Traffic Volume and Speeding Incidents Analysis

Objective:

The project analyses traffic volume and speeding incidents using temporal factors such as hour of the day, day of the week, month, weekend/weekday distinctions, and seasons. The aim is to identify high-risk road segments, uncover traffic patterns, and recommend interventions to enhance road safety.

Dataset Overview:

The dataset contains traffic data with the following features:

- **Temporal Features**: hour, day_of_week, month, weekend, season, and time_of_day.
- **Vehicle Data**: Light and heavy vehicles (e.g., Light_Vehicles, Trucks, Articulated_Vehicles).
- **Traffic Metrics**: speed_limit, average_speed, Total_Traffic_Volume, and speeding incidents.
- **Geospatial Information**: Latitude, Longitude to identify road segments.

Data Preparation:

1. **Datetime Feature Engineering**:

    - Combined date and time into a datetime field.
    - Extracted features like hour, day_of_week, month, year, time_of_day, and a binary **weekend** indicator.

2. **Feature Engineering for Traffic Analysis**:

    - Created temporal categories:

        a. **Hour of the Day**

        b. **Day of the Week**: Monday to Sunday.

        c. **Month Names**: January to December.

        d. **Time of Day**: Morning, Afternoon, Evening, Night.

        e. **Seasons**: Summer, Winter, Spring, and Autumn.

Findings

Traffic Volume Analysis:

1. **Hour of the Day**:

    - **Rush Hours (7-9 AM, 4-6 PM)**: The highest traffic volumes occur during peak ommuting hours. The morning rush hour has heavy inbound traffic toward business districts, while the evening rush experiences outbound traffic.

- **Late Night (12 AM - 4 AM)**: Traffic volume drops significantly, but speeding incidents increase during this period due to clear roads and reduced enforcement.

2. **Day of the Week**:

- **Monday** and **Friday**: These days exhibit higher traffic volumes. Monday mornings see more inbound traffic, while Friday evenings have increased outbound traffic as people leave for the weekend.
- **Weekends (Saturday and Sunday)**: Overall traffic decreases, particularly in business areas. However, suburban and recreational areas might see increased traffic during midday or afternoons.

3. **Monthly and Seasonal Patterns**:

- **Summer (December - February)**: Traffic patterns shift toward recreational areas, such as beaches and parks, especially on weekends. Business districts show reduced traffic volumes during the holiday period.
- **Winter (June - August)**: Lower traffic volumes overall, but speeding incidents increase at night, especially on clear winter nights when roads are emptier.
- **Holiday Season (December - January)**: A noticeable dip in traffic volume occurs during the holiday period, with a corresponding rise in speeding incidents as roads become less congested.

4. **Weekday vs. Weekend**:

- **Weekdays**: Higher traffic volumes during peak hours (7-9 AM and 4-6 PM). Speeding incidents are fewer due to congestion and increased law enforcement presence.
- **Weekends**: Lower traffic volumes overall, but speeding incidents rise, particularly on late-night drives and during weekends in suburban areas.

Speeding Incidents Analysis:

1. **Daily Patterns**:

- Speeding incidents are more frequent on **Saturday** compared to other days, likely due to reduced traffic. **Monday** and **Friday** also exhibit higher speeding incident rates, possibly linked to end-of-week fatigue or the start-of-week rush.
- **Weekends** consistently show increased speeding activity, especially during the afternoons and late evenings when roads are clearer.

2. **Time of Day**:

- **Morning (6 AM - 12 PM)**: Speeding incidents are lower due to congestion, especially during rush hours.
- **Afternoon (12 PM - 4 PM)**: Speeding increases slightly, especially in areas outside business districts.
- **Evening (4 PM - 8 PM)**: Speeding incidents begin to rise after rush hour, particularly after 6 PM as traffic clears up.

- **Night (8 PM - 6 AM)**: Speeding is most frequent at night, especially between midnight and 4 AM, when traffic volume is at its lowest.

3. **Seasonal Trends**:

   - **Winter**: Shows an increase in speeding incidents during clear nights when the roads are less congested.
   - **Summer**: Speeding tends to rise during weekends when traffic is lighter, particularly in suburban and recreational areas.

Correlation and Heatmap Insights:

1. **Correlation Between Traffic Volume and Speeding**:

   - **Traffic volume** and **speeding incidents** have a moderate negative correlation. As traffic volume increases, the number of speeding incidents generally decreases, likely due to congestion during peak times. This suggests that most speeding violations occur during low traffic volume periods, particularly at night or during weekends.
   - **Vehicle Types and Speeding**: Roads with a higher percentage of light vehicles show a positive correlation with speeding incidents, while roads with more heavy vehicles (such as trucks and buses) tend to have lower speeding incidents due to slower-moving traffic.

2. **Speed Limit and Speeding Incidents**:

   - Roads with higher speed limits show a greater tendency for speeding incidents. Drivers may feel more comfortable exceeding the speed limit on roads that are already designed for higher speeds, particularly in suburban and rural areas where enforcement is lower.

3. **Time-of-Day Correlations**:

   - There is a strong correlation between late-night hours and speeding incidents. As the correlation matrix suggests, hours between **12 AM and 4 AM** show the highest speeding rates due to the absence of traffic and reduced law enforcement presence.

4. **Seasonal Effects**:

   - **Summer months** show a correlation between lower traffic volume and increased speeding. Recreational areas exhibit higher speeding rates, especially on weekends. **Winter nights** also see an increase in speeding, likely due to clear roads and minimal traffic.

Key Insights:

1. **High-Risk Time Frames**:

   - **Late Night (12 AM - 4 AM)** and **weekends** (Saturday and Sunday) are the periods most associated with increased speeding incidents. Traffic enforcement and interventions should focus on these time frames.

2. **High Traffic Volume Areas**:

   - Weekday mornings (7-9 AM) and evenings (4-6 PM) see the highest traffic volumes, especially in business districts. Dynamic traffic management systems could help ease congestion during these periods by adjusting traffic light timings based on real-time conditions.

3. **Seasonal Impact**:

   - **Summer weekends** see a significant shift in traffic toward recreational areas, with increased speeding incidents in suburban zones. **Winter nights** also experience higher speeding incidents, requiring targeted enforcement.

4. **Traffic and Speeding Relationships**:

   - There is an inverse relationship between traffic volume and speeding incidents. When traffic volume is low (such as during late nights or weekends), speeding incidents rise. Congested roads naturally inhibit speeding, but clear roads at night or in less monitored areas encourage drivers to exceed speed limits.

Recommendations:

1. **Targeted Enforcement**:

   - Increase law enforcement presence during late-night hours (12-4 AM) and weekends, particularly in high-risk areas where speeding incidents are more frequent.

2. **Dynamic Traffic Management**:

   - Implement real-time traffic management strategies to optimize traffic flow during peak hours on weekdays, and adjust signals for weekend traffic in recreational areas.

3. **Infrastructure Improvements**:

   - Consider improvements in areas with high traffic volumes during rush hours, such as additional lanes or better traffic signal synchronization, to reduce congestion and the likelihood of speeding.

4. **Public Awareness Campaigns**:

   - Launch campaigns to raise awareness about the dangers of speeding, particularly during late-night hours and weekends when drivers may be more tempted to exceed speed limits.