Geographic Market Segmentation for EV Startup

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1 Introduction

The Indian electric vehicle (EV) market is undergoing a significant transformation, driven by environmental concerns, rising fuel costs, and favorable government policies. As India accelerates its shift towards sustainable mobility, electric vehicles are poised to play a critical role in shaping the future of transportation. However, the EV landscape in India is highly diverse and segmented — varying across regions, vehicle categories, consumer preferences, and infrastructural readiness.

Our team has been tasked with supporting a startup that is currently exploring opportunities to enter this dynamic EV market. The startup is in the early stages of defining its product strategy and is evaluating different vehicle and customer segments to determine where its initial focus should lie — be it 2-wheelers, 3-wheelers, 4-wheelers, or commercial electric vehicles such as buses.

The primary objective of this project is to analyze the Indian EV market through the lens of segmentation analysis, with the aim of identifying high-potential market segments that exhibit strong adoption patterns and future growth opportunities. To this end, we are focused on geographic segmentation, examining state-wise EV sales data across multiple years and vehicle categories. By understanding regional adoption trends, cluster patterns, and category-specific dominance, we aim to provide data-driven recommendations that can inform the startup's market entry and expansion strategy.

This report presents the findings of our analysis, including descriptive insights, spatial visualizations through choropleth maps, clustering-based segmentation, and category-level trends across Indian states. Based on these insights, we propose strategic directions for the startup to consider as it prepares to enter the EV ecosystem in India.

2 Data Collection

To initialize the implementation of the market segmentation analysis for our EV startup's Indian launch, we started with the data acquisition efforts. Through meticulous research, we delved into various data sources available on the internet to gather appropriate and relevant data for the project. This comprehensive data collection exercise lays the groundwork for the next crucial step: identifying the most promising segment for our startup's successful entry into the electrifying Indian EV market.

The dataset used in this analysis can be accessed at: EV Sales Dataset – India (2014–2024). The data was meticulously scraped from the Clean Mobility Shift website, and then thoroughly preprocessed to ensure accuracy and relevance. All null values have been removed, and the dataset has been cleaned to prepare it for immediate use in exploration, visualization, and analytical projects. The dataset used for this analysis contains state-wise monthly sales data of electric vehicles (EVs) in India. It provides granular insights into the adoption of EVs across

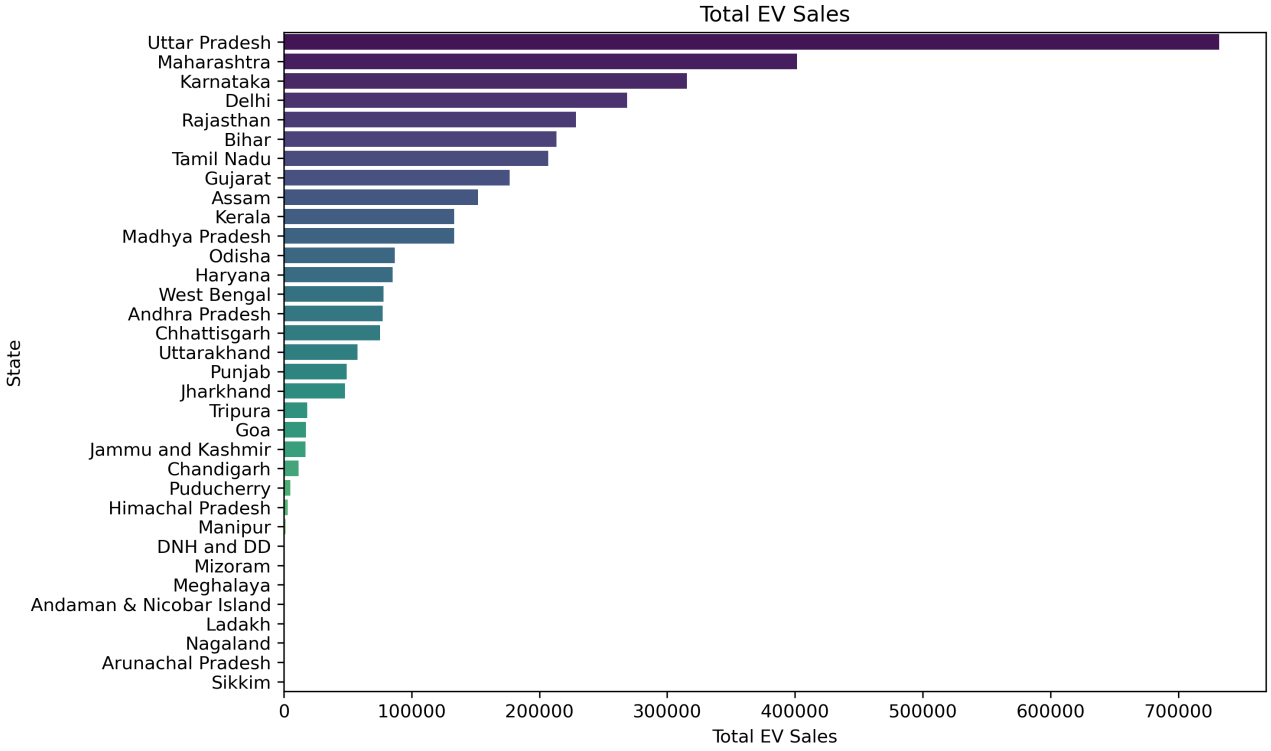
various vehicle categories and regions over time. It provides monthly sales data of various electric vehicles in all states of India from January 2014 to August 2024.

Libraries Used

- *pandas*: Used for data loading, cleaning, transformation, and tabular analysis (e.g., grouping sales data by state, category, or time).
- *numpy*: Provided numerical operations, especially for array manipulation and integration with other libraries.
- *matplotlib*: Used for creating static visualizations such as bar charts, line plots, pie charts, and map-based visual summaries.
- *seaborn*: Built on top of matplotlib, seaborn enabled enhanced statistical plots with built-in aesthetics and simplified syntax for bar and line charts.
- *scikit-learn (sklearn)*: Used for performing machine learning tasks including feature scaling (via StandardScaler) and clustering (using KMeans), as well as the Elbow method for choosing the optimal number of clusters.
- *geopandas*: Enabled geographical analysis and visualization by allowing spatial joins, geometry manipulation, and plotting EV sales cluster maps across Indian states using GeoJSON data.
- *datetime*: Handled date parsing and manipulation, particularly to extract and process monthly and yearly sales trends.

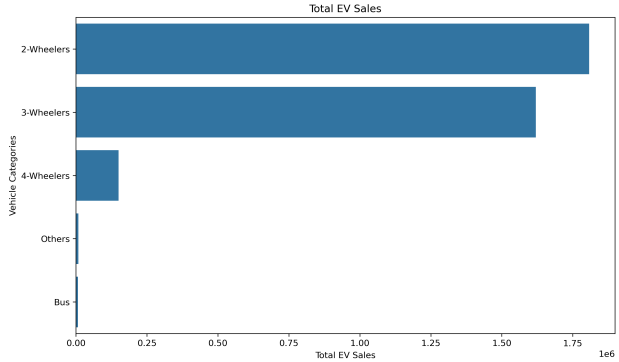
3 Exploratory Data Analysis

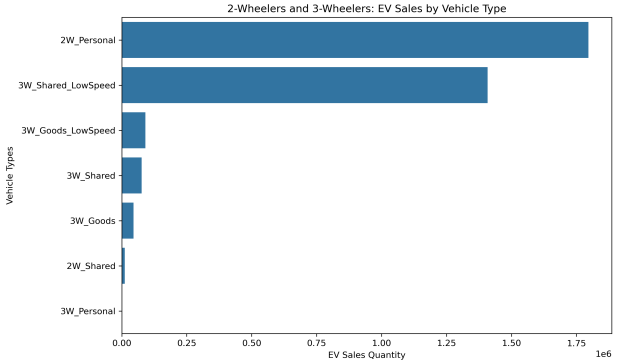
To understand the overall distribution of electric vehicle adoption across India, we aggregated the total EV sales by state using the cumulative sales from all vehicle categories and time periods. The resulting bar plot clearly highlights the states with the highest EV adoption. States like Uttar Pradesh, Maharashtra, Karnataka, Delhi, and Rajasthan emerged as top contributors to the national EV sales, indicating strong regional interest and market readiness in these areas. This analysis serves as a crucial input for geographically targeted market entry strategies.



To gain a more detailed understanding of customer behavior within the most popular EV segments, we analyzed the distribution of sales across different vehicle types within the 2-Wheelers and 3-Wheelers categories. The plots below illustrate the total EV sales for each vehicle type in these two segments.

For 2-Wheelers, the market is largely dominated by scooters and motorcycles, reflecting individual and urban commuter usage. In contrast, the 3-Wheelers segment is primarily composed of passenger carriers (E-Rickshaws), indicating strong commercial adoption, particularly in intra-city logistics and last-mile transport. These insights help identify the most active subsegments and can guide the startup's decision on which vehicle types to prioritize based on existing demand.

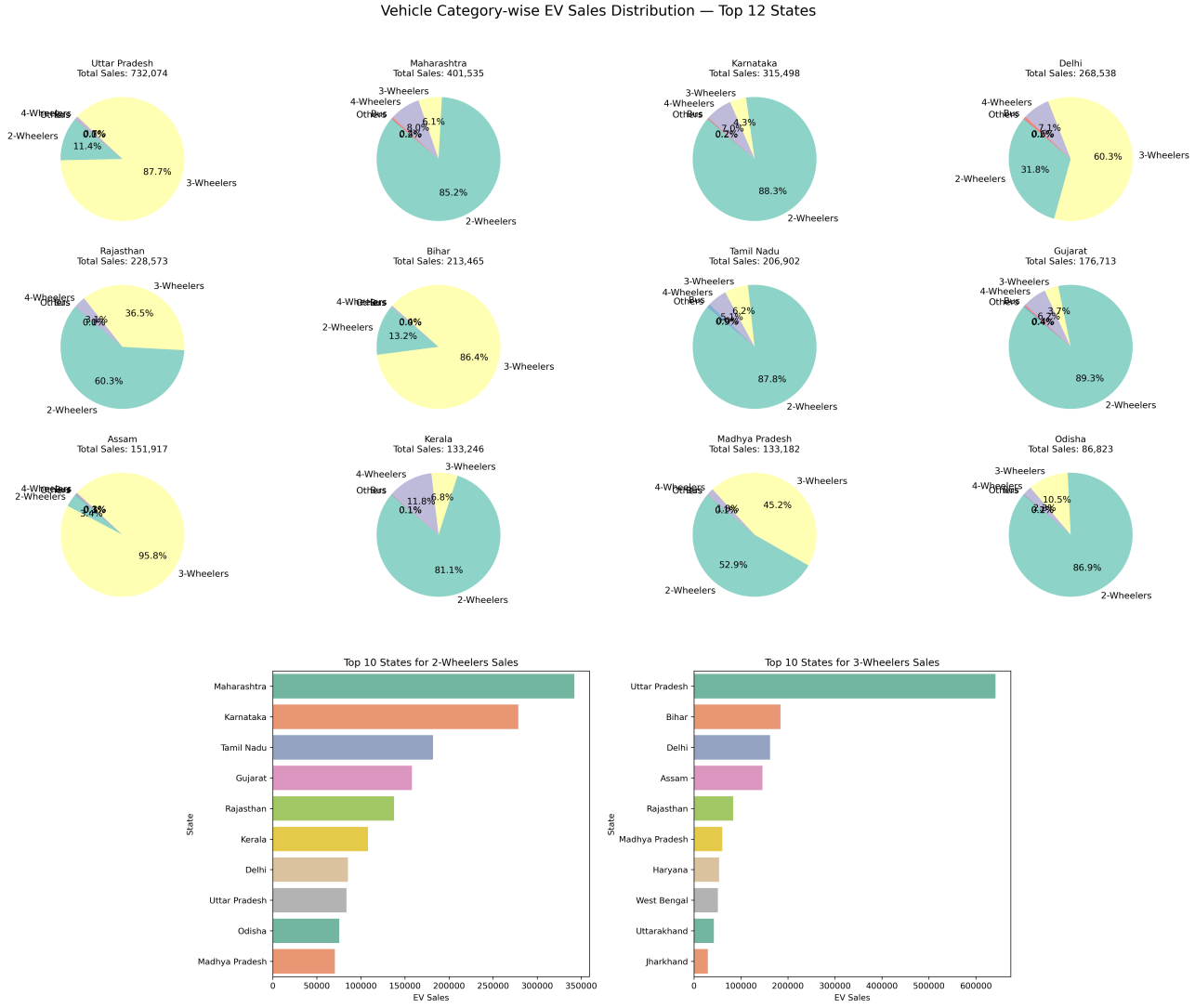




To further understand the composition of EV adoption in high-performing regions, we analyzed the vehicle category distribution in the top 10 EV-selling states. The pie charts below illustrate how different categories — such as 2-Wheelers, 3-Wheelers, 4-Wheelers, Buses, and Others — contribute to total EV sales in each state.

These visualizations reveal that the sales mix varies significantly across regions. For instance, some states show strong dominance of 3-Wheelers (e.g., Uttar Pradesh, Bihar), while most have strong dominance of 2-Wheelers (e.g., Karnataka, Maharashtra, Tamil Nadu). This

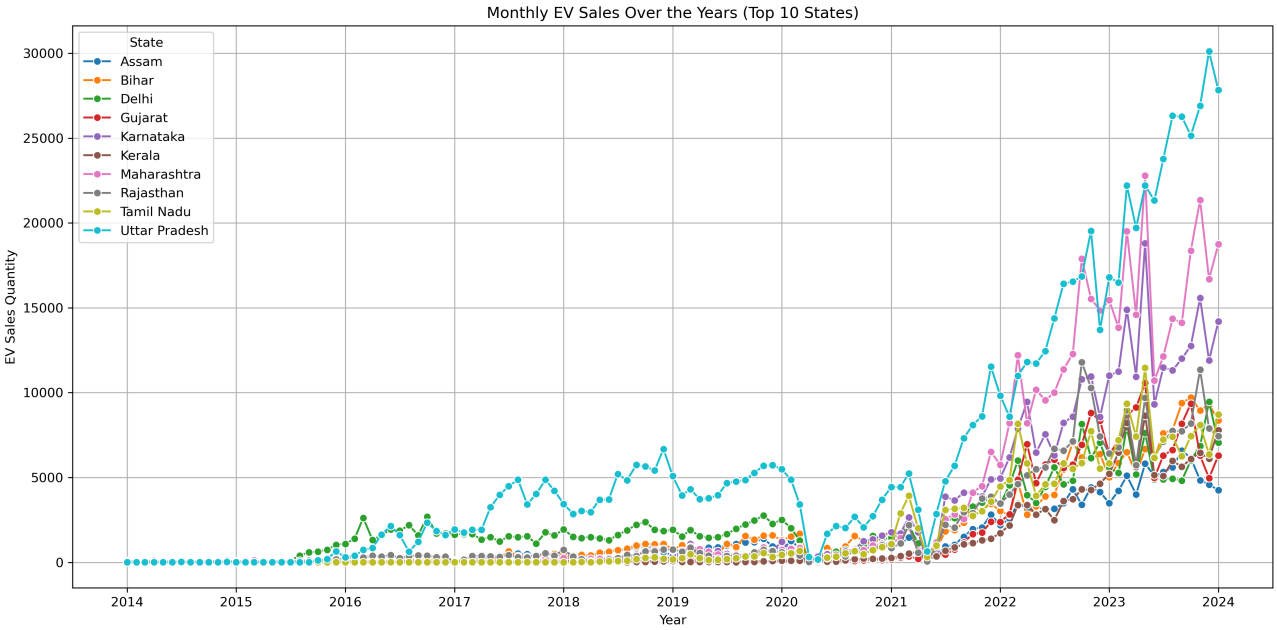
helps identify category-specific regional opportunities for EV product targeting.



Monthly Sales Trends (all categories)

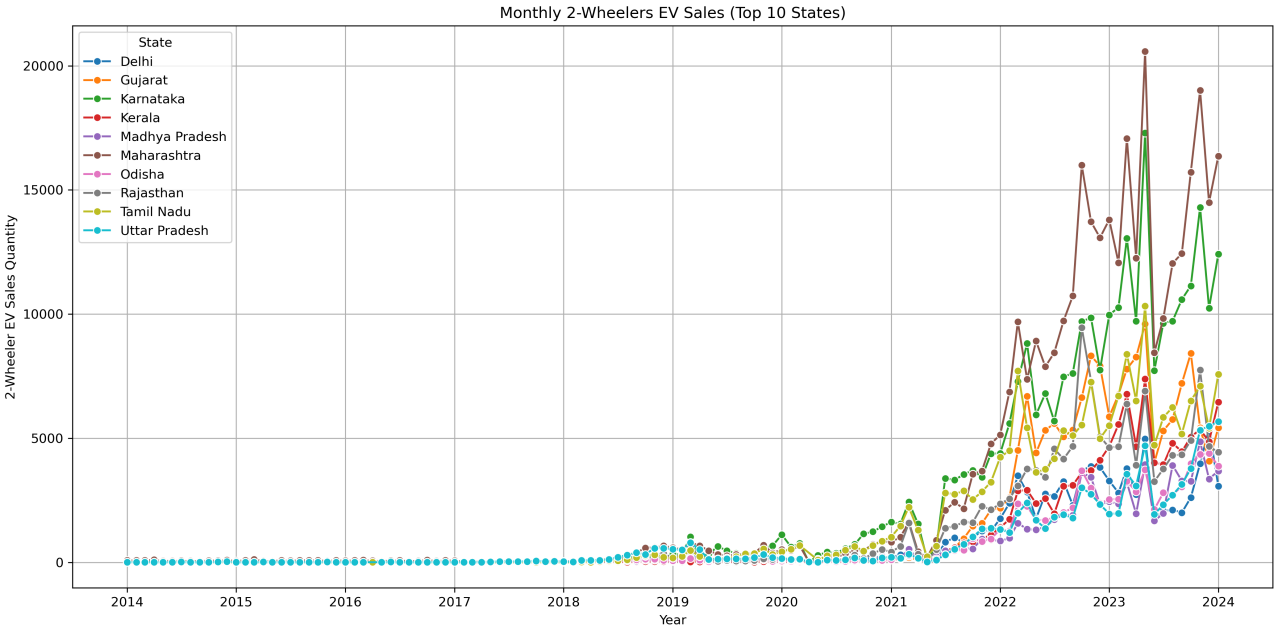
To understand the temporal evolution of electric vehicle adoption across different regions, we analyzed monthly EV sales trends from January 2014 to August 2024 for the top 10 states in terms of total EV sales. The line plot below visualizes how each state's EV adoption has progressed over time.

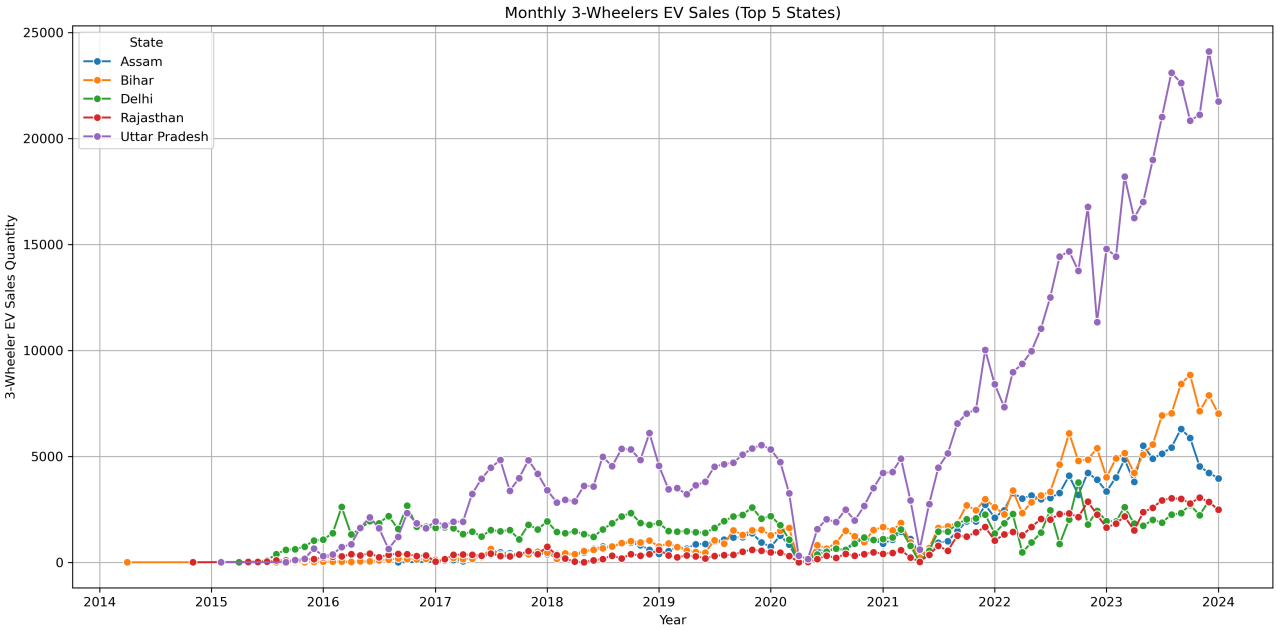
The plot reveals that certain states — such as Uttar Pradesh, Maharashtra, and Karnataka — have shown consistent and accelerating growth in EV sales. Seasonal variations are also visible in some states, possibly due to policy changes, subsidy rollouts, or fiscal year influences. This trend-based analysis helps identify states where EV demand is rapidly expanding, which is crucial for determining optimal market entry timing and regional prioritization.



Monthly Sales Trends for 2-Wheelers and 3-Wheelers

To gain deeper insights into specific vehicle segments, we analyzed monthly EV sales for 2-Wheelers and 3-Wheelers across their leading states. The first plot illustrates the monthly sales trends for the top 10 states in 2-Wheelers, highlighting strong and consistent growth in regions like Karnataka, Maharashtra, and Tamil Nadu. The second plot focuses on 3-Wheelers, restricted to the top 5 states due to relatively lower sales in other regions. This includes dominant performers such as Uttar Pradesh and Delhi, where 3-Wheelers form a major share of EV adoption. These trends help identify which regions are more inclined toward specific vehicle categories, offering strategic insight into potential market segmentation.

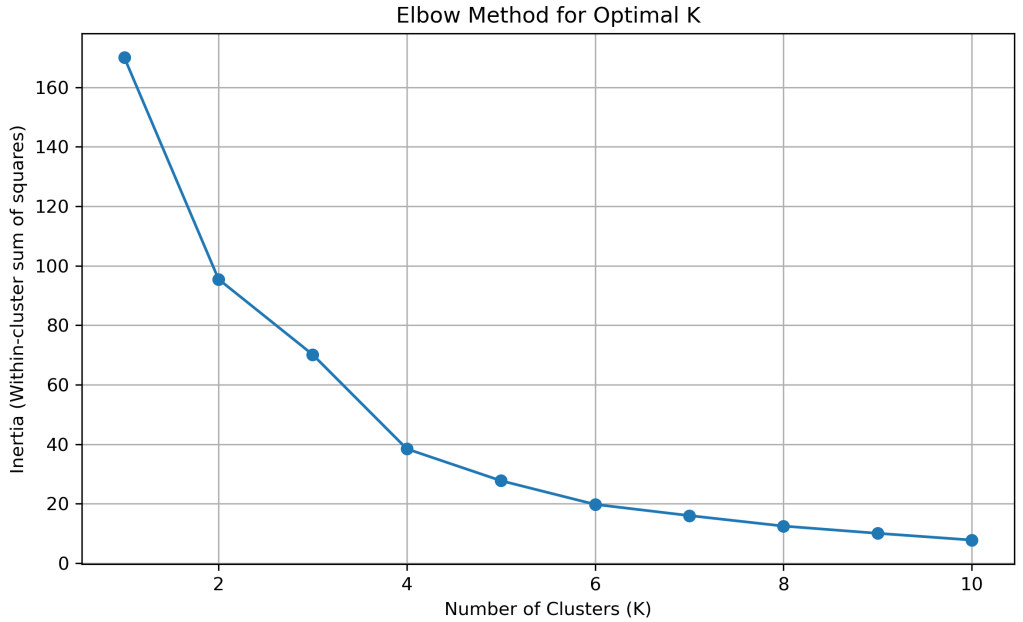




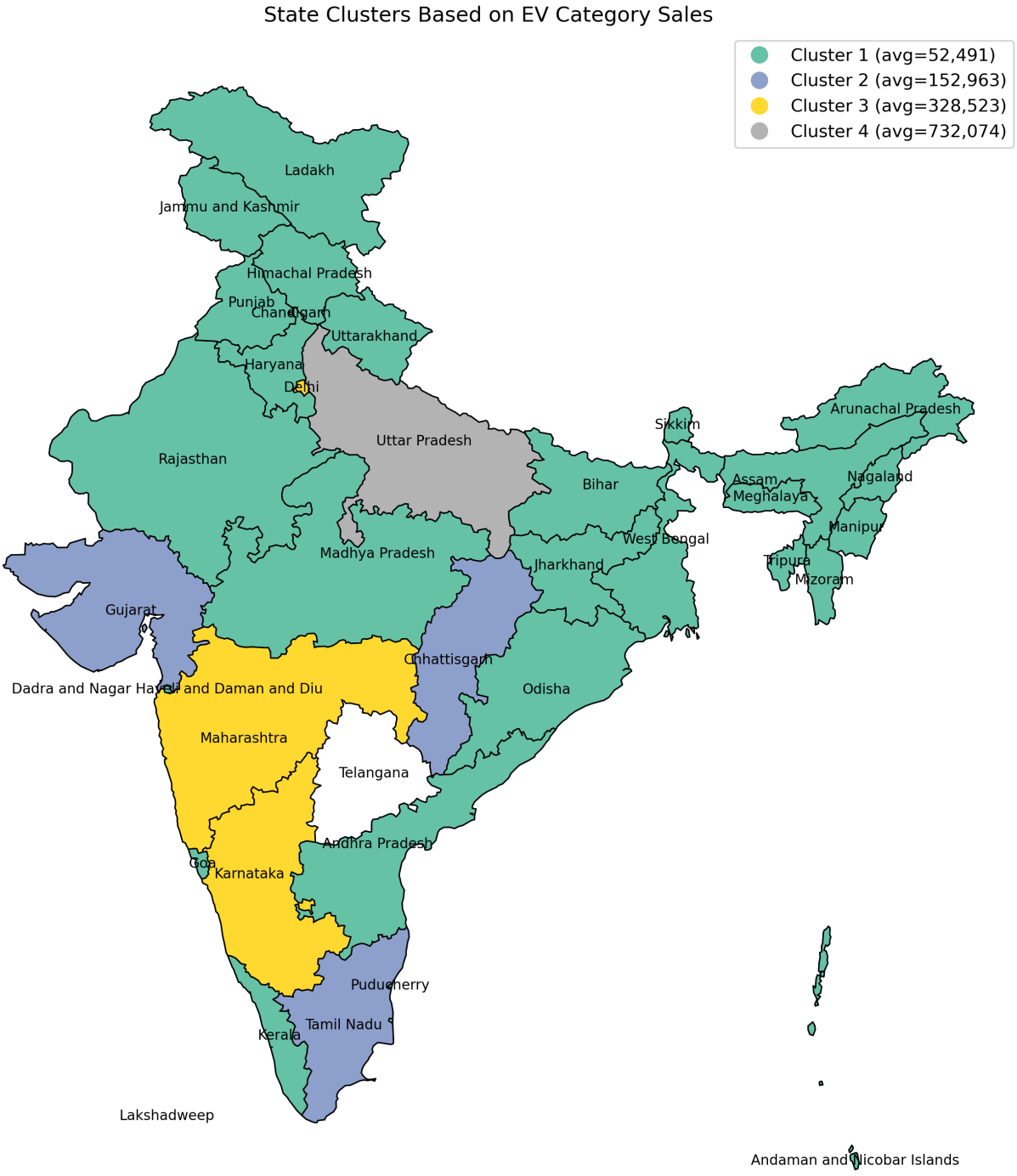
4 Market Segmentation using Clustering

To uncover meaningful geographic segments based on EV adoption patterns, we applied **K-Means Clustering** on state-wise electric vehicle sales data. We used a pivot table where each row represents a state and each column corresponds to a vehicle category (2-Wheelers, 3-Wheelers, 4-Wheelers, Bus, Others), with the values indicating cumulative sales. To ensure fair clustering, the features were normalized using StandardScaler.

To determine the optimal number of clusters, we employed the **Elbow Method**. This technique involves plotting the inertia (sum of squared distances within clusters) against different values of K. As shown in the Elbow Curve below, the "elbow point" suggests the ideal number of clusters that balances model simplicity with segmentation quality.



Clustering Visualization on India Map

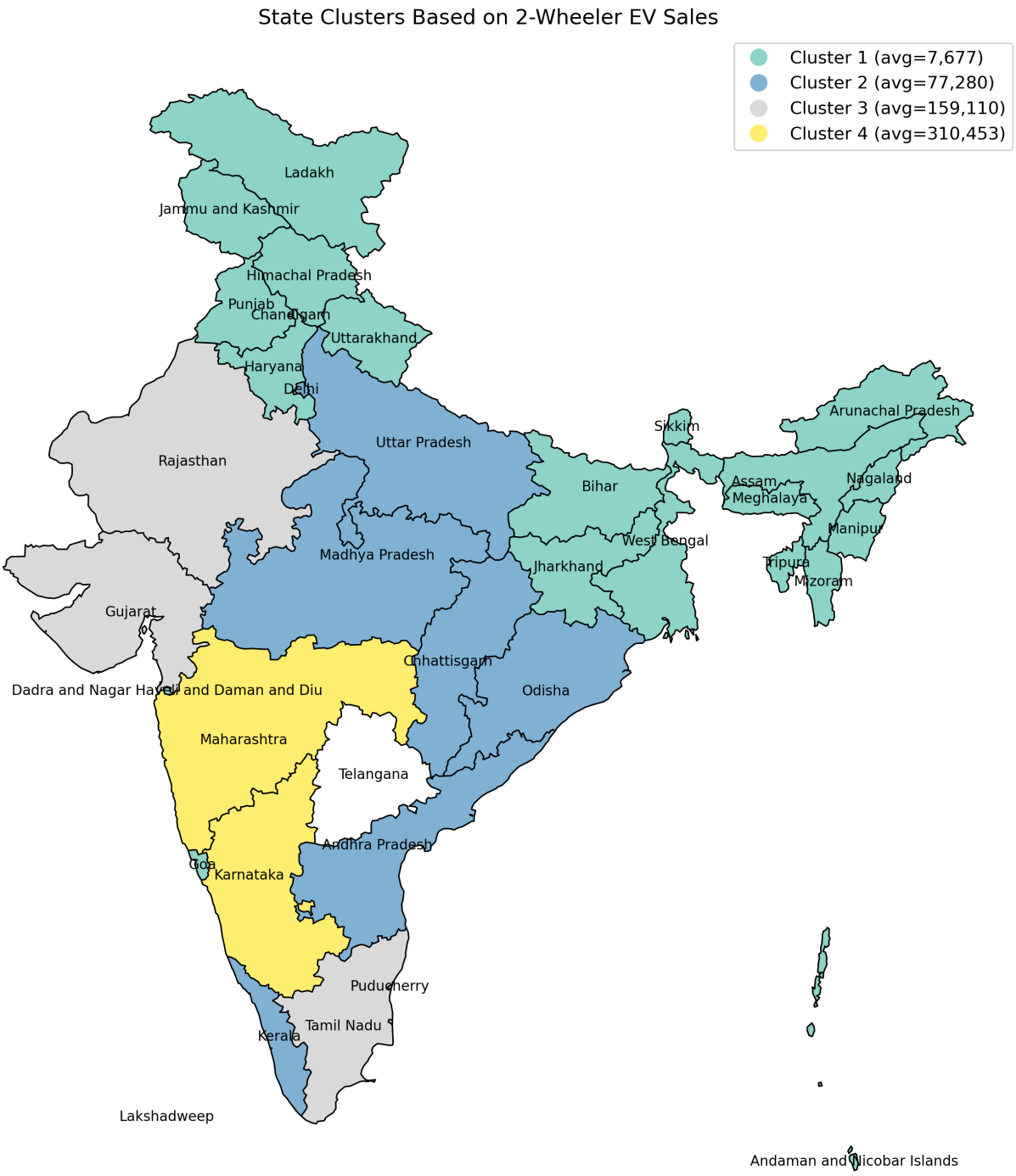


After determining the optimal number of clusters (K=4), we applied the K-Means algorithm to categorize Indian states based on their cumulative electric vehicle sales across different vehicle categories. Each state was assigned a cluster based on the similarity of its sales distribution.

To visualize these clusters geographically, we created a choropleth map of India, where each state is color-coded according to its assigned cluster. The clusters are labeled qualitatively, based on their average total EV sales, helping to interpret them in terms of relative market potential. State names are overlaid at representative locations for clarity.

This visual segmentation enables quick identification of high-potential regions and patterns of adoption, supporting the formulation of region-specific EV strategies for the startup. For instance, states in clusters with higher average sales may represent early adopters and promising launch markets.

Clustering States Based on 2-Wheeler EV Sales



To identify patterns in electric 2-wheeler adoption across Indian states, K-Means clustering was applied using cumulative sales data for each state. First, an elbow plot was generated

to determine the optimal number of clusters by analyzing the within-cluster sum of squares (inertia) for cluster counts ranging from 1 to 10. The elbow was observed at K = 4, indicating the ideal number of clusters.

After clustering, states were grouped based on similarity in their 2-wheeler EV sales volumes. The resulting clusters were visualized on an India map, where each color represents a distinct sales category. Notably, Cluster 1, comprising **Karnataka** and **Maharashtra**, had the highest average sales (310,453), reflecting their leadership in EV adoption. Cluster 2, with **Gujarat**, **Rajasthan**, and **Tamil Nadu**, also showed strong performance, averaging over 159,000 units.

These insights provide a clearer understanding of regional EV adoption trends and can inform policy-making and infrastructure planning.

5 Conclusion

The Electric Vehicle (EV) market in India exhibits strong regional and categorical variations, making geographic segmentation a vital tool for market entry strategy.

- 2-Wheelers, particularly electric scooters and motorbikes, constitute the largest share of EV sales across most states, reflecting high consumer demand for affordable and efficient personal transport.
- The top five states in terms of 2-Wheeler EV sales are: Maharashtra, Karnataka, Tamil Nadu, Gujarat, and Rajasthan.
- Uttar Pradesh leads the nation by a significant margin in 3-Wheeler (E-rickshaw) sales, indicating widespread adoption in public and semi-public transport.
- K-Means clustering helped identify state groups with similar EV adoption patterns, revealing high-performing clusters and emerging markets. These insights are crucial for targeted product launches, infrastructure deployment, and policy alignment.

Overall, the analysis supports a region-specific EV strategy where the startup can prioritize high-potential markets (e.g., 2-Wheelers in South and West India, 3-Wheelers in North India) for effective penetration and sustained growth.