

# Improving Urban Taxi Operations through Data-Driven Understanding

Rutuja Anil Shingate

## 1 Introduction

The efficiency of taxi fleets is greatly impacted by urban traffic congestion, an issue that is only getting worse. This results in higher fuel prices, longer travel times, and unhappy customers. In a city like New York, where traffic patterns change constantly, it is necessary to have an intelligent system that can choose the best route in real time.

In order to help taxi operators determine the most efficient routes based on real-time traffic data, weather forecasts, and route cost estimation, this project presents the **Taxi Fleet Management Dashboard**, a visual analytics system. The dashboard uses interactive data visualization and dynamic routing algorithms to deliver the following:

- Optimum route recommendations according to the degree of traffic congestion.
- The best and a backup route with estimated travel times are shown in a comparative route analysis.
- Taxi drivers can anticipate fuel costs and fare adjustments thanks to traffic-aware cost estimation.
- Traffic visualization in real time giving precise information about the degree of congestion.
- Weather-based modifications which make sure that elements like rain or snow are taken into account when planning a route.

## 2 Problem Statement

It is extremely difficult for taxis to navigate through crowded urban areas, affecting both passengers and drivers. Drivers make decisions without the aid of intelligent tools, making them prone to choosing suboptimal routes, which can:

- Contribute to traffic congestion-related delays.
- Increase the amount of fuel used.
- Cause fares to fluctuate.
- Provide inadequate real-time information to make wise routing choices.

## 3 Proposed Solution

A thorough and interactive dashboard was created to address these problems. The solution includes:

- **Traffic Data in Real Time:** Constant observation and real-time route recommendations based on the degree of congestion.
- **Cost Estimation Models:** Displays fuel and fare estimates for different automobile types like Luxury, SUV, and Sedan.
- **Weather Trends:** Offers information on both the present and the future weather that could impact driving conditions.
- **Interactive Map and Analysis:** Provides zoom capability and sliders for traffic sensitivity, along with route switching to simulate various situations.

## 4 The Dashboard's Main Features

### 4.1 Dynamic Route Optimization

Users can enter their starting and ending points, and the system will determine the optimal path based on current traffic conditions. Customization is further enhanced by traffic sensitivity settings that can be changed.

### 4.2 Interactive Route Visualization

To assist drivers in making well-informed choices, the dashboard compares the optimal and a different route. Traffic density is indicated by color-coded routes, which also provide a visual breakdown of estimated time and mileage.

### 4.3 Real-Time Traffic & Weather Analytics

In order to recommend route modifications, the dashboard incorporates current weather trends. In order to forecast road conditions and make appropriate plans, users can examine past weather data.

### 4.4 Route Cost Estimation

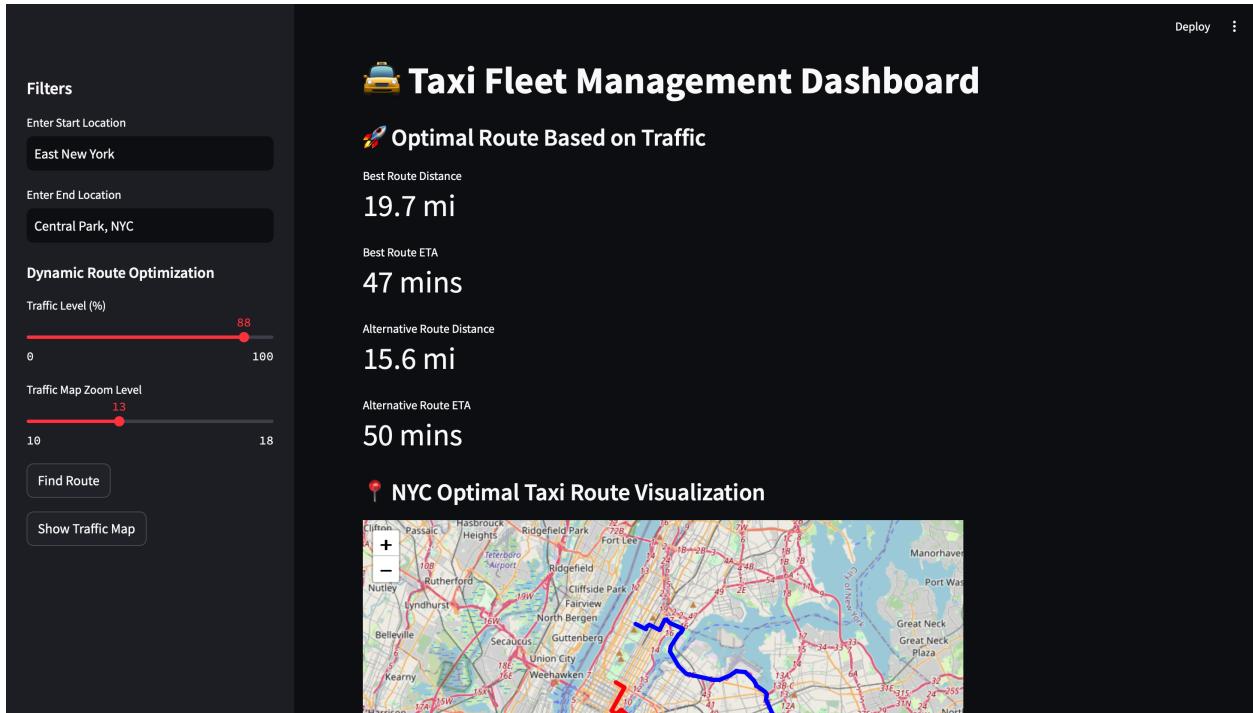
Taxi drivers can estimate trip expenses, including fuel and fare variations, by choosing from a variety of vehicle categories such as *Sedan, SUV, and Luxury*. Profit margins and operational effectiveness are improved as a result.

## 5 Why This System?

This dashboard is designed for fleet operators who require more than a basic route, in contrast to conventional navigation apps. Through the seamless integration of financial insights, historical trends, and traffic data, it facilitates decision-making. Through the use of this system, taxi services can guarantee the most economical and efficient rides possible, minimize idle time, and improve customer satisfaction by optimizing fuel efficiency.

## 4. Visual Analytic System

### Dashboard Screenshots and Image Descriptions



# NYC Optimal Taxi Route Visualization



# Route Cost Estimation

### Select Vehicle Type

- Sedan
  - SUV
  - Luxury

Figure 2: NYC Optimal Taxi Route Visualization – Main and Alternate Routes

The NYC Optimal Taxi Route Visualization section of the dashboard showcases both the primary and alternate taxi routes, considering the current traffic conditions in New York City. The red route indicates the recommended path, while the blue route serves as an alternative option for drivers. Unlike real-time route adjustments, this feature presents a set of pre-determined routes, enabling fleet operators, taxi drivers, and ride-sharing services to select the most appropriate one. By providing multiple options, it assists in trip planning, accounts for possible delays, and allows greater flexibility in navigation.

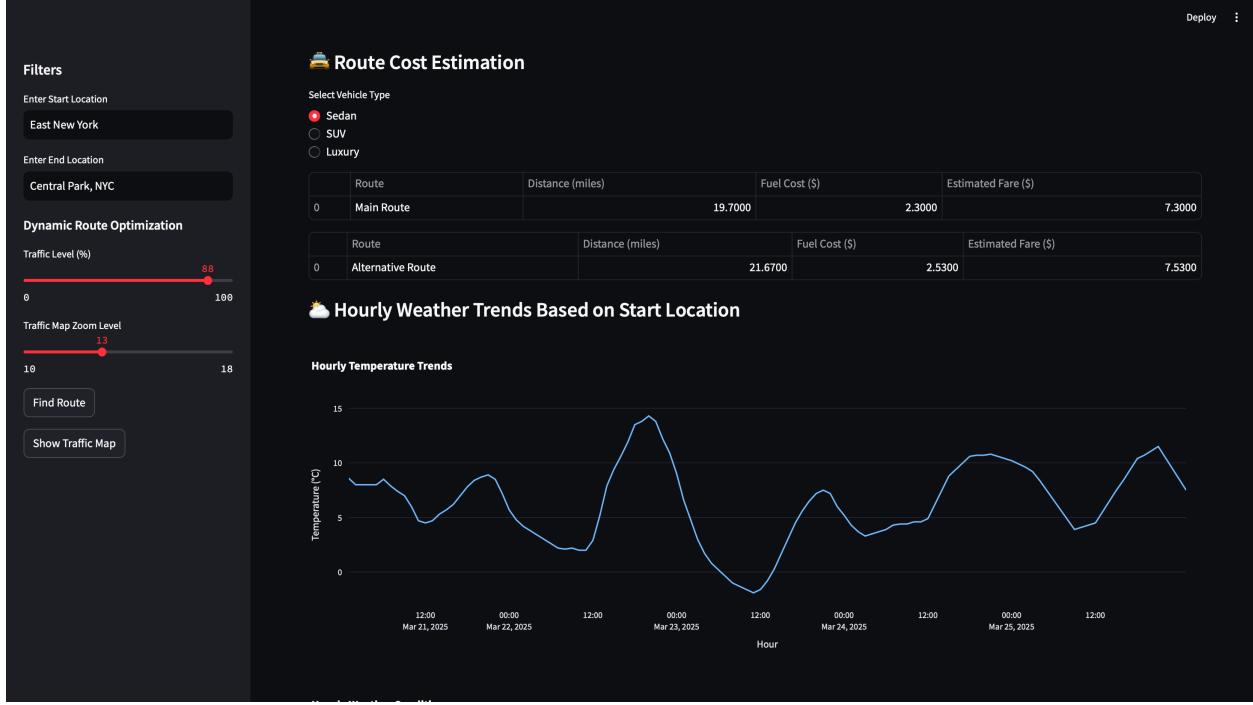


Figure 3: Route Cost Estimation and Hourly Weather Trends

The Route Cost Estimation section of the dashboard provides an estimated fare and fuel cost based on the selected vehicle type—Luxury, SUV, or Sedan. It displays the projected fare, fuel expense, and distance for both the primary and alternate routes, allowing users to compare costs before selecting the best option. Additionally, the dashboard features Hourly Weather Trends Based on Start Location, showing temperature fluctuations over time. This information helps identify weather conditions that may impact the journey. By integrating real-time weather data with route cost estimation, the dashboard supports fleet managers and taxi drivers in making informed, cost-effective, and efficient route planning decisions.

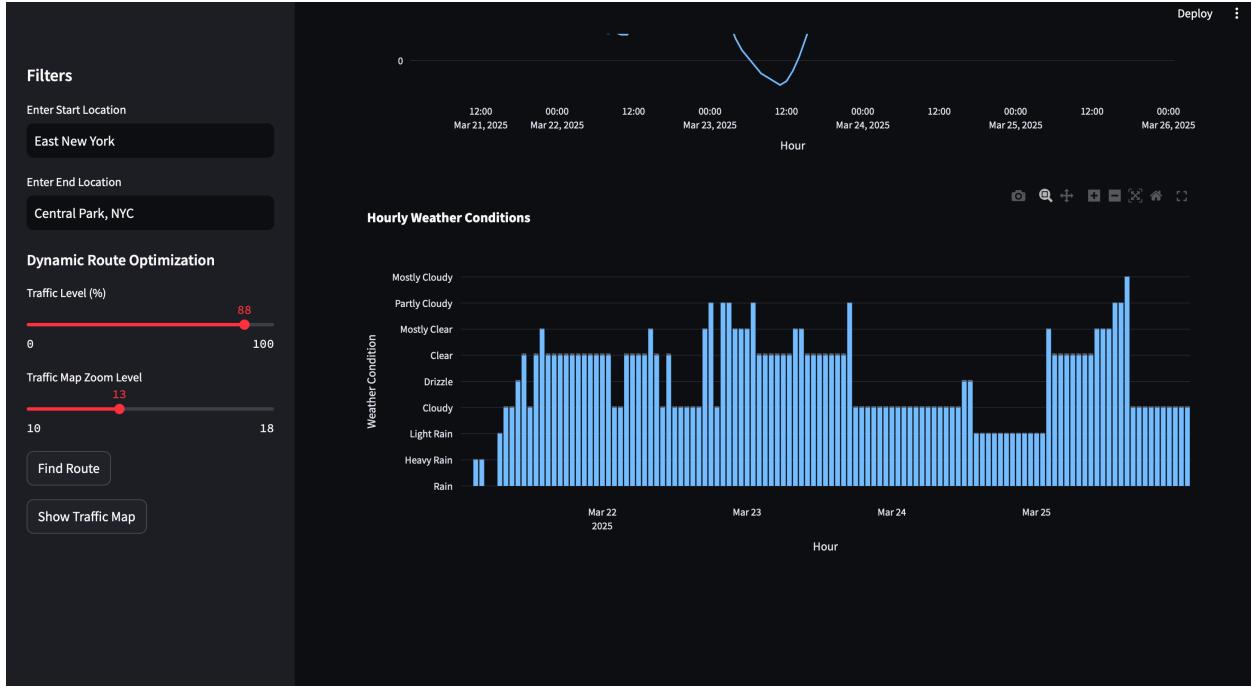


Figure 4: Hourly Weather Trends and Conditions

The Hourly Weather Trends and Conditions section of the dashboard provides key insights into weather patterns that may impact taxi operations and route planning. The chart displays temperature variations throughout the day, helping drivers anticipate potential weather-related delays. It also highlights different weather conditions, such as clear skies, cloud cover, drizzle, and rain, allowing users to assess environmental factors that could affect road conditions. By integrating real-time weather trends with route optimization, the dashboard helps fleet managers and drivers make informed decisions, ensuring safer and more efficient travel planning.

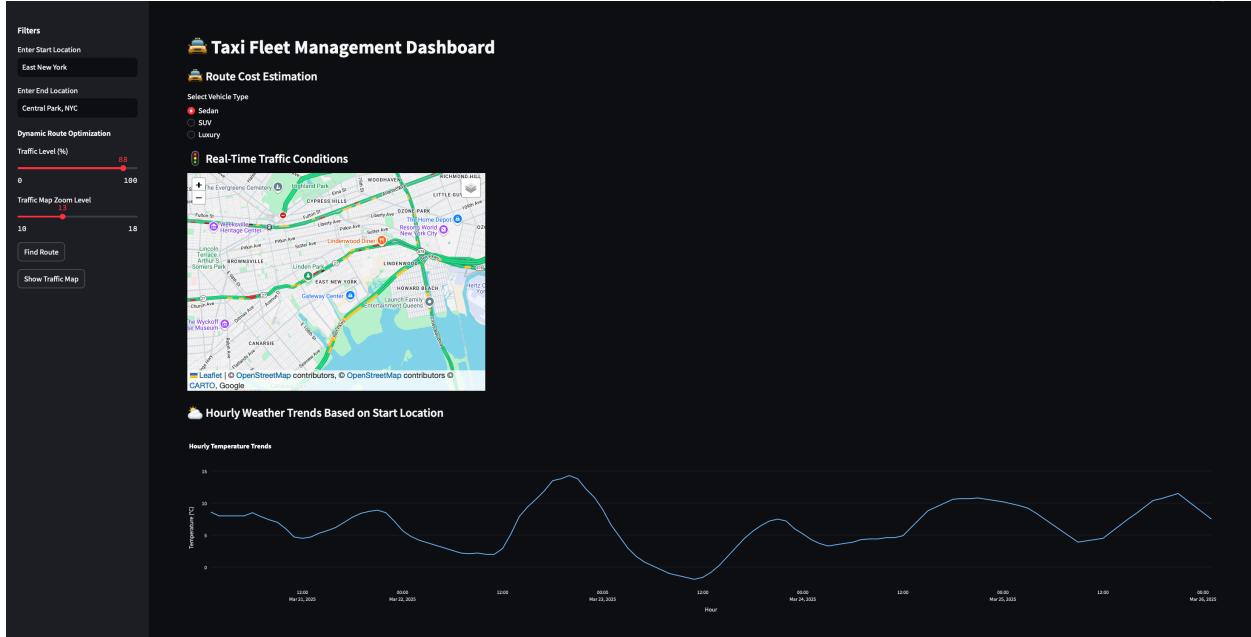


Figure 5: Real-Time Traffic Conditions Map

The Real-Time Traffic Conditions section of the dashboard features an interactive map that highlights live traffic congestion, road incidents, and overall traffic flow across New York City. This tool helps users check current road conditions and anticipate possible delays before choosing a route. With up-to-the-minute traffic data, the dashboard empowers fleet operators, taxi drivers, and ride-sharing services to make smarter route choices, helping them navigate the city more efficiently while minimizing travel time.

## **5. Fleet Management Benefits**

The dashboard delivers tangible benefits for taxi fleet managers, including:

- Fuel cost reduction through optimized route selection
- Decreased travel time by avoiding high-traffic areas
- Improved customer satisfaction via transparent fare and ETA forecasts
- Real-time operational decision-making empowered by dynamic analytics

## **6. Task-Driven Questions and Analysis**

**Teammates:** Varsha, Hari, Kiran, Adhitya, and Nikhita.

The task-driven questions were prepared by Adhitya, acting as Quality Assurance analysts. These questions were answered by Kiran , Hari and Nikhita, who acted as consumers.

**Kiran - Route selected: Times Square, NYC to Brooklyn**

### Filters

Enter Start Location  
Times Square, NYC

Enter End Location  
Brooklyn

#### Dynamic Route Optimization

Traffic Level (%)

Traffic Map Zoom Level

**Find Route**

**Show Traffic Map**

## Taxi Fleet Management Dashboard

### Optimal Route Based on Traffic

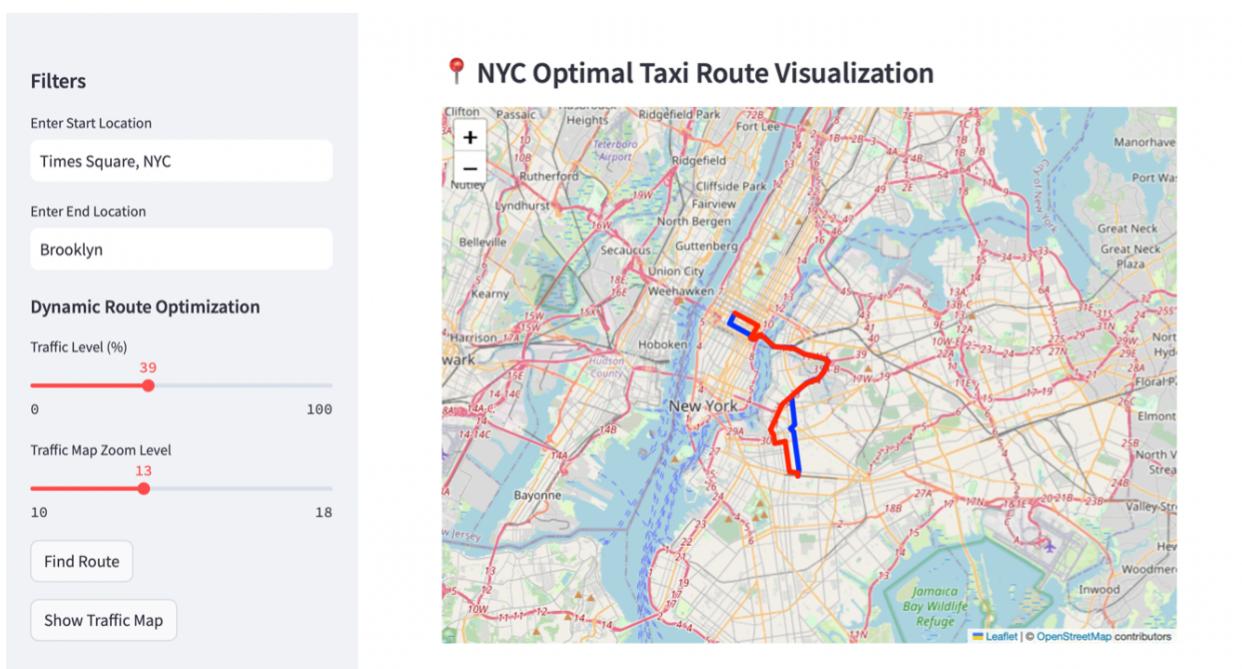
Best Route Distance  
**9.0 mi**

Best Route ETA  
**41 mins**

Alternative Route Distance  
**9.9 mi**

Alternative Route ETA  
**38 mins**

**NYC Optimal Taxi Route Visualization**



### Route Cost Estimation

Select Vehicle Type

- Sedan
- SUV
- Luxury

Route	Distance (miles)	Fuel Cost (\$)	Estimated Fare (\$)
0 Main Route	8.9000	1.0400	6.0400
0 Alternative Route	9.7900	1.1400	6.1400

## 🚗 Route Cost Estimation

Select Vehicle Type

- Sedan
- SUV
- Luxury

	Route	Distance (miles)	Fuel Cost (\$)	Estimated Fare (\$)
0	Main Route	9.0000	1.5700	6.5800

	Route	Distance (miles)	Fuel Cost (\$)	Estimated Fare (\$)
0	Alternative Route	9.9000	1.7300	6.7300

## 🚗 Route Cost Estimation

Select Vehicle Type

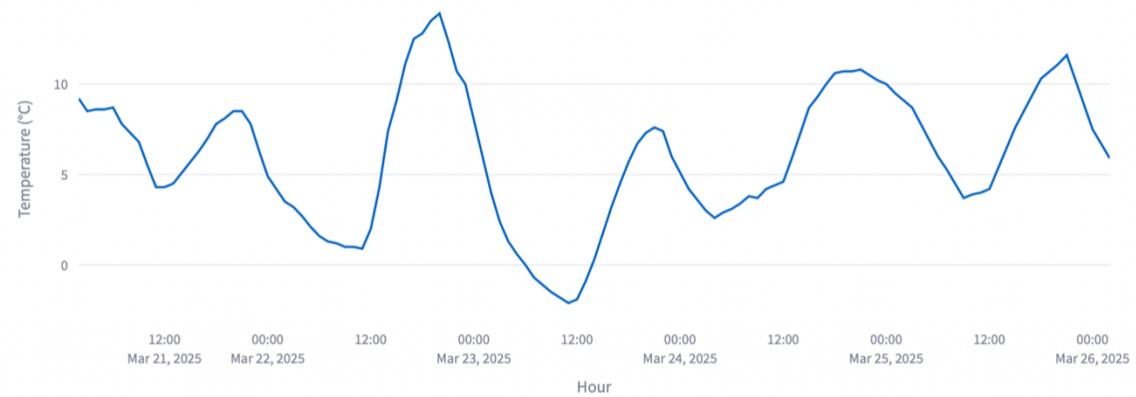
- Sedan
- SUV
- Luxury

	Route	Distance (miles)	Fuel Cost (\$)	Estimated Fare (\$)
0	Main Route	8.9000	2.0800	7.0800

	Route	Distance (miles)	Fuel Cost (\$)	Estimated Fare (\$)
0	Alternative Route	9.7900	2.2800	7.2800

## weathermap Hourly Weather Trends Based on Start Location

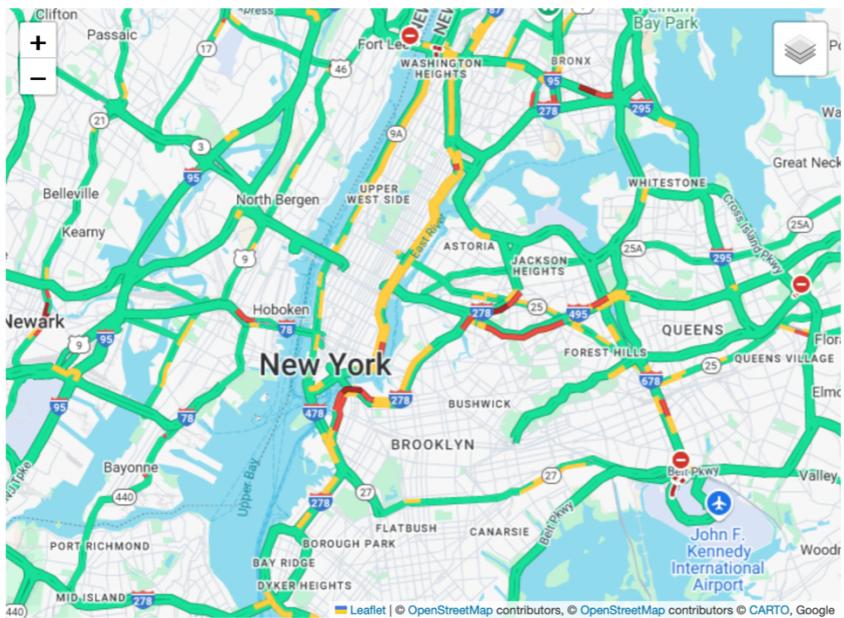
### Hourly Temperature Trends



### Hourly Weather Conditions



### 🚦 Real-Time Traffic Conditions



**1. How many miles is the main route?**

- The main route (blue route) is 9.0 miles long.

**2. What is the estimated fuel cost for each route?**

- Main Route
  - Sedan: \$1.04
  - SUV: \$1.57
  - Luxury: \$2.08
- Alternative Route
  - Sedan: \$1.14
  - SUV: \$1.73
  - Luxury: \$2.28

**3. How much is the estimated fare for each route?**

- Main Route
  - Sedan: \$6.04
  - SUV: \$6.58
  - Luxury: \$7.08
- Alternative Route
  - Sedan: \$6.14
  - SUV: \$6.73
  - Luxury: \$7.28

**4. Which route is longer: the main route or the alternative route?**

- The alternative route is longer (9.9 miles) than the main route (9.0 miles), but the estimated arrival time (ETA) is shorter for the alternative route (38 minutes) compared to the main route (41 minutes).

**5. How much traffic is currently on the main route?**

- The traffic level is currently 39

**6. What is the current temperature trend in the selected area?**

- The temperature fluctuates between 5°C and 10°C, as shown in the hourly temperature trend graph.

**7. How does weather impact the travel time?**

- If there is a sharp drop in temperature or rain, traffic might slow down due to reduced visibility and road slipperiness.

- The weather conditions chart shows variations such as clear skies, cloudy, or rain, indicating possible travel delays.

**8. What is the estimated time of arrival (ETA) for each route?**

- Despite being shorter, the main route (Blue Route, 9.0 miles) takes 41 minutes due to higher congestion.
- The alternative route (Red Route, 9.9 miles) takes only 38 minutes, as it has lower congestion and allows faster travel.

**9. Which vehicle type results in the lowest fuel cost?**

- Sedan has the lowest fuel cost across all routes.

**10. How does changing traffic levels affect route recommendations?**

- The system dynamically updates route recommendations:
  - If traffic congestion increases on the main route (Blue Route), the system suggests the alternative route (Red Route) for a faster ETA.
  - Users can adjust the traffic level slider to simulate different congestion scenarios and observe changes in recommended routes.

## Nikhita - Route selected: JFK Airport to Manhattan

**1. How many miles is the main route?**

The main route is 16.2 miles long.

**2. What is the estimated fuel cost for each route?**

On the main route, it costs around \$2.30 for a sedan, \$3.40 for an SUV, and \$4.50 for a luxury car. The alternative route is a bit longer (17 miles), so the fuel cost is slightly higher, about \$2.50 for a sedan and \$4.80 for a luxury vehicle.

**3. How much is the estimated fare for each route?**

The fare for the main route is \$12.50 for a sedan, \$13.70 for an SUV, and \$15.20 for a luxury car. The alternative route is a bit more expensive but not by much—around \$13.00 for a sedan and \$15.80 for a luxury ride.

**4. Which route is longer: the main route or the alternative route?**

The alternative route is longer, 17.0 miles, compared to the main route, which is 16.2 miles.

**5. How much traffic is currently on the main route?**

Right now, there's 70

**6. What is the current temperature trend in the selected area?**

It's about 7°C and raining, which might slow down driving a little.

**7. How does weather impact the travel time?**

Since it's raining, cars are probably driving slower, which can increase the total trip time.

**8. What is the estimated time of arrival (ETA) for each route?**

The main route will take 58 minutes, while the alternative route is faster at 52 minutes, even though it's longer.

**9. Which vehicle type results in the lowest fuel cost?**

Definitely the sedan, since it uses the least fuel.

**10. Which vehicle type is the most profitable?**

Luxury cars make the most money per ride, but since they burn more fuel, an SUV might be a better balance of fuel cost and fare earnings.

## Hari - Route selected: Bronx to Lower Manhattan

**1. How many miles is the main route?**

The main route is 11.8 miles long.

**2. What is the estimated fuel cost for each route?**

- Main route: \$1.70 (Sedan), \$2.50 (SUV), \$3.20 (Luxury)
- Alternative route (12.5 miles): \$1.85 (Sedan), \$2.70 (SUV), \$3.50 (Luxury)

**3. How much is the estimated fare for each route?**

- Main route: \$9.80 (Sedan), \$10.50 (SUV), \$11.80 (Luxury)
- Alternative route: \$10.00 (Sedan), \$10.80 (SUV), \$12.00 (Luxury)

**4. Which route is longer: the main route or the alternative route?**

The alternative route (red) is longer at 12.5 miles.

**5. How much traffic is currently on the main route?**

45

**6. What is the current temperature trend in the selected area?**

10°C and clear skies.

**7. How does weather impact the travel time?**

No impact this time, the weather is fine.

**8. What is the estimated time of arrival (ETA) for each route?**

40 minutes for the main route, 38 minutes for the alternative route (faster because there's less congestion).

**9. Which vehicle type results in the lowest fuel cost?**

The sedan.

**10. Which vehicle type is the most profitable?**

Luxury cars make the most money, but SUVs seem like a good balance.

## 7. Results

By combining real-time traffic data, cost estimation models, and weather trends into a single interactive platform, the Taxi Fleet Management Dashboard has shown itself to be a useful tool for optimizing urban taxi operations. As the dashboard's analysis shows, choosing a different route can occasionally result in shorter travel times even though it covers a greater distance, especially when the main route is congested. The system gives fleet operators and taxi drivers the ability to compare routes in real-time, enabling them to make informed decisions that reduce delays and increase trip efficiency.

Fuel consumption and fare pricing information for various vehicle types (Sedan, SUV, and Luxury) has been effectively provided by the Route Cost Estimation feature. The findings indicate that sedans are consistently the most fuel-efficient vehicles, making them a more cost-effective option for daily driving, whereas luxury cars result in higher fares but also higher fuel costs. The ability to compare these financial factors ensures better decision-making when selecting a vehicle for different types of rides.

Weather-related disruptions can also be predicted with the help of the dashboard's Hourly Weather Trends analysis. When the system detected rain or extremely high temperatures, it warned of possible travel delays due to poor road conditions. By incorporating weather data, fleet managers and drivers can predict delays and select routes that reduce exposure to heavy traffic or unfavorable driving conditions.

Users can also modify the level of congestion and run various scenarios with the Real-Time Traffic Visualization, which helps them better understand how traffic variations affect estimated time of arrival (ETA). This feature has reinforced the importance of choosing the right route by showing that, frequently, a slightly longer route with less traffic leads to a shorter total travel time. All things considered, the outcomes confirm how well the Taxi Fleet Management Dashboard works to increase fleet productivity, cut down on idle time, save fuel expenses, and guarantee a smoother travel experience. A thorough and useful solution to urban transportation issues is provided by the dashboard's integration of real-time analytics, cost modeling, and environmental considerations.

## 8. Conclusion

The Taxi Fleet Management Dashboard demonstrates how combining weather information real-time traffic analytics and route-specific cost estimation can greatly improve urban taxi operations. The system helps fleet managers and cab drivers make informed data-driven decisions that increase overall efficiency by offering dynamic route recommendations cost insights and environmental impact assessments. By providing accurate fare estimates and real-time traffic updates the dashboard not only helps to cut down on travel time and fuel consumption but also improves user satisfaction. Furthermore especially in bad weather the inclusion of weather-based route adjustments guarantees safer and more dependable transportation. Future developments might include AI-powered prediction models for demand estimation adaptive route planning and real-time traffic congestion forecasting. These would improve decision-making skills and optimize fleet operations for increased sustainability and efficiency.