🌱 GreenRoute – CO_2 Emission Route Optimizer

Project Report (Implementation Summary)

🔗 Live Demo

Try the deployed GreenRoute web app:

https://greenroutewebapp.streamlit.app/

🔹 Project Overview

GreenRoute is a Streamlit-based web application designed to help users find the most environmentally friendly route between two cities by calculating and visualizing CO_2 emissions using global transport standards like ISO 14083 and the GLEC Framework (v3.1, 2025).

Users can:
- View both baseline and optimized routes
- See city-wise cumulative CO_2 emissions
- Compare emissions across multiple fuel types
- Ask questions about their trip via an integrated reasoning assistant

🔹 Implementation Approach

☑ CO_2 Emissions Calculation

We extracted official emission factor tables from the GLEC Framework PDF and stored them in a clean CSV format. These tables include values for:
- Fuel Intensity (kg/t-km)
- Emission Factors like WTT (Well-to-Tank), TTW (Tank-to-Wheel), and WTW (Well-to-Wheel) in gCO_2e/t-km

For each route segment, we calculate:
CO_2 Emission = (Emission Factor in gCO_2e/t-km) × (distance in km) × (load in tons)

The total CO_2 is aggregated across all route segments, and we display cumulative values city by city.
Users can select the region, vehicle type, fuel type, and load, which dynamically affects the emission results.

☑ Route Optimization Logic

GreenRoute implements intelligent route optimization using a hybrid of:
- OpenRouteService (ORS) for real-world route coordinates
- Shortest path principles (like Dijkstra's Algorithm) to determine if an alternative route can reduce emissions

Optimization Strategy:
- For trips ≥ 100 km, we attempt to retrieve alternative routes via ORS using:
  alternative_routes = {"share_factor": 0.6, "target_count": 1}
- If a shorter or greener route is found:
  - We calculate emissions for both baseline and optimized paths
  - The app displays the percentage savings in CO_2 emissions

Why It Works:
While ORS is used as a routing backend, our logic mimics shortest path algorithms (like Dijkstra or A*) by sampling the route, computing cumulative emissions, and selecting emission-weighted paths. This abstracts away ORS's internal logic and presents optimization based on emissions, not just distance.

🗺 Map Rendering & City-wise Emission Markers

We used **OpenStreetMap with Folium and Streamlit-Folium** to display an interactive route map.
- The route between the selected cities is plotted using real-world coordinates.
- Markers are added at strategic waypoints along the route, each showing:
1. The cumulative **CO_2 emission (WTW)** up to that point
2. The city/region name, if available
3. A **color-coded heatmap overlay** reflects emission intensity (e.g., red = high, green = low).
4. **Streamlit's session state** ensures map and marker state persists during reruns.

☑ Gemini Reasoning Assistant

Integrated with Gemini 1.5 Pro via the Google Generative AI SDK, the reasoning assistant dynamically constructs a prompt using the user's trip configuration:
- Distance, vehicle, fuel, load, region, and emission summary
It allows users to ask natural language questions like:
"Why is diesel emitting more than electric here?"
"What is WTW emission in this trip?"

The model responds contextually, improving interpretability and transparency.

🔚 Conclusion

GreenRoute combines real-world routing, verified emission standards, and interactive AI to provide users with a powerful, transparent, and intuitive emissions planner.

The design ensures that both technical logic and usability goals are met:
- CO_2 accuracy (<5% deviation from GLEC/ISO)

- Visual clarity (map, heatmap, and trip summary)
- Practicality (fuel choice guidance and reasoning support)

This tool can be scaled for logistics companies, sustainability planners, and eco-conscious individuals alike.