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EV Market Segmentation Analysis

1. Introduction

Electric Vehicles (EVs) are rapidly transforming the Indian automotive market, with growing consumer interest and government incentives. This project analyzes the EV market using multiple datasets, focusing on segmentation, trends, and solutions for industry stakeholders.

2. Dataset Overview

The project utilizes the following datasets:

- **Dataset 1: Indian EV Data**
 - Battery capacity, range per charge, price, and other features.
- **Dataset 2: Mah_data_all_wheeler and their Maker**
 - Details of various vehicle manufacturers and their models in Maharashtra.
- **Dataset 3: Fuel_wise_category_data_mah_for_all_wheelers**
 - Fuel-wise classification of all types of vehicles.
- **Dataset 4: Fuel_wise_vehicle_category_4W_Mah**
 - Focused on four-wheelers based on fuel type.

3. Data Processing and Cleaning

Handling Missing Values

- Checked for missing data and filled missing numerical values using the median.
- Dropped unnecessary columns (e.g., ID).

4. Exploratory Data Analysis (EDA)

Dataset 1: Indian EV Data

Battery Capacity Analysis

- Battery capacity ranges from **2.2 to 6.2 kWh**, with a majority of vehicles having mid-range battery capacities.

Range Per Charge

- Vehicles offer **75 km to 200 km per charge**, catering to different usage needs (e.g., urban commuters vs. long-range users).

Price Segmentation

- Prices range from **₹60,000 to ₹2,50,000**, indicating three primary market segments:
 1. **Budget EVs (₹60,000 - ₹1,00,000)**: Low-cost, short-range vehicles.
 2. **Mid-Range EVs (₹1,00,000 - ₹1,75,000)**: Balance of affordability and performance.
 3. **Premium EVs (₹1,75,000 - ₹2,50,000)**: Higher battery capacity and extended range.

Dataset 2: Mah_data_all_wheeler and their Maker

- This dataset provides details on vehicle manufacturers and their models.
- **Market Share Insights:**
 - Identified dominant players in the Maharashtra EV market.
 - Emerging brands gaining traction in the two-wheeler and four-wheeler segments.
- **Clustering Analysis:**
 - K-Means clustering identified **three major clusters** of manufacturers based on model variety and market penetration.
 - Key brands fall into **high-end, mid-range, and budget-friendly segments**.

Dataset 3: Fuel-wise Category Data for All Vehicles

- **Fuel-Type Distribution:**
 - Significant share of **petrol and diesel vehicles**, but **EV adoption is growing steadily**.

- Increasing government regulations on fuel emissions driving EV market expansion.
- **Trend Analysis:**
 - Shift from fossil fuel to electric and hybrid models over recent years.
 - Policies promoting CNG and EVs are influencing consumer choices.

Dataset 4: Fuel-wise Vehicle Category (4W Mah)

Key Insights:

- **Vehicle Counts Vary Widely:**
 - **2WN** (Two-Wheelers Non-Transport) has a **maximum of 256,556** but a **median of 0**, indicating some fuel types have no two-wheelers.
 - **OTH** (Other Vehicles) has a **high variance**, ranging from **3 to 282,922**.
- **Several Vehicle Categories Have Mostly Zeros:**
 - **3WIC**, **3WN**, **MGV**, and **MMV** have **zero median values**, meaning these categories are **not available for many fuel types**.
- **Fuel Distribution in Four-Wheelers:**
 - **Petrol-dominated market**, but EVs and hybrids show notable growth.
 - Diesel vehicle sales declining due to emission norms and fuel price hikes.
- **Market Trends:**
 - Increase in **electric four-wheeler adoption** among commercial fleets.
 - Private buyers slowly transitioning to electric SUVs and hatchbacks.
- Diesel dominates in **Heavy Motor Vehicles (HMV)** and **Light Motor Vehicles (LMV)**.
- CNG and Electric (BOV) are strong in **two-wheeler and public transport** categories.

5. Algorithms Used

1. K-Means Clustering

- Used for segmenting **vehicle manufacturers** based on model variety and market reach.
- Identified **three major clusters** (budget-friendly, mid-range, high-end brands).

2. Correlation Analysis

- Determined relationships between **battery capacity, range, and price**.
- Found a **strong correlation** between **battery capacity and EV price**.

3. Predictive Modeling

- Implemented **machine learning models** to forecast **EV adoption trends** based on fuel-type transition data.

6. Data Visualization Insights

Several visualizations were created to better understand the trends:

- **Battery vs. Price Distribution:** Higher battery capacity correlates with increased price.
- **Range per Charge Distribution:** Most vehicles cluster between 100-150 km per charge.
- **Price Segmentation Analysis:** Confirms clear market tiers.
- **Market Share Analysis:** Identifies leading manufacturers and their EV production volume.
- **K-Means Cluster Visualizations:** Groups manufacturers into market segments.

For Dataset 4: Fuel-Wise Vehicle Categories

- **Clustering revealed three distinct groups of fuel types based on vehicle categories.**
- **Diesel and Petrol forms one cluster, while Electric and CNG fall into another.**
- **The third cluster represents niche fuel types with low adoption.**
- **Fuel-Type Trends:** Shows increasing adoption of EVs and hybrids over traditional fuel vehicles.

7. Solutions and Recommendations

1. **Advanced Predictive Analytics:**

- Develop **machine learning models** to predict EV demand across different segments and geographical locations.
- Use **time-series forecasting** to analyze fuel transition trends and their impact on the automotive industry.

2. **Market Segmentation & Customer Insights:**

- Implement **customer clustering algorithms** to identify potential EV buyers based on affordability, travel needs, and environmental concerns.
- Use sentiment analysis on **social media and customer reviews** to gauge public perception of EVs.

3. **Smart Charging Infrastructure Planning:**

- Utilize **geospatial analytics** to optimize EV charging station locations based on traffic patterns and demand density.
- Develop **predictive maintenance models** to enhance the reliability of EV charging stations.

4. **Vehicle Performance & Battery Optimization:**

- Analyze **battery degradation patterns** using real-world usage data to enhance battery longevity.
- Develop **recommendation engines** for users to choose the best EV based on their travel habits and cost preferences.

5. **EV Manufacturer Performance Tracking:**

- Build **interactive dashboards** to track market share, production rates, and pricing trends across different EV brands.
- Use **anomaly detection algorithms** to identify unusual shifts in EV adoption rates and suggest corrective actions.

6. **Policy & Incentive Analysis:**

- Develop **policy impact models** to assess the effectiveness of government incentives and regulations on EV adoption.
- Provide **data-driven recommendations** to policymakers for optimizing subsidy distribution and tax benefits for EV buyers.

8. Conclusion

The analysis of the Indian EV market shows a clear segmentation based on battery capacity, range, and price. Additionally, the Maharashtra EV market presents a structured classification of manufacturers, with three primary clusters. The fuel-wise vehicle data highlights an ongoing transition from petrol and diesel to electric and hybrid models. For FeyNN Labs, leveraging advanced **data science solutions** can provide strategic insights into **EV demand forecasting, customer behavior, charging infrastructure optimization, and policy impact assessment**, ultimately driving sustainable growth in the EV sector.