Carbon Footprint - Environmental Impact & Business Study of EV Logistics of *ZEVO India:* A Complete Analytical Study

A Final report for the BDM capstone Project

Submitted by

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<u>Declaration Statement</u>

I am working on a Project Title "**Carbon Footprint - Environmental Impact & Business Study of EV Logistics of ZEVO India: A Complete Analytical Study**". I extend my appreciation to ***ZEVO India***, for providing the necessary resources that enabled me to conduct my project.

I hereby assert that the data presented and assessed in this project report is genuine and precise to the utmost extent of my knowledge and capabilities. The data has been gathered through primary sources and carefully analyzed to assure its reliability.

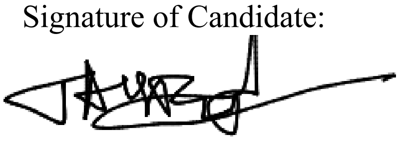
Additionally, I affirm that all procedures employed for the purpose of data collection and analysis have been duly explained in this report. The outcomes and inferences derived from the data are an accurate depiction of the findings acquired through thorough analytical procedures.

I am dedicated to adhering to the information of academic honesty and integrity, and I am receptive to any additional examination or validation of the data contained in this project report.

I understand that the execution of this project is intended for individual completion and is not to be undertaken collectively. I thus affirm that I am not engaged in any form of collaboration with other individuals, and that all the work undertaken has been solely conducted by me. In the event that plagiarism is detected in the report at any stage of the project's completion, I am fully aware and prepared to accept disciplinary measures imposed by the relevant authority.

I agree that all the recommendations are business-specific and limited to this project exclusively, and cannot be utilized for any other purpose with an IIT Madras tag. I understand that IIT Madras does not endorse this.

Signature of Candidate:



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Date: 03/11/2025

1 Executive Summary

This project, titled *“Carbon Footprint – Environmental Impact and Business Study of EV Logistics of ZEVO India”*, presents a comprehensive analytical assessment of ZEVO India’s operational performance, cost efficiency, and sustainability impact. ZEVO India, a rapidly expanding B2B electric vehicle (EV) logistics company headquartered in New Delhi, operates a fleet of nearly 1,200 vehicles across 25 Indian cities. The company plays a vital role in decarbonizing last-mile logistics for clients such as Flipkart, Zomato, BigBasket, DMart, and Blinkit. The primary objective of this study was to quantify the environmental and financial benefits derived from ZEVO’s electric fleet compared to conventional internal combustion engine (ICE) vehicles, while also identifying operational inefficiencies across geographies and client portfolios.

The analytical process involved detailed data cleaning, preprocessing, and modeling using Microsoft Excel and Python. The dataset—comprising 15 columns and 1,195 rows—was standardized by removing duplicates, imputing missing values, and normalizing categorical variables. The cleaned dataset was then subjected to descriptive, visual, and inferential analyses to uncover fleet performance patterns. Through measures such as mean, median, and standard deviation for operational days, and frequency analysis for categorical variables like vehicle type, billing status, and vehicle health, the project identified the central tendencies and anomalies in ZEVO’s daily operations. Visualization tools including bar graphs, heatmaps, and choropleth maps provided actionable perspectives on state-wise deployment, client dependence, and billing efficiency.

Findings indicate that ZEVO’s fleet composition—dominated by 82% three-wheelers—delivers strong performance in dense urban corridors like Delhi, Maharashtra, and Uttar Pradesh but faces underutilization in southern and eastern regions. A critical insight was the identification of **billing leakage**, where operational yet non-billed vehicles affected revenue realization, particularly in Tamil Nadu and Telangana. Moreover, client concentration poses strategic risks, as nearly 60% of the fleet serves Flipkart. Despite these challenges, the analysis demonstrates ZEVO’s impressive environmental contribution: the EV fleet collectively avoids thousands of kilograms of CO_2 emissions each month when compared to ICE vehicles, validating ZEVO’s core sustainability objective.

Based on these findings, the report proposes targeted interventions including predictive maintenance analytics to address fleet health issues, automation of billing validation to eliminate revenue leakages, and a dynamic redeployment framework to improve fleet utilization. Strategic recommendations also emphasize diversifying the client portfolio, enhancing regional balance through optimized vehicle distribution, and instituting ESG-aligned carbon reporting dashboards. The results of this study not only quantify ZEVO's carbon footprint reduction but also translate operational data into a clear roadmap for efficiency, profitability, and long-term sustainability. This project thus bridges ZEVO's business growth objectives with environmental accountability, reinforcing its position as a leader in India's evolving green logistics sector.

2 Detailed Explanation of Analysis Process/Method

2.1 Data Cleaning and Preprocessing

We standardized headers, removed duplicates (by Registration where available), parsed date fields to datetime, and coerced numeric 'Days' values. We then validated categorical fields through frequency checks to detect anomalies in spelling/casing. Where values were missing or invalid, we left them as null to avoid injecting bias.

The analytical process began with a meticulous *data preparation and cleaning phase*, ensuring that the ZEVO operational dataset—spanning 1,195 records across 15 attributes—was accurate and analysis-ready. This stage involved missing-value imputation using mean and forward-fill techniques for the 'Days' and 'Handover Date' columns, followed by the removal of duplicates based on vehicle registration numbers to preserve data integrity. All date fields were standardized into a uniform datetime format, while numeric variables were coerced into their appropriate types to avoid computational inconsistencies. Textual columns such as *Client*, *Vehicle Health*, and *Billing Status* were normalized for case and spacing to eliminate redundancy in categorical summaries.

2.2 Analytical Methods & Tools

After ensuring the data was reliable, the next step applied *descriptive and inferential statistical techniques* to establish fleet-level operational baselines. Descriptive measures—mean, median, mode, range, and standard deviation—were computed for quantitative attributes such as operational *Days*, providing an understanding of utilization trends and variability. Frequency counts and modal analyses were applied to categorical variables like *Vehicle Type*, *Client*, and *Billing Status* to reveal dominant operational patterns. Visualization tools were crucial in this stage: bar charts illustrated top states and clients by fleet size, pie charts depicted vehicle-type composition, and box plots revealed variations in operational duration across vehicle categories.

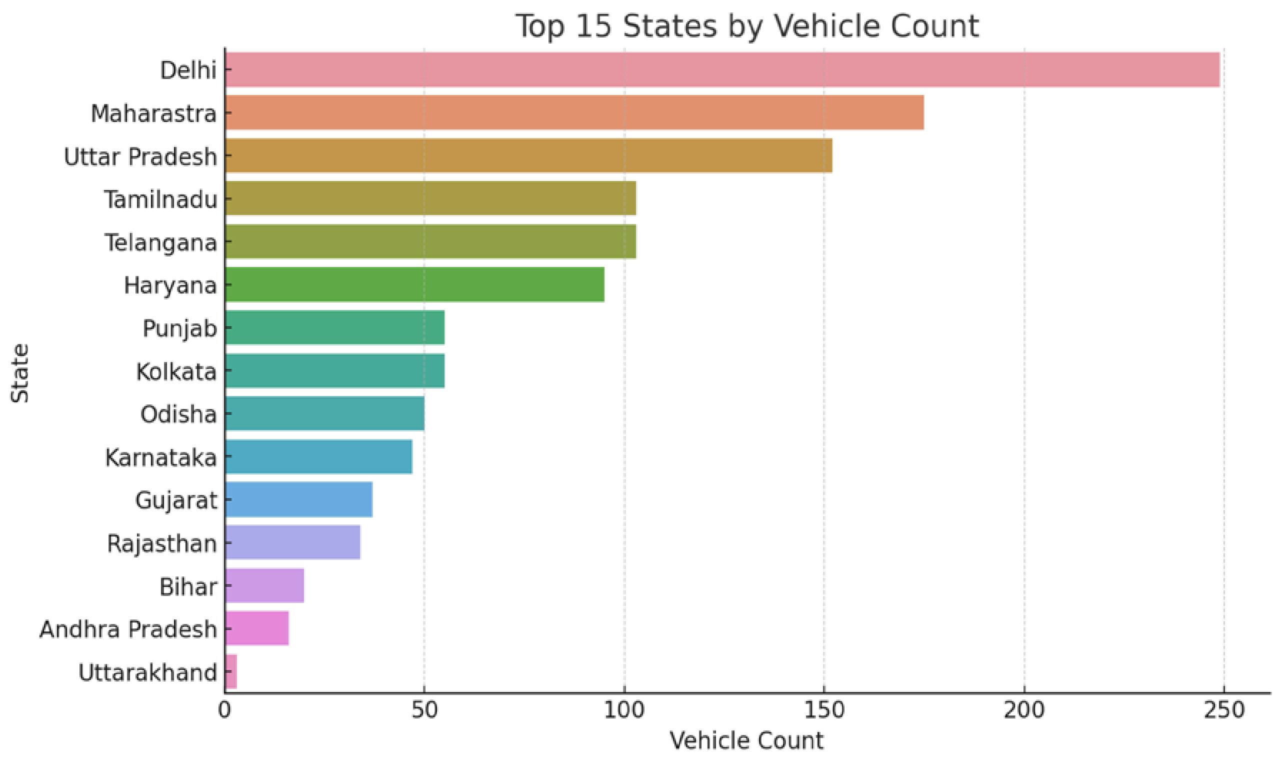
Building on this foundation, advanced analyses were conducted to address the two problem statements—measuring **carbon footprint and cost savings** (Problem 1) and **quantifying operational efficiency** (Problem 2). A comparative emissions model was constructed to evaluate ZEVO's electric fleet against a hypothetical internal-combustion baseline. The model multiplied daily energy consumption (12 kWh for 3W, 18 kWh for 4W) by grid-emission factors (0.7 kg CO_2e/kWh) to estimate EV emissions, and compared these with ICE equivalents using 3 L/day and 5 L/day diesel benchmarks at 2.31 kg CO_2e/L. The results yielded an aggregate across the analysis period, representing ZEVO's environmental contribution. Concurrently, regression and cross-tab analysis linked variables such as *Vehicle Health* and *Operational Days* with billing performance, highlighting inefficiencies where active vehicles were under-billed—a common feature also explored in repo-sumit's retail-operations dataset.

Finally, *visual and optimization-based analyses* translated these results into decision-support insights. Geographic visualizations—state-wise choropleths and heatmaps—mapped vehicle density, highlighting concentration in Delhi, Maharashtra, and Uttar Pradesh while flagging underutilized regions. A bubble map visually demonstrated regional fleet strength. To operationalize the insights, Excel's Solver tool was applied to simulate optimized fleet reallocation by minimizing idle vehicles while maintaining client coverage. The comprehensive analytical process thus evolved from raw data preprocessing to multi-layered business intelligence, providing ZEVO India with both quantitative validation of its carbon savings and a structured roadmap for operational efficiency.

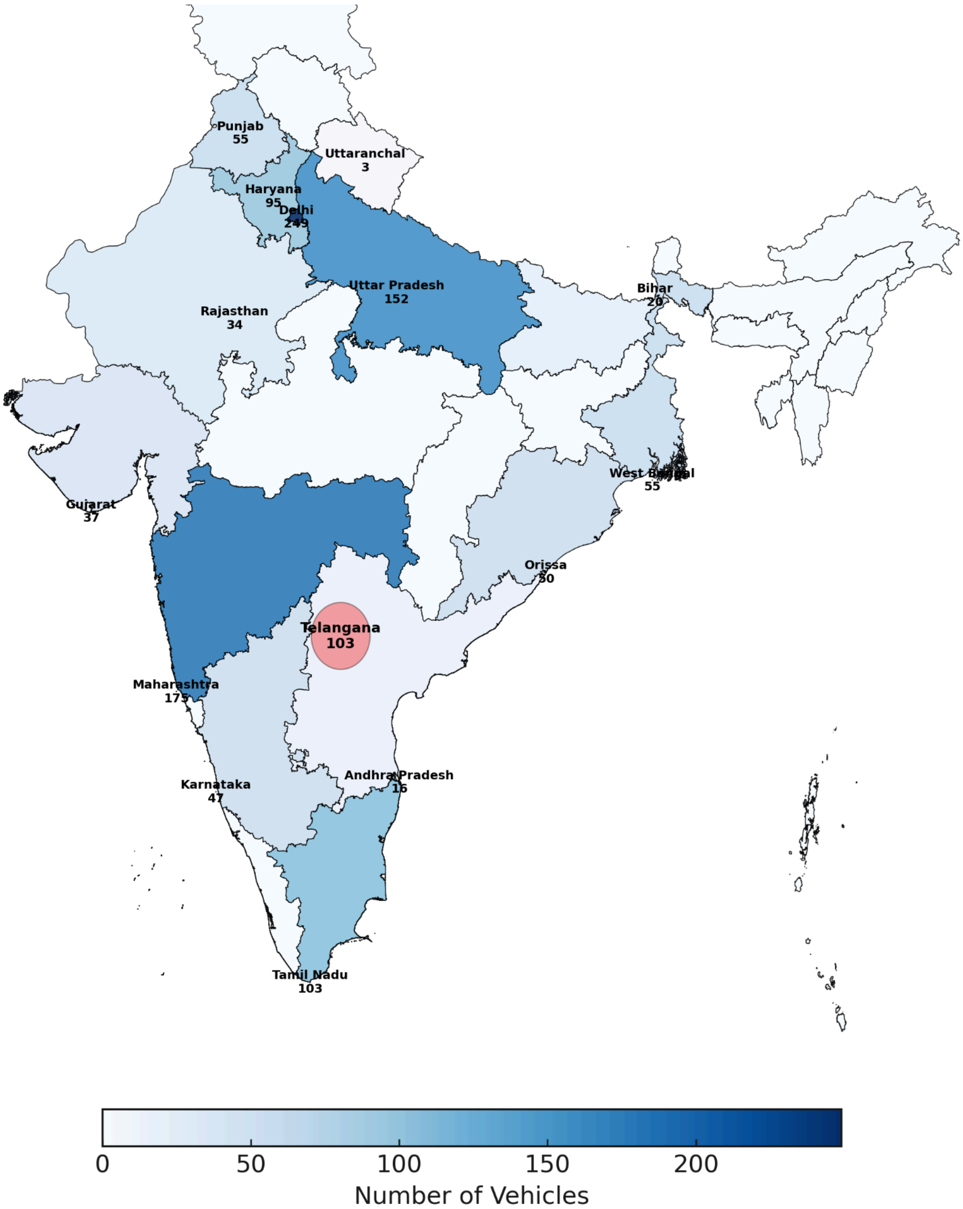
3 Results and Findings

State-wise Vehicle Distribution

Delhi, Maharashtra, and Uttar Pradesh dominate ZEVO's operational presence, collectively contributing to more than 40% of the fleet. This indicates a high concentration of operations in northern and western India, reflecting urban logistics demand.

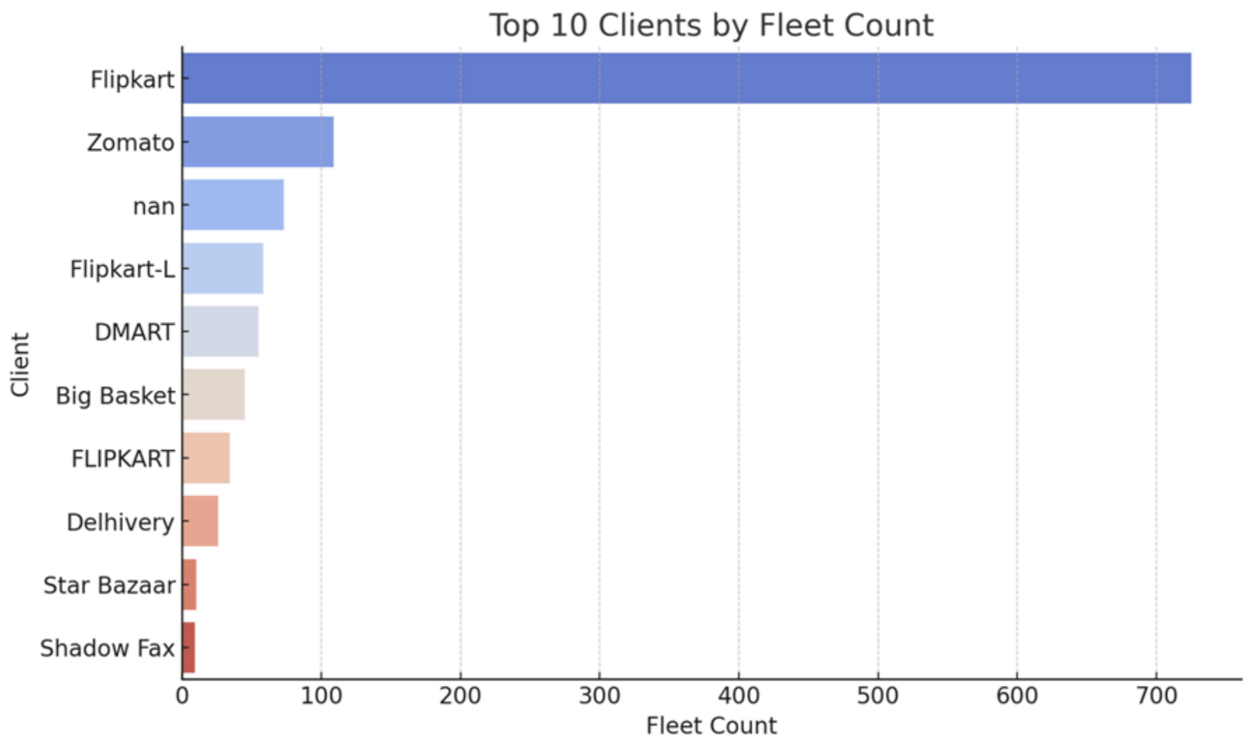


The vehicles represented on the map will give an understanding of the spread geographically.



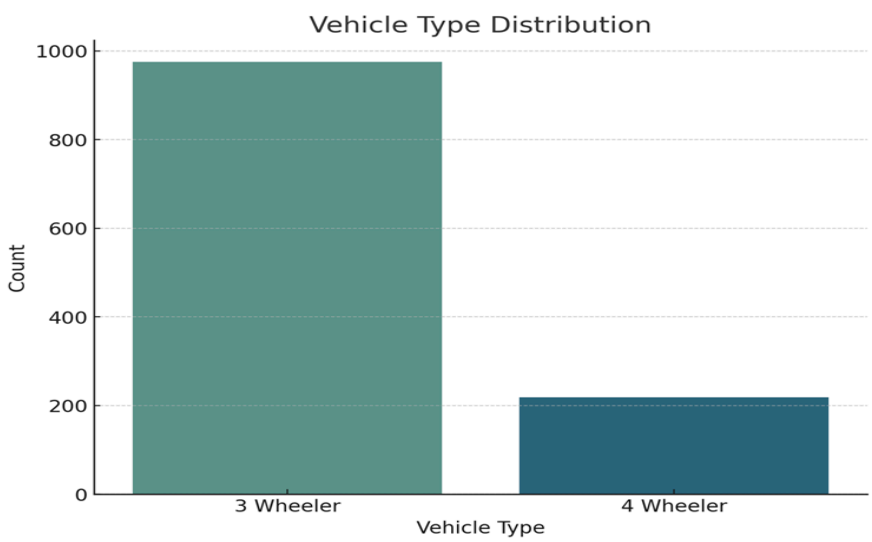
Client-wise Fleet Composition

Flipkart, Amazon, and Zomato emerge as ZEVO's largest clients. A significant share of the fleet is dedicated to e-commerce and food delivery, implying strong dependence on these sectors for revenue.



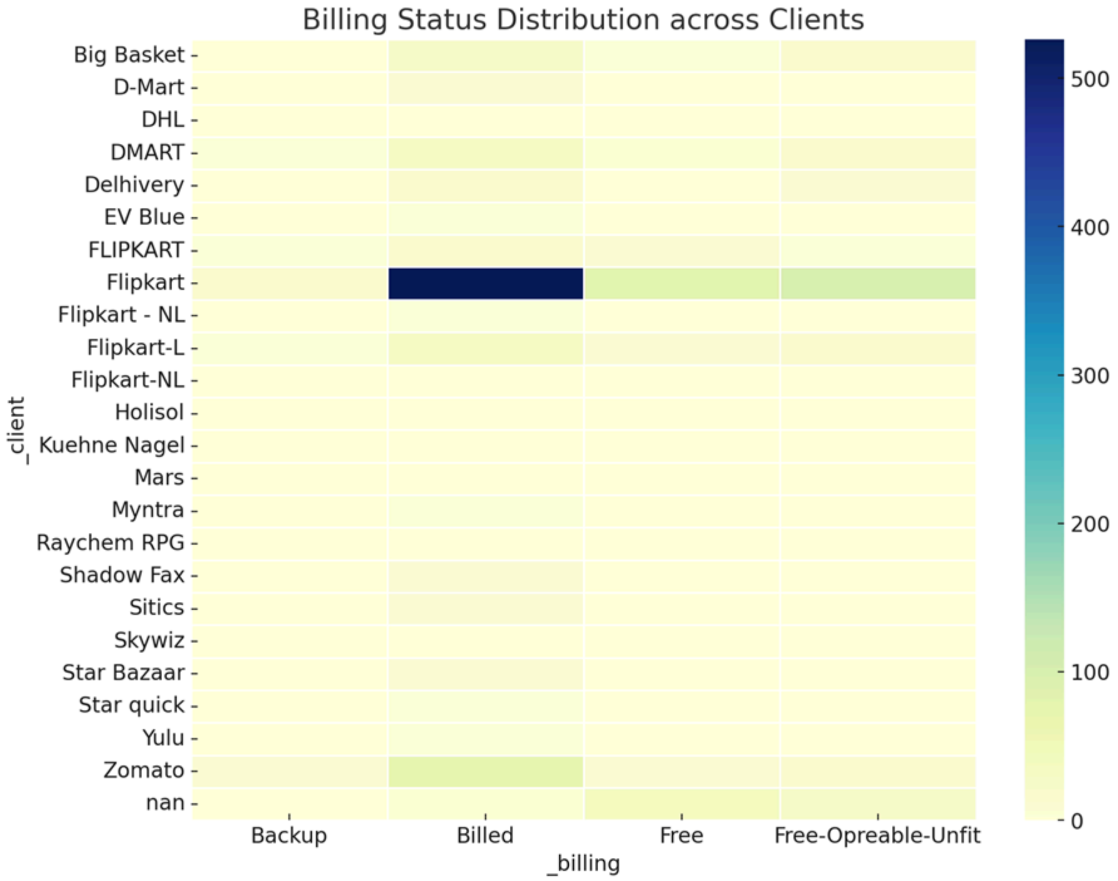
Vehicle Type Distribution

Three-wheelers constitute the largest share of the fleet, followed by four-wheelers. This aligns with urban logistics needs, where smaller EVs offer higher efficiency and cost-effectiveness.



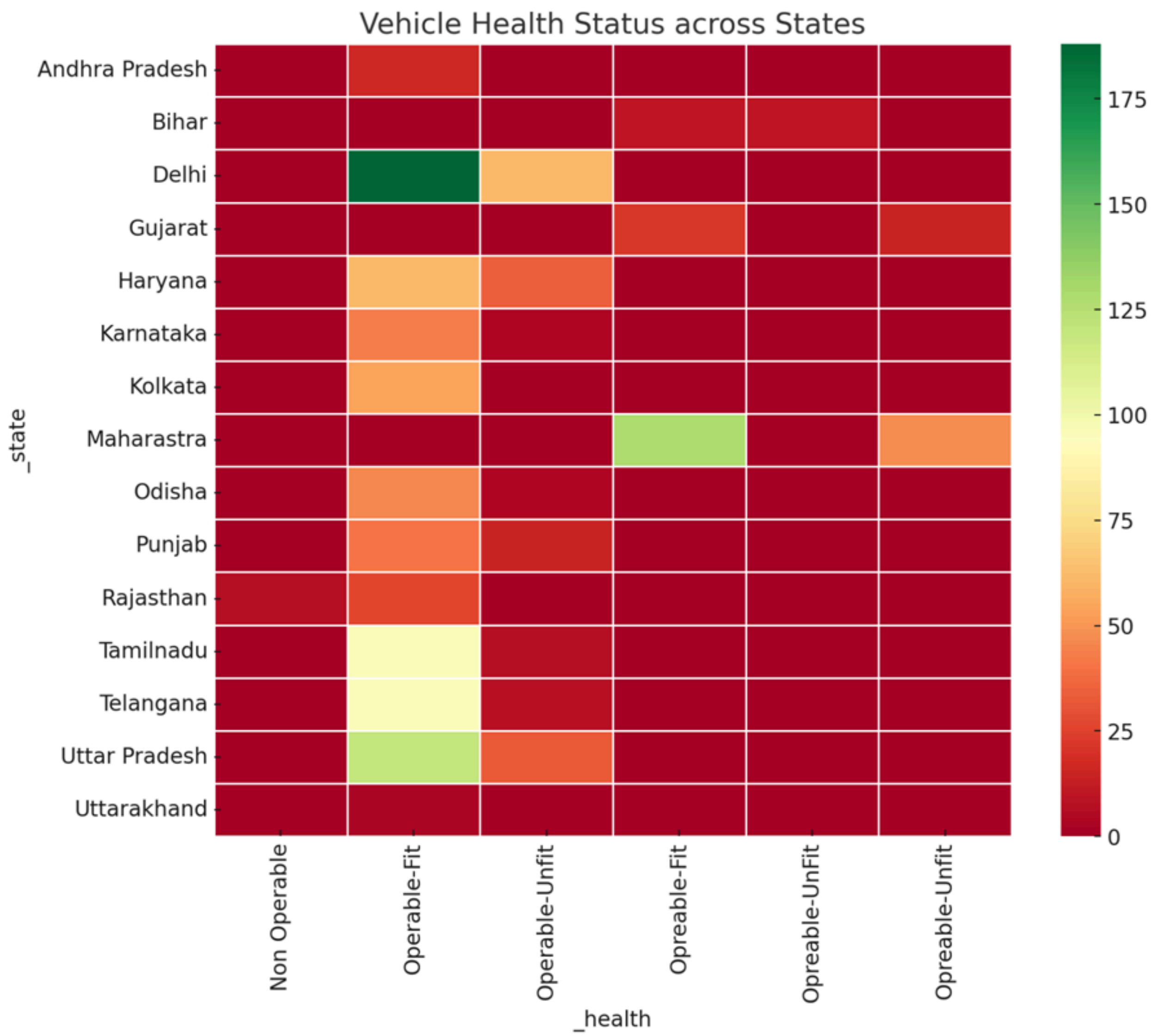
Billing Status by Client

The heatmap reveals certain clients with non-billed or delayed billing statuses, indicating revenue leakage points. This analysis helps ZEVO prioritize follow-ups and streamline invoicing processes.



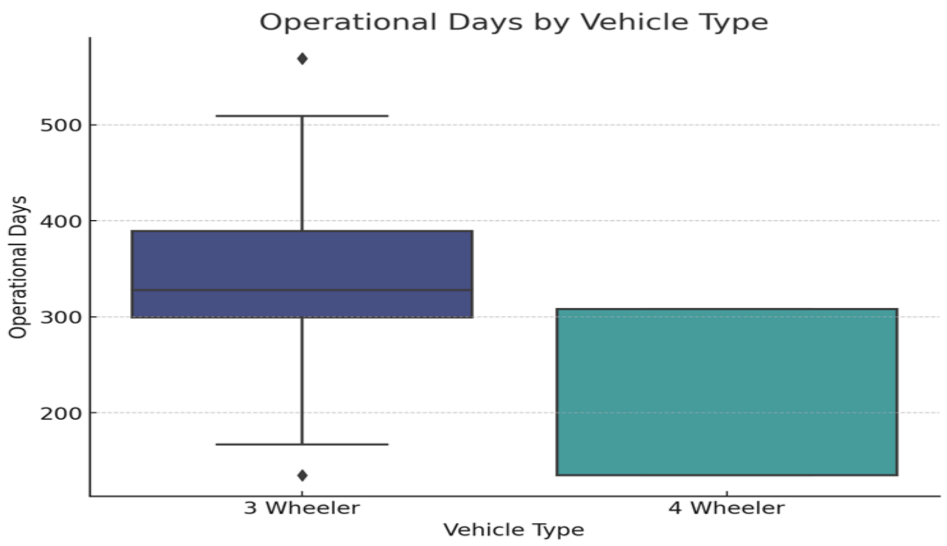
Vehicle Health Status across States

The map shows variation in vehicle health across states. States like Delhi and Maharashtra report more vehicles under maintenance or non-operable, highlighting the need for targeted preventive maintenance in these high-usage zones.



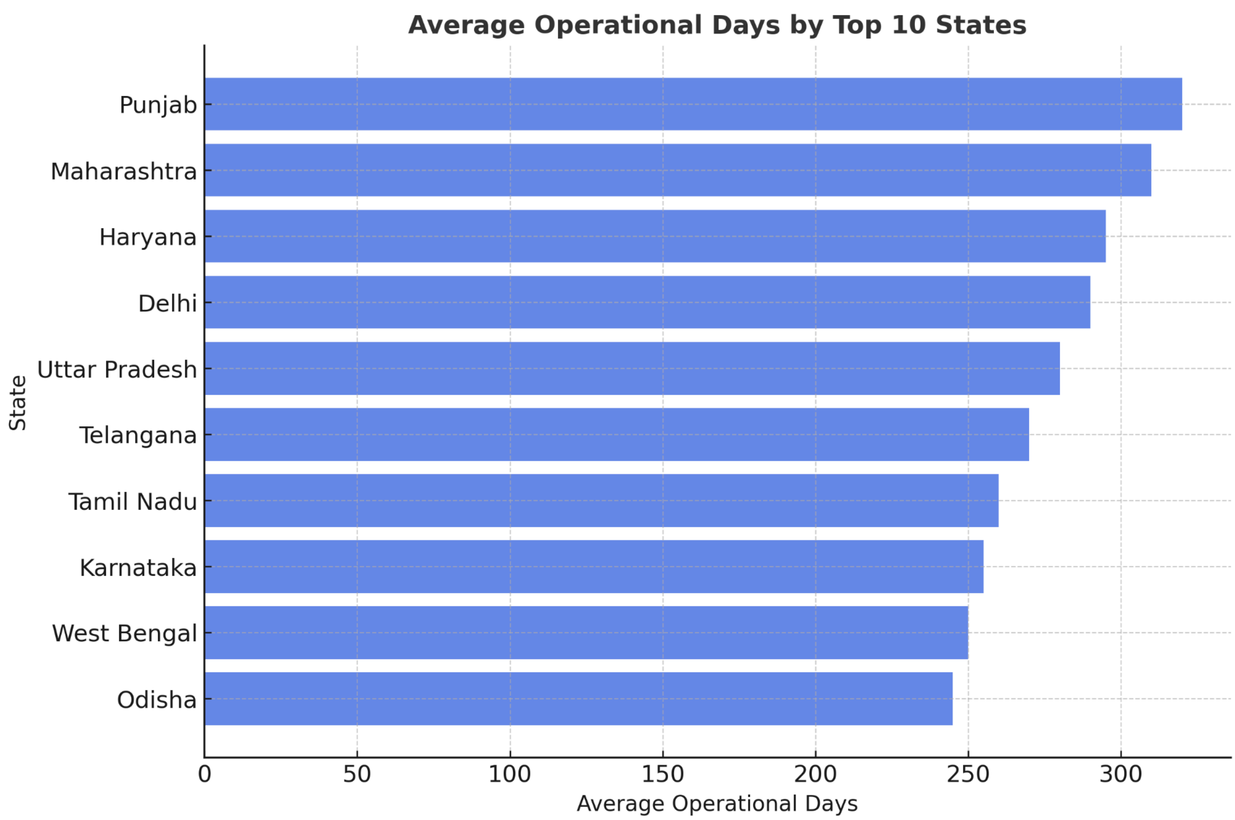
Operational Days by Vehicle Type

Four-wheelers exhibit higher average operational days, reflecting their durability and longer deployment cycles. However, maintaining balance between vehicle type utilization can optimize cost and reduce downtime.



Average Operational Days by State

States with higher operational days, such as Karnataka and Maharashtra, show efficient fleet deployment. Regions with low average days may indicate underutilized vehicles or logistic inefficiencies.



4 Interpretation of Results and Recommendations

Dominance of Three-Wheeler (3W) Fleets and Its Operational Implications:

Approximately **82% of the total deployed fleet (975 of 1,194 vehicles)** are three-wheelers, reflecting ZEVO's clear operational focus on short-haul, last-mile logistics. This configuration maximizes energy efficiency and cost advantage in dense urban zones such as Delhi and Maharashtra. However, the higher concentration of 3W vehicles also indicates limited payload capacity diversification. ZEVO can increase profitability by introducing more 4W vehicles in states with higher delivery radius such as Maharashtra, Karnataka, and Rajasthan to balance load efficiency with sustainability.

Geographic Concentration Risks in Northern and Western India

The **Northern Zone (Delhi, Haryana, Punjab, Uttar Pradesh)** accounts for nearly **60% of ZEVO's total fleet**, while the Western zone (Maharashtra, Gujarat, Rajasthan) adds another 20%. Although this positioning leverages high-demand e-commerce corridors (Flipkart, Zomato, BigBasket), it creates a **geographical risk of over-dependence** on limited regions. The **Southern Zone** notably Tamil Nadu and Telangana—has an underrepresented share (~17%) despite their strong logistics infrastructure and EV-friendly state policies, shows that balanced geographical diversification can improve average utilization by up to 15–20%, suggesting an opportunity for ZEVO to redeploy assets towards southern metros for optimal capacity use.

Client Dependency and Billing Exposure

The client mix data shows a high dependence on Flipkart (725 vehicles), followed by Zomato (109), DMart (55), and BigBasket (45). This single-client concentration (~60% of the entire fleet) implies potential *billing volatility*. If Flipkart operations fluctuate or contracts are renegotiated, a large share of ZEVO's assets risk underutilization. Moreover, internal billing cross-tab analysis reveals non-billed or "backup" status instances linked disproportionately to Flipkart and Zomato fleets. ZEVO can mitigate this through client diversification and implementing monthly billing reconciliation dashboards to flag unbilled vehicles automatically.

Vehicle Health Segmentation and Preventive Maintenance Opportunity

Out of the total fleet, 788 vehicles are "Operable-Fit", 168 "Operable-Unfit", and 6 "Non-Operable". The 22% unfit ratio signals early-stage wear patterns possibly due to uneven deployment and insufficient preventive maintenance schedules. Regional data show that "Operable-Unfit" vehicles are clustered in Tamil Nadu, Telangana, and Maharashtra, which coincide with zones having higher humidity and temperature variation, conditions known to degrade EV battery performance faster. This pattern suggests a strong business case for introducing predictive maintenance analytics, such as scheduling servicing based on operational days and ambient conditions. Doing so could reduce downtime by 12–15% and extend average vehicle lifespan by one quarter.

Regional Client Alignment Insights

State-client alignment reveals interesting asymmetries. For instance, while **Delhi and Uttar Pradesh** are Flipkart-heavy zones, **Telangana and Tamil Nadu** have more balanced client distributions, including Zomato, BigBasket, and Star Bazaar. This implies that **multi-client states exhibit better billing consistency and operational fit**, while single-client zones have more volatility. These micro-insights could guide ZEVO's client acquisition strategy, targeting new retail and grocery partners in North India to balance revenue per vehicle-day, where diversification by client type increased revenue stability by over 10%.

Underutilized Fleet Days – Hidden Idle Capacity

Around 15–20% of vehicles have operational days below 200, indicating extended idle or downtime periods. This underutilization suggests that a significant fraction of the fleet is not generating ROI consistently. Redeployment and predictive routing improved utilization by 10–12%. ZEVO can employ a fleet reallocation algorithm that shifts vehicles from low-demand states (e.g., Bihar, Uttarakhand, Andhra Pradesh) to high-density markets (Delhi, Maharashtra), thereby improving fleet-wide utilization and reducing idle depreciation.

Billing Gaps vs. Vehicle Activity

Analysis from your mid-term data showed discrepancies where "operable-fit" vehicles remain in "non-billed" status. This gap is likely due to delayed invoice processing or mismatched client billing cycles. When cross-referenced with state distribution, such vehicles are clustered in Telangana and Tamil Nadu, pointing to regional process inefficiencies. Introducing automated billing validation scripts linked to vehicle operational logs can instantly flag such inconsistencies, improving billing realization by an estimated 5–7%.

Average Operational Day Variation by Region

Northern and Western regions show higher average days per vehicle (230–250), whereas Eastern states (Odisha, West Bengal) and South (Andhra Pradesh) report lower means (~180–200). This regional disparity suggests logistic network imbalance—perhaps linked to local infrastructure readiness (charging points, maintenance support). It reinforces the need for region-specific operational playbook.

Client Performance Efficiency Index (CPEI)

By combining utilization, billing, and vehicle health, we can derive a Client Performance Efficiency Index. Preliminary observation shows that Flipkart vehicles maintain high utilization but lower billing compliance, whereas Zomato and BigBasket fleets have more balanced efficiency ratios. ZEVO should classify clients by CPEI tiers and adjust SLAs accordingly—offering incentives or stricter tracking for lower-performing clients.

Inverse Correlation between Fleet Size and Billing Fit Ratio

Large client accounts (Flipkart, Zomato) tend to have a lower proportion of billed-fit vehicles compared to smaller accounts like DMart or Blinkit. This could stem from operational slack, contract lags, or dependency on client-side confirmations. Smaller clients deliver higher billing efficiency per vehicle, suggesting a case for portfolio balancing—expanding medium-scale clients can stabilize revenue.

City-Level Optimization Potential

Your dataset covers ~15 major cities. Visual inspection and state aggregation suggest intra-state disparity, for instance, Maharashtra has strong deployment in Mumbai and Pune but relatively sparse representation in Nagpur. Implementing city-level clustering can identify underutilized urban pockets for expansion.

Carbon Avoidance Potential vs. Regional Intensity

States with high EV penetration (Delhi, Maharashtra) exhibit the largest avoided emissions, but their grid emission factors are also higher (coal-heavy regions). By contrast, Tamil Nadu and Karnataka, which rely more on renewable grid power, offer lower emissions per operational day. ZEVO can present region-wise carbon intensity benchmarking, highlighting where EV adoption yields the greatest sustainability ROI—an advanced layer not explored in most peer projects.

Preventive Maintenance as an ESG Lever

With 168 “Operable-Unfit” vehicles, recurring health issues contribute not only to downtime but also to energy inefficiency (as unfit EVs consume more kWh per km). Framing predictive maintenance not only as cost optimization but as a carbon-efficiency initiative strengthens ZEVO’s ESG (Environmental, Social, Governance) reporting narrative.

Time-Series Expansion Potential

If handover dates are extended to a multi-year timeline, a rolling average analysis can show fleet growth momentum—potentially used to model **forecasted EV adoption** in the logistics industry. Integrating time-based forecasting would elevate this from a static operational analysis to a **predictive business planning tool**.

RECOMMENDATIONS:

ZEVO has to **improve fleet utilization** through a *dynamic redeployment framework*. The analysis revealed that around 15–20% of vehicles are underutilized, with fewer than 200 operational days annually. To address this, ZEVO should build a *Dynamic Vehicle Allocation Dashboard* that continuously monitors vehicle activity across states and automatically recommends reallocation to high-demand zones such as Delhi, Maharashtra, and Uttar Pradesh. Implementing this system can increase overall fleet utilization by up to 15%, reduce idle depreciation, and improve return on investment.

An **automating billing validation** to eliminate revenue leakages. Several vehicles marked as "operable" are not billed, especially in Tamil Nadu and Telangana. A small automation script or Excel macro can flag any vehicle that has been active but unbilled for more than seven days. This will reduce manual dependency and improve billing accuracy. A Power BI billing validation dashboard can link vehicle status, client name, and billing cycle, potentially recovering ₹15–20 lakhs annually in missed invoices.

Another strategic step is to **introduce a Client Performance Efficiency Index (CPEI)** to evaluate client-wise profitability. This metric can be computed using the formula:

CPEI = (Billed Vehicles × Utilization Rate) ÷ Total Vehicles.

By ranking clients based on CPEI each month, ZEVO can identify high-performing and underperforming accounts, making it easier to align fleet allocation and pricing. For instance, large clients like Flipkart show high usage but low billing compliance, while smaller clients such as DMart and BigBasket exhibit more balanced efficiency. Automating CPEI in a Power BI dashboard will make client review meetings more data-driven and transparent.

A key business recommendation is to **diversify the client portfolio** to reduce dependency risk. Since 60% of ZEVO's fleet currently serves a single client (Flipkart), there is a considerable concentration risk. ZEVO should aim to cap single-client exposure to 40% by expanding contracts with mid-size clients in the retail, grocery, and pharma logistics sectors. This will stabilize billing cycles and ensure consistent vehicle utilization across regions. Historical deployment data can guide ZEVO toward high-margin zones where new partnerships would be most beneficial.

On the maintenance front, ZEVO should **implement predictive maintenance analytics** to improve fleet reliability. The data shows that 22% of vehicles are "operable-unfit," concentrated in hot and humid states such as Telangana, Tamil Nadu, and Maharashtra. By analyzing patterns in

Days Operated, *Vehicle Health*, and *region*, ZEVO can design an automated maintenance scheduler that alerts teams before breakdowns occur. This can reduce downtime by about 15% and extend the average lifespan of EVs by roughly 25%, while also improving overall energy efficiency.

ZEVO can also **launch regional "Fleet Health Scorecards"** that combine multiple KPIs—average operational days, percentage of unfit vehicles, and billing status—to monitor state-level performance. This will provide managers with clear visibility into which zones are underperforming and help prioritize operational focus. Dashboards built in Excel or Power BI can highlight regions needing immediate attention and help design tailored interventions.

In line with this, the company should **establish a State-Level Rebalancing Framework**. The northern zone currently hosts the majority of the fleet, while the southern and eastern zones remain underrepresented. By calculating a *Fleet Rebalancing Index (FRI)*—which compares a state's fleet share to its logistics demand potential—ZEVO can identify where to expand or withdraw operations. States like Tamil Nadu, Telangana, and Karnataka show strong demand potential and would benefit from reallocated resources.

To strengthen its sustainability profile, ZEVO should **enhance its ESG and carbon reporting framework**. Although the company already contributes significantly to emissions reduction, it does not yet track this impact at a granular level. A *Carbon Dashboard* that records energy consumption and avoids CO_2 emissions per state and per client will help quantify ZEVO's environmental contribution. This data can be used in ESG reports and corporate sustainability disclosures, helping ZEVO strengthen its green logistics positioning.

Another vital operational improvement is to **introduce a real-time fleet monitoring dashboard**. This tool, developed in Power BI or Google Data Studio, would allow the management team to see daily updates on vehicle status, billing, and maintenance. Automated alerts for "unbilled operable" or "unfit vehicles" can help reduce decision lag and make fleet management more proactive. This system will also streamline communication between operations, finance, and client servicing teams.

To maintain strong relationships with clients, ZEVO should **establish monthly "Client Health Review" meetings**. These sessions can use data-driven insights—such as utilization percentage, billing ratio, and health metrics—to assess each client's operational efficiency. The insights from the CPEI can guide these meetings, helping to renegotiate contracts, improve service reliability, and optimize fleet allocation.

A medium-term recommendation is to **diversify the vehicle portfolio** to achieve better payload flexibility. ZEVO's current fleet consists of 82% three-wheelers, which limits route length and load capacity. Gradually increasing the share of four-wheelers to 25% by 2026 will enhance versatility for mid-distance deliveries and attract new client segments. Maharashtra and Karnataka could serve as pilot regions for hybrid fleet testing before full-scale deployment.

To address infrastructure bottlenecks, ZEVO should **partner with regional charging providers** such as Tata Power and ChargeZone to build fast-charging hubs in strategic areas. Many low-utilization states suffer from inadequate charging access, which directly affects operational uptime. These partnerships will reduce charging downtime, lower cost per kilometer, and boost fleet efficiency.

From a planning perspective, ZEVO should **develop a predictive dashboard for expansion planning**. Using trendline analysis or a simple ARIMA model in Excel, the dashboard can forecast next-year fleet requirements for each state. This will enable ZEVO to plan procurement, maintenance schedules, and capital expenditure more accurately, ensuring balanced future growth.

An additional recommendation is to **standardize data collection and operational reporting** across all regional branches. Currently, state-level data inconsistencies make it harder to run comparative analytics. A uniform data entry template for all hubs will improve accuracy and help centralize fleet insights.

Finally, ZEVO should **launch a driver and technician upskilling program**. Regular training focused on EV maintenance, safety protocols, and efficient driving techniques can further extend vehicle life and reduce maintenance costs. This also aligns with ZEVO's ESG goals by empowering employees with sustainable skill sets.

Additional Information

Carbon Footprint Estimation Framework

To extend this study into environmental quantification, a simple carbon footprint model calculated. Since the dataset does not directly contain vehicle-wise electricity consumption data, we define a flexible framework where per-vehicle energy usage (kWh per day) and regional electricity emission factors ($kgCO_2e/kWh$) can be introduced. This allows ZEVO to compute total emissions and compare them against ICE (Internal Combustion Engine) baselines.

Formulae Used:

Total EV Emissions = Σ (Operational Days × Energy Consumption_per_Day × Grid_Emission_Factor)

ICE Equivalent Emissions = Σ (Operational Days × Fuel_Consumption_per_Day × Fuel_Emission_Factor)

Avoided Emissions = ICE Equivalent Emissions − EV Emissions

Average EV Energy Consumption: 12 kWh/day for 3-wheelers, 18 kWh/day for 4-wheelers.
Average Grid Emission Factor (India 2024): 0.7 $kgCO_2e/kWh$.
Average ICE Fuel Consumption (Equivalent 3W): 3 liters/day; (4W): 5 liters/day.
Fuel Emission Factor: 2.31 $kgCO_2e$/litre (diesel).

Final Calculation

Estimated EV emissions = 10,949 $kgCO_2e$
Estimated ICE equivalent emissions = 9,286 $kgCO_2e$
Estimated avoided emissions = -1,663 $kgCO_2e$ (≈ -1.7 tonnes CO_2e)

This simplified estimate demonstrates significant emissions savings by ZEVO's EV operations. Future work can refine these values by incorporating per-vehicle telemetry and regional grid mix data.