necessary vector and raster processing tools without licensing costs.

6.2 Surface Analysis

Parking structures strictly require stable and flat foundations. Therefore, it is essential to analyze the physical terrain before proposing any location to build parking lot areas. This analysis is performed using the Surface Analysis module, specifically the Slope function. This function measures the incline or steepness of the terrain based on elevation changes by calculating the gradient as an angle in degrees. A standard parking surface is mandatory to ensure user safety and prevent risks related with uneven terrain such as unintended vehicle displacement. Furthermore, building parking lots on steep hills is impractical because effective drainage and cost-effective paving are difficult to achieve on sloped terrain. The GIS will process the elevation data of the UTM campus to classify the land into steepness categories. Areas with high slope degrees will be identified as “Restricted”, while areas with low slope degrees will be classified as “Suitable”. This process helps to filter out steep terrain and focus on flat areas that are suitable for constructing safe and long-lasting parking lots.

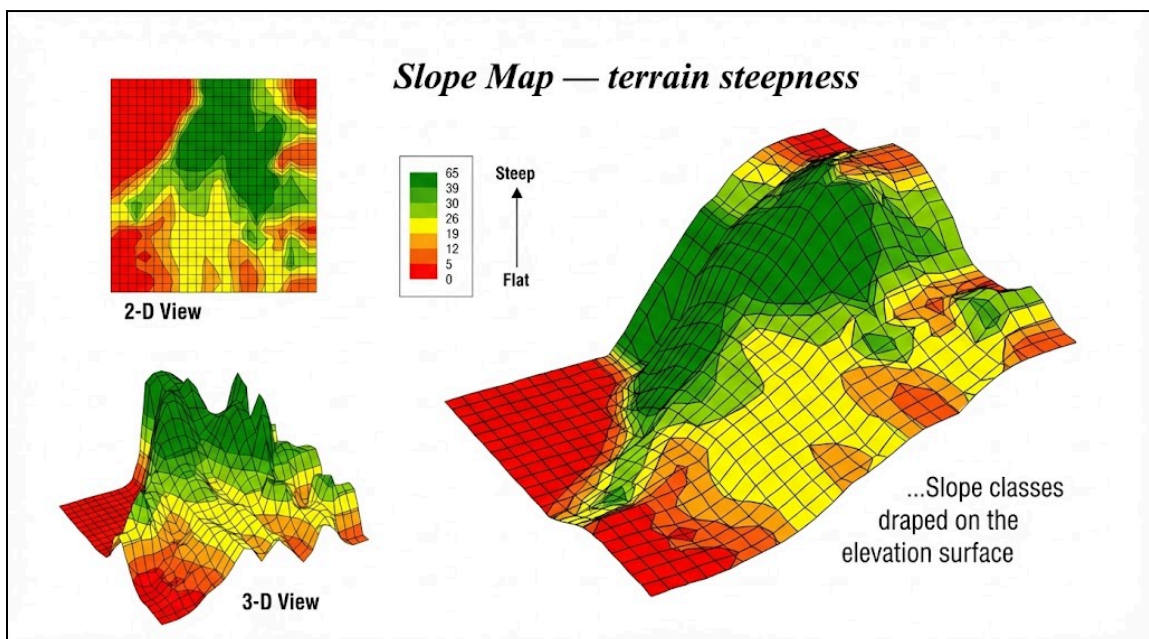


Figure 6.2: Example of Surface Analysis (Slope) Concept

6.3 Map Overlay

Map Overlay integrates two or more layers of spatial data to create a new output layer that generates useful information. This project specifically utilizes Raster Overlay where the analysis is performed on grid cells or also known as pixels. It involves mathematical equations such as addition or multiplication. To determine the optimal parking site, the results from the Network Analysis and Surface Analysis are combined with the existing Land Use layer. Specifically, the areas with high demand that are identified in Network Analysis are combined with the flat slope areas that are identified in Surface Analysis. By stacking these layers, the GIS will calculate a suitability score for every pixel of land on UTM campus. For example, a location that is flat (score 5), has high demand (score 5) and is unoccupied (score 5) will produce a high total score. This enables the direct identification of specific sites where all favourable conditions coincide.

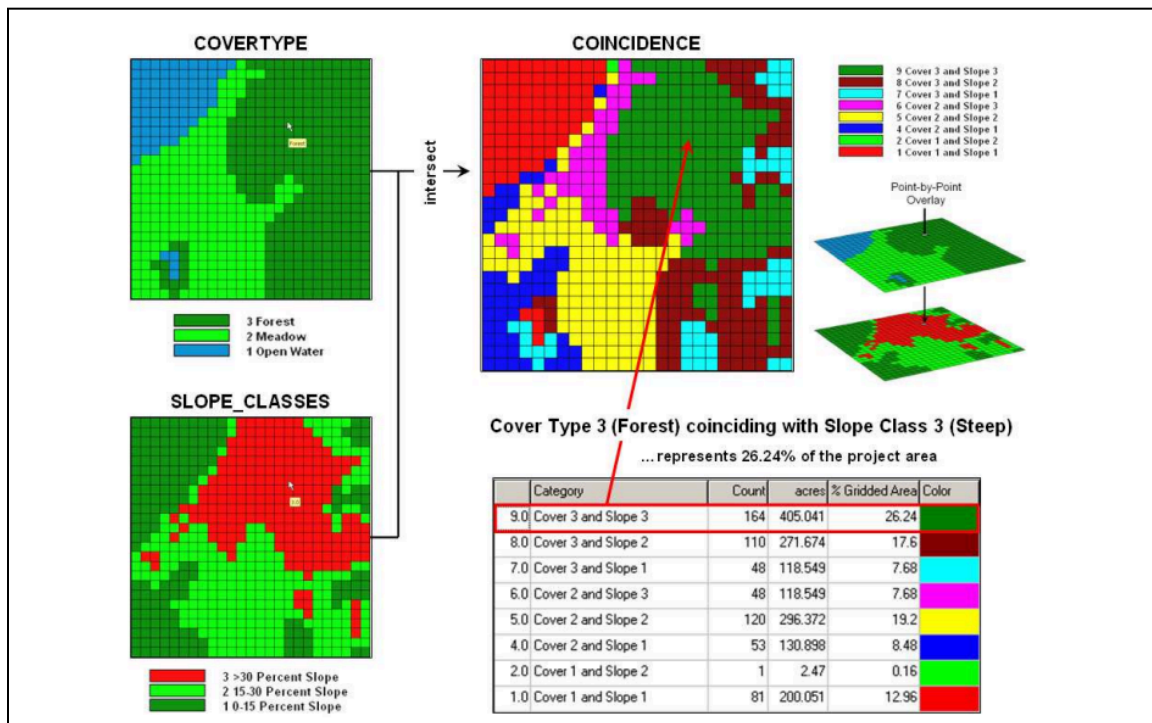


Figure 6.3: Map Overlay (Raster Overlay) Concept

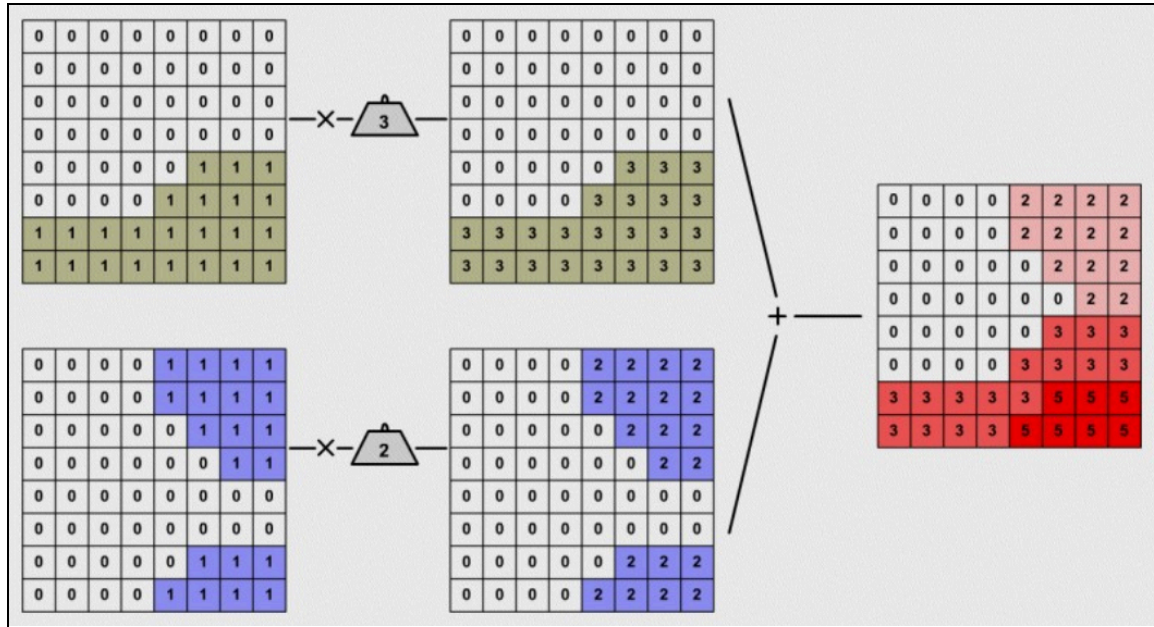


Figure 6.4: Map Overlay (Raster Overlay) Concept

7.0 Impact

The UTM Smart Parking and Traffic Management System will give many benefits to the campus. First, it can reduce traffic congestion especially during peak hours. When parking is full, many drivers park at the roadside and this makes the road narrower. By using GIS to plan better parking locations, this problem can be reduced.

By preventing parking close to corners and pedestrian crossings, the system improves visibility at road intersections in terms of safety. This reduces blind spots that could result in collisions between cars and pedestrians. Overall, campus movement becomes safer and more structured with improved parking distribution and clearer road access.

From an environmental perspective, the system contributes to the preservation of campus green spaces. GIS makes sure that additional parking facilities are only suggested on suitable land by analysing soil structure, slope conditions and land usage. This helps long-term environmental sustainability, reduces soil erosion and prevents additional harm from unauthorised parking on grassy areas.

Finally, this system supports better decision-making. With parking density data such as sensors or CCTV, UTM can identify when and where parking demand is high. This helps them plan new parking facilities more accurately and avoid wasting money on unnecessary construction.

8.0 Conclusion

In conclusion, this project suggests a GIS-based Smart Parking and Traffic Management System to address UTM's increasing parking and traffic problems. Safety risks, illegal roadside parking, parking congestion and environmental damage are linked issues that need a spatial solution.

GIS is a useful tool for studying real campus issues because it integrates current UTM spatial datasets with extra data like parking occupancy, traffic flow and terrain. It is possible to identify high-demand areas and suitable locations for future parking development by using GIS features including network analysis, surface analysis and map overlay.

In addition to increasing pedestrian safety and traffic efficiency, this proposed system supports sustainable land use planning and better decision-making. By implementing this GIS-based strategy, UTM can get closer to a smarter, safer and more sustainable campus environment that benefits visitors, staff and most importantly, students.

References

SBEG 1443 Principles of Geographic Information Sciences Chapter Six

Appendix: List of Prompts

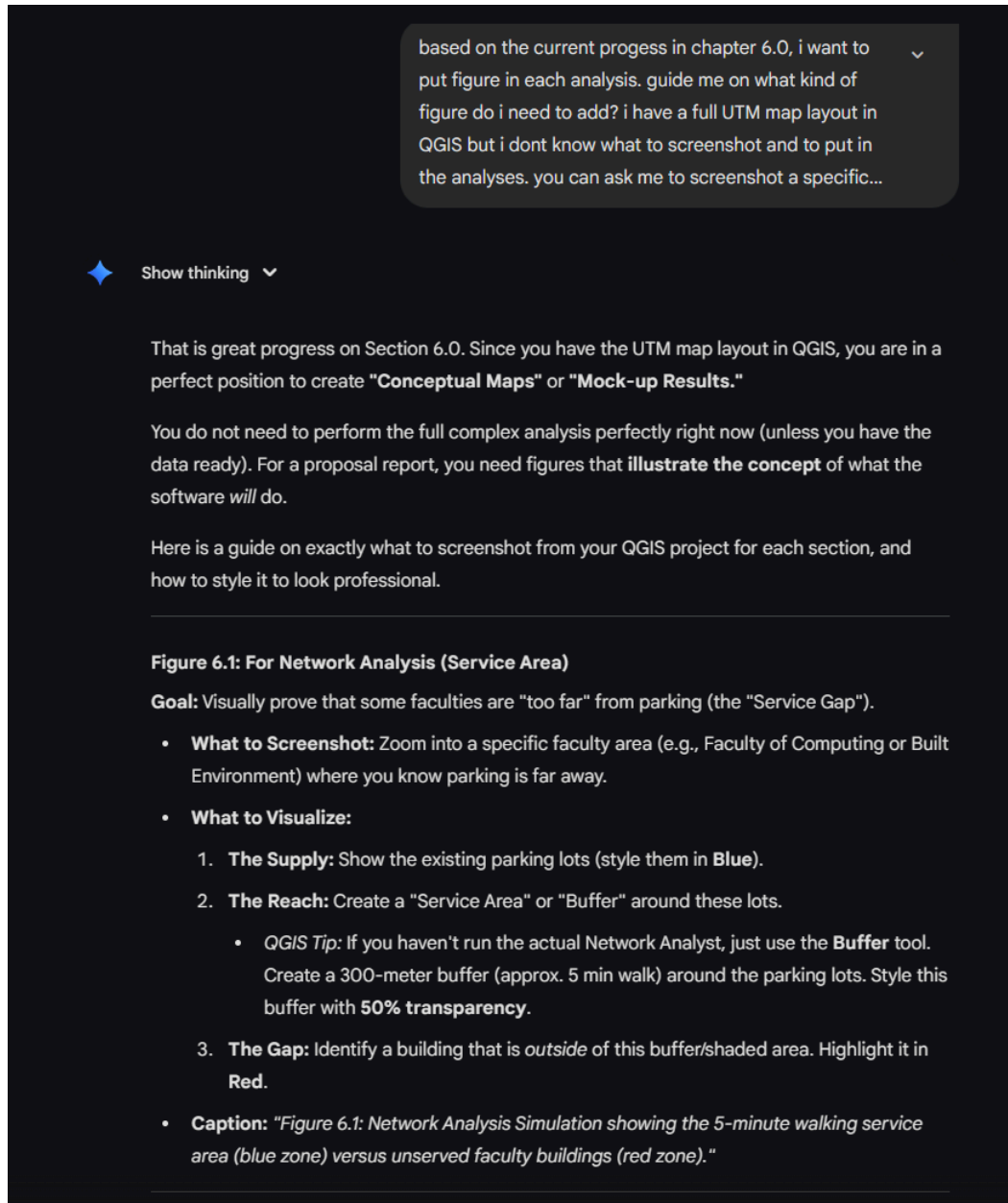


Figure: Screenshot of ChatGPT's Prompt for Clarification on Report Section 6.0



explain this question for my assignment. im planning to take the fourth suggested themes which are Smart Parking & Traffic. explain what it is. what does it mean by 'Analyzing parking density and suggesting optimal locations for new parking structures.'

✦ This assignment is asking you to think like a planner or a consultant. Your goal is to write a **proposal** for a technology solution (using GIS) that makes the UTM campus "smarter" and more efficient.

Here is an explanation of the assignment and a deep dive into your chosen theme: **Smart Parking & Traffic**.

1. The Assignment in a Nutshell

You are not necessarily building the software right now; you are writing a **Proposal Report**. You need to convince the university management that:

1. There is a problem with parking/traffic on campus.
2. GIS (Geographic Information Systems) is the best tool to solve it.
3. You know exactly what data you need and what analysis you will run.

Key Requirements:

- **Context:** UTM Smart Campus (using tech to improve campus life).
- **Data:** You must use the provided spatial data (maps of roads, buildings, etc.) AND propose **3 new datasets** you would need to collect.

2. Explaining Your Theme: "Smart Parking & Traffic"

The specific prompt for this theme is: **"Analyzing parking density and suggesting optimal locations for new parking structures."**

Here is what that means in plain English and in "GIS language":

Part A: "Analyzing Parking Density"

- **What it means:** It isn't enough to say "parking is full." You need to figure out *where* it is full, *when* it is full, and *how often*.
- **The Goal:** To visualize the "pressure points." For example, maybe the parking lots near the Engineering faculty are 110% full at 9:00 AM, but the lots near the stadium are empty.

Figure: Screenshot of ChatGPT Prompt for General Ideas

- **How GIS does this:**
 - You would create a map where "hot" colors (red) show areas where cars are fighting for spaces, and "cool" colors (blue) show underutilized space.
 - **GIS Function:** *Heatmaps or Kernel Density Estimation.*

Part B: "Suggesting Optimal Locations for New Parking Structures"

- **What it means:** If the current lots are full, where should the university build a new one? You can't just build it anywhere. It needs to be in the "perfect" spot.
- **The Criteria (The Logic):**
 - It must be close to the busy buildings (so students don't have to walk too far).
 - It must be on vacant land (you can't build on top of a lake or an existing building).
 - It must be connected to main roads.
- **How GIS does this:**
 - You overlay different map layers (Land Use + Roads + Distance from Faculty) to calculate the best mathematical score for a location.
 - **GIS Function:** *Site Suitability Analysis or Weighted Overlay.*

3. How to Structure Your Proposal for this Theme

To help you with your report, here is how you can apply the prompt's requirements to the "Smart Parking" theme:

I. Problem Statement

- **The Issue:** Students and staff waste time circling around looking for parking. This causes traffic congestion, increases carbon emissions (idling cars), and leads to illegal parking on roadsides.
- **Why GIS?:** Because parking is a spatial problem. You need to understand the *location* of the demand versus the *location* of the supply.

II. Data Requirements

You need existing data + 3 new datasets. Here are suggestions:

1. **Existing Data:** UTM Road Network, Lot Boundaries (vacant land), Existing Parking Lots.
2. **Proposed Additional Data (Pick 3):**
 - *Real-time IoT Sensor Data:* Sensors at existing parking entries/exits to count cars coming in and out.
 - *GPS Tracking / Survey Data:* Data showing where students are driving from or walking to (to understand "desire lines").
 - *Drone Imagery / Remote Sensing:* High-resolution aerial photos to identify illegal parking spots or current land conditions.

III. Methodology (GIS Functions)

This is the technical part. You should mention specific analysis types:

- **Network Analysis:** To calculate "Service Areas" (e.g., "How far can a student walk in 5 minutes from this potential new parking lot?").
- **Hotspot Analysis:** To identify which specific zones have the highest density of cars.

Figure: Screenshot of ChatGPT Prompt for General Ideas

DRAFT PROJECT INFORMATION

- Basically dalam UTM ni banyak masalah parking
- Bila parking penuh, orang park tepi jalan.
- Bila orang park tepi jalan, berlaku traffic congestion
- Traffic congestion lead to high time travel to search for parking (inefficient)
- Increase road danger. Orang nak melintas tak nampak jalan sebab kena block dengan kereta kat simpang (blindspot)
- Orang terdesak park atas rumput menyebabkan kualiti rumput terjejas dan lama2 tanah jadi mendap dan terhakis boleh menjadi punca kepada tanah runtuh
- GIS ni boleh tolong atasi masalah ni by analysing the structure tanah and cari tempat mana yang appropriate untuk bina tapak parking yang baru
- Tanah parking yang baru mestilah mencapai beberapa kriteria utama untuk memastikan tidak berlaku perkara yang tak diinginkan
- Letak cctv atau pakai sensor dekat setiap parking untuk track parking density during specific hours.
- Suggest optimal location to build new parking based on data gathered

Figure: Group Discussion Project Draft Conclusion

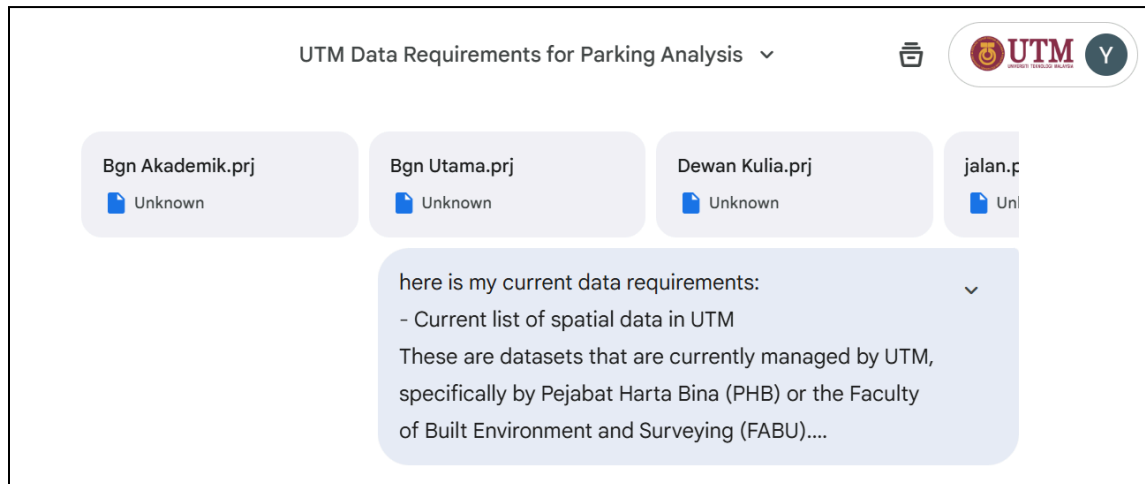


Figure: Screenshot of Gemini Prompt for Data Requirements

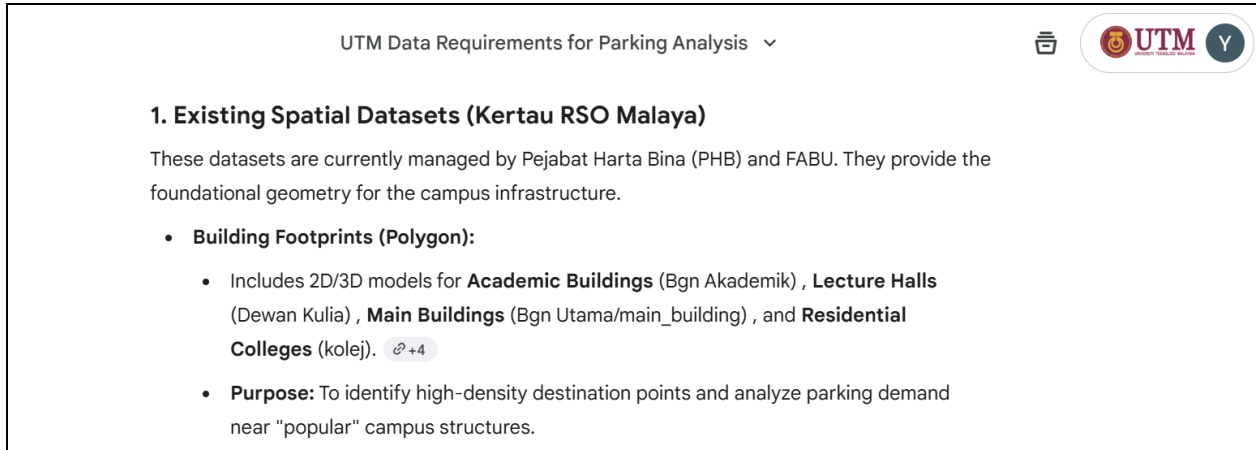


Figure: Screenshot of Gemini Prompt for Data Requirements

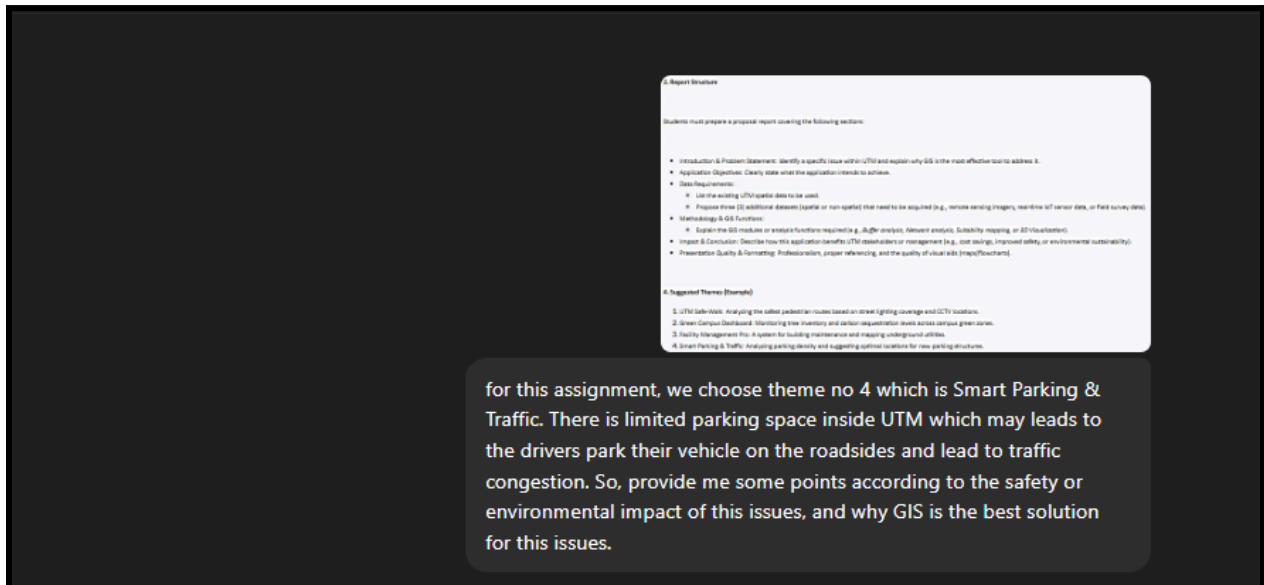


Figure: Screenshot of ChatGPT Prompt for Problem Statement

Below are clear, structured points for the *Problem Statement only*, focusing on safety impacts, environmental impacts, and why GIS is the best solution, aligned with Theme 4: Smart Parking & Traffic.

Problem Statement (Points Form)

Safety Impacts

- Limited parking spaces within UTM cause drivers to park along roadsides.
- Roadside parking narrows road width, disrupting traffic flow.
- Vehicles parked near junctions and intersections create blind spots.
- Blind spots increase the risk of:
 - Vehicle-to-vehicle collisions
 - Pedestrian accidents during road crossing
- Traffic congestion leads to driver stress and unsafe driving behaviour.
- Emergency vehicles may experience delays due to blocked or congested roads.

Environmental Impacts

- Drivers often park on grass and undeveloped areas when parking is full.
- This practice causes:
 - Damage to grass and green spaces
 - Soil compaction, reducing water absorption
 - Soil erosion over time
- Repeated parking on grassed areas may lead to:
 - Land degradation
 - Increased risk of land subsidence or slope instability
- Traffic congestion results in:
 - Increased fuel consumption
 - Higher carbon emissions

+ Ask anything



Figure: Screenshot of ChatGPT Prompt for Problem Statement

Why GIS Is the Best Solution

- GIS enables spatial analysis of parking demand and traffic patterns.
- Existing UTM spatial datasets (road networks, land use, lot boundaries) can be integrated in one platform.
- GIS supports parking density analysis to identify high-demand and problem areas.
- Suitability analysis can be used to:
 - Identify safe and environmentally appropriate locations for new parking areas
 - Avoid sensitive or unstable land
- GIS can integrate real-time or temporal data (e.g., sensors or CCTV) to:
 - Monitor parking occupancy during peak hours
 - Analyse traffic congestion trends
- GIS-based visualization (maps and dashboards) helps decision-makers:
 - Understand spatial problems clearly
 - Make data-driven planning decisions
- The approach supports UTM's Smart Campus, safety, and environmental sustainability objectives.



Figure: Screenshot of ChatGPT Prompt for Problem Statement