Exploring the EV Charging Station Landscape

The dataset encompasses various attributes, including latitude, longitude, payment modes, vendor names, and station types. As part of the preprocessing phase, duplicates were removed, and categorical variables were encoded. The resulting CSV document comprises 25 columns and 2706 rows, providing a comprehensive overview of EV charging station details in the region.

Import Libraries

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
```

Loading The Data

```
df = pd.read_excel('ev_final.xlsx')
df
```

```
           uid                      name              vendor_name  \
0     STATIC12  GensolCharge Pvt. Ltd.  GensolCharge Pvt. Ltd.
1     STATIC14                    REIL                    REIL
2     STATIC15                    REIL                    REIL
3     STATIC16                    REIL                    REIL
4     STATIC17                BluSmart                BluSmart
...        ...                     ...                     ...
2700      1028     EESL Nehru Park Met                    EESL
2701      1028     EESL Nehru Park Met                    EESL
2702      1028     EESL Nehru Park Met                    EESL
2703    BSES-1                BSES-DEL           Verdemobility
2704    BSES-1                BSES-DEL           Verdemobility

                                            address   latitude
longitude  \
0                      NDSE Grid, BRPL South Extension  28.568238
77.219666
1                                Scada office kalka ji  28.541995
77.260583
2                             Ashram Chowk Mathura Road  28.571189
77.259806
3                            Nizamuddin Railway station  28.588991
```

```
77.253240
4            BSES Bhawan, Nehru Place, New Delhi 110048  28.549427
77.254636
...                                                   ...        ...
...
2700  Near Solar plant bus stop,  Sastri Nagar,  Che...  13.078481
80.249480
2701  Near Solar plant bus stop,  Sastri Nagar,  Che...  13.078481
80.249480
2702  Near Solar plant bus stop,  Sastri Nagar,  Che...  13.078481
80.249480
2703  Opposite Crime Police Office Sector-9 Rama Kri...  28.572632
77.169680
2704  Opposite Crime Police Office Sector-9 Rama Kri...  28.572632
77.169680

           city country      open     close  ... postal_code  \
0         Delhi   India  00:00:00  23:59:59  ...      110001
1         Delhi   India  00:00:00  23:59:59  ...      110001
2         Delhi   India  00:00:00  23:59:59  ...      110001
3         Delhi   India  00:00:00  23:59:59  ...      110001
4         Delhi   India  00:00:00  23:59:59  ...      110001
...         ...     ...       ...       ...  ...         ...
2700    Chennai   India     00:00     23:59  ...      600031
2701    Chennai   India     00:00     23:59  ...      600031
2702    Chennai   India     00:00     23:59  ...      600031
2703  New Delhi   India  00:00:00  23:59:59  ...      110022
2704  New Delhi   India  00:00:00  23:59:59  ...      110022

                  zone   0 available   capacity    cost_per_unit
power_type  \
0        central-delhi NaN       NaN      15 kW              NaN
DC
1        central-delhi NaN       NaN     3.3 kW              NaN
AC
2        central-delhi NaN       NaN      15 kW              NaN
DC
3        central-delhi NaN       NaN      15 kW              NaN
DC
4        central-delhi NaN       NaN      15 kW              NaN
DC
...                ...  ..       ...        ...              ...
...
2700               NaN NaN       0.0   15.00 kW  ₹12.93 per unit
DC
2701               NaN NaN       0.0  142.00 kW  ₹20.14 per unit
DC
2702               NaN NaN       0.0  142.00 kW  ₹20.14 per unit
DC
```

```
2703  south-west-delhi NaN       2.0     7.4 kW     ₹16 per unit
AC
2704  south-west-delhi NaN       2.0     3.3 kW     ₹11 per unit
AC

      total           type        vehicle_type
0       2.0    BEVC DC 001              ['4W']
1       3.0    BEVC AC 001  ['2W', '3W', '4W']
2       2.0    BEVC DC 001              ['4W']
3       4.0    BEVC DC 001              ['4W']
4       1.0    BEVC DC 001              ['4W']
...     ...            ...                 ...
2700    1.0         DC-001              ['4W']
2701    2.0       CCS (DC)              ['4W']
2702    2.0   CHAdeMO (DC)              ['4W']
2703    2.0  TYPE - 2 (AC)              ['4W']
2704    2.0          AC001  ['2W', '3W', '4W']

[2705 rows x 25 columns]
```

Data Exploration

```
print(f'List of columns - {df.columns}')

print(f'Shape of the dataframe - {df.shape}')
```

```
List of columns - Index([            'uid',             'name',
'vendor_name',
               'address',        'latitude',       'longitude',
                  'city',         'country',            'open',
                 'close',        'logo_url',           'staff',
         'payment_modes', 'contact_numbers',    'station_type',
           'postal_code',            'zone',                 0,
             'available',        'capacity',   'cost_per_unit',
            'power_type',           'total',            'type',
          'vehicle_type'],
      dtype='object')
Shape of the dataframe - (2705, 25)
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2705 entries, 0 to 2704
Data columns (total 25 columns):
 #   Column           Non-Null Count  Dtype
---  ------           --------------  -----
 0   uid              2705 non-null   object
```

```
 1   name              2705 non-null   object
 2   vendor_name       2705 non-null   object
 3   address           2705 non-null   object
 4   latitude          2705 non-null   float64
 5   longitude         2705 non-null   float64
 6   city              2705 non-null   object
 7   country           2705 non-null   object
 8   open              2705 non-null   object
 9   close             2705 non-null   object
 10  logo_url          2238 non-null   object
 11  staff             2705 non-null   object
 12  payment_modes     2705 non-null   object
 13  contact_numbers   2705 non-null   object
 14  station_type      2705 non-null   object
 15  postal_code       2705 non-null   int64
 16  zone              2410 non-null   object
 17  0                 0 non-null      float64
 18  available         2467 non-null   float64
 19  capacity          2497 non-null   object
 20  cost_per_unit     2453 non-null   object
 21  power_type        2497 non-null   object
 22  total             2497 non-null   float64
 23  type              2497 non-null   object
 24  vehicle_type      2497 non-null   object
dtypes: float64(5), int64(1), object(19)
memory usage: 528.4+ KB
```

```
df.head().T
```

```
                                                    0
1  \
uid                                          STATIC12
STATIC14
name                          GensolCharge Pvt. Ltd.
REIL
vendor_name                   GensolCharge Pvt. Ltd.
REIL
address           NDSE Grid, BRPL South Extension  Scada office kalka
ji
latitude                                    28.568238
28.541995
longitude                                   77.219666
77.260583
city                                           Delhi
Delhi
country                                        India
India
open                                        00:00:00
00:00:00
close                                       23:59:59
```

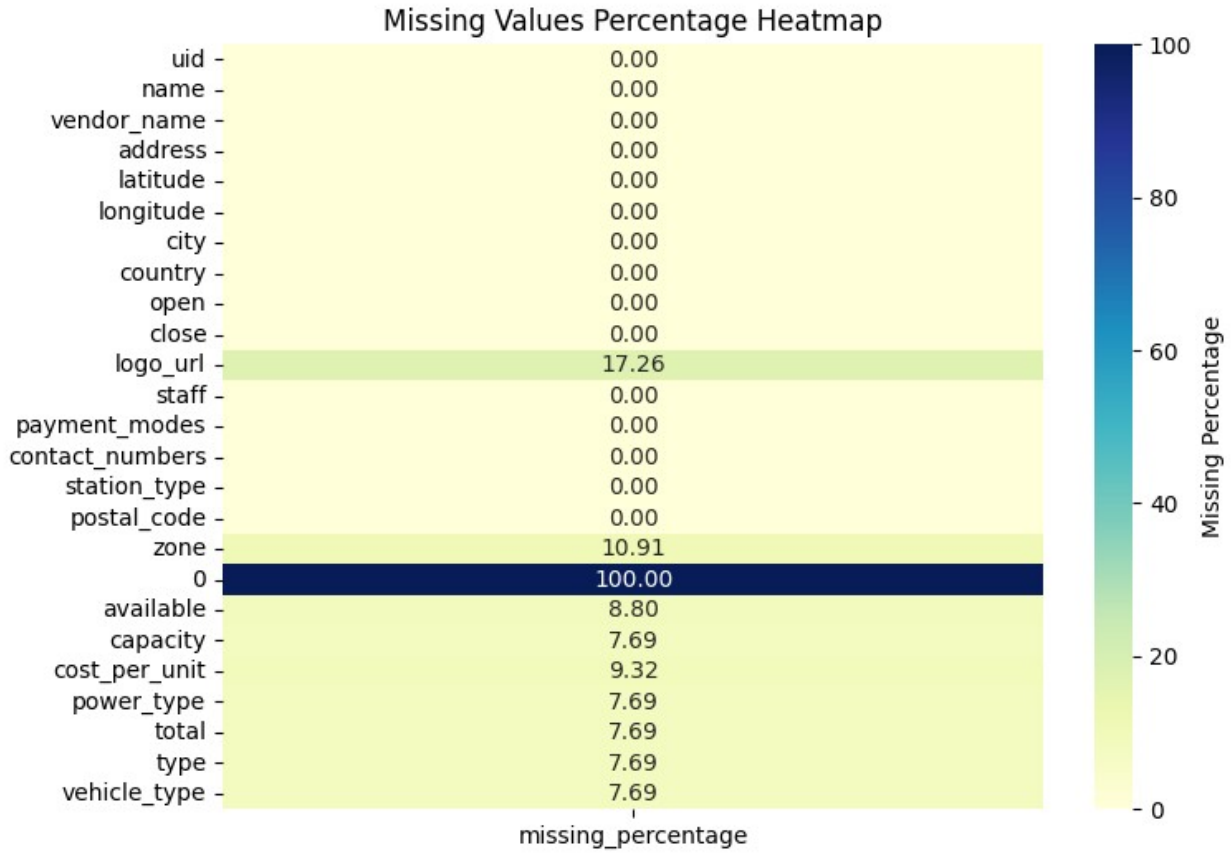
```
23:59:59
logo_url                                        NaN                                        NaN
staff                                      Unstaffed                                  Unstaffed
payment_modes                  Card, E-Wallet, UPI                                E-Wallet
contact_numbers                     ["7042406677"]                             ["11399999228"]
station_type                              charging                                   charging
postal_code                                110001                                     110001
zone                                central-delhi                              central-delhi
0                                               NaN                                        NaN
available                                       NaN                                        NaN
capacity                                  15 kW                                    3.3 kW
cost_per_unit                                   NaN                                        NaN
power_type                                       DC                                         AC
total                                           2.0                                        3.0
type                                 BEVC DC 001                                BEVC AC 001
vehicle_type                              ['4W']                          ['2W', '3W', '4W']

                                               2                                          3
\
uid                                  STATIC15                                   STATIC16

name                                     REIL                                       REIL

vendor_name                              REIL                                       REIL

address          Ashram Chowk Mathura Road  Nizamuddin Railway station

latitude                            28.571189                                  28.588991

longitude                           77.259806                                   77.25324

city                                     Delhi                                      Delhi

country                                  India                                      India
```

open	00:00:00	00:00:00
close	23:59:59	23:59:59
logo_url	NaN	NaN
staff	Unstaffed	Unstaffed
payment_modes	E-Wallet	Cash/E-Wallet
contact_numbers	["9811024398"]	["9717632007"]
station_type	charging	charging
postal_code	110001	110001
zone	central-delhi	central-delhi
0	NaN	NaN
available	NaN	NaN
capacity	15 kW	15 kW
cost_per_unit	NaN	NaN
power_type	DC	DC
total	2.0	4.0
type	BEVC DC 001	BEVC DC 001
vehicle_type	['4W']	['4W']

	4
uid	STATIC17
name	BluSmart
vendor_name	BluSmart
address	BSES Bhawan, Nehru Place, New Delhi 110048
latitude	28.549427
longitude	77.254636
city	Delhi
country	India
open	00:00:00
close	23:59:59
logo_url	NaN
staff	Unstaffed
payment_modes	Cash/E-Wallet
contact_numbers	["7042406677"]
station_type	charging

```
postal_code                                                110001
zone                                                central-delhi
0                                                             NaN
available                                                     NaN
capacity                                                15 kW
cost_per_unit                                                 NaN
power_type                                                     DC
total                                                         1.0
type                                                   BEVC DC 001
vehicle_type                                               ['4W']
```

```
# Calculate the percentage of missing values for each column
missing_percentage = df.isnull().mean() * 100

# Create a DataFrame with missing percentage information
missing_info = pd.DataFrame({'column': df.columns,
'missing_percentage': missing_percentage})

# Create a heatmap grid highlighting missing values percentage
plt.figure(figsize=(8, 6))
sns.heatmap(missing_info[['missing_percentage']], cmap='YlGnBu',
annot=True, fmt='.2f', cbar_kws={'label': 'Missing Percentage'})
plt.title('Missing Values Percentage Heatmap')
plt.show()
```



Data Processing

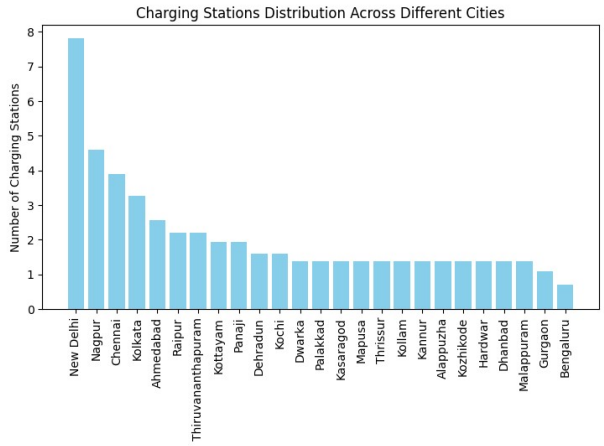
```
df['capacity'].fillna('0 kW', inplace=True)

# Replace 'Delhi' with 'New Delhi' in the 'city' column
df['city'] = df['city'].replace('Delhi', 'New Delhi')

# Make data consistent
df['staff'] = df['staff'].replace('Staffed', 'staffed')
df['staff'] = df['staff'].replace('UnStaffed', 'unstaffed')
df['staff'] = df['staff'].replace('Unstaffed', 'unstaffed')
```

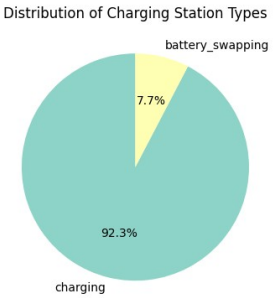
The Big Picture

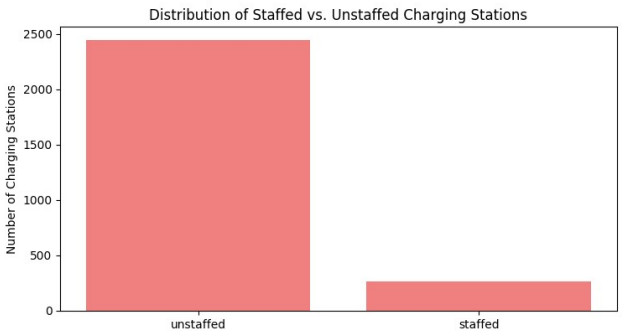
```
# Set up subplots
fig, axes = plt.subplots(3, 2, figsize=(15, 15))
```

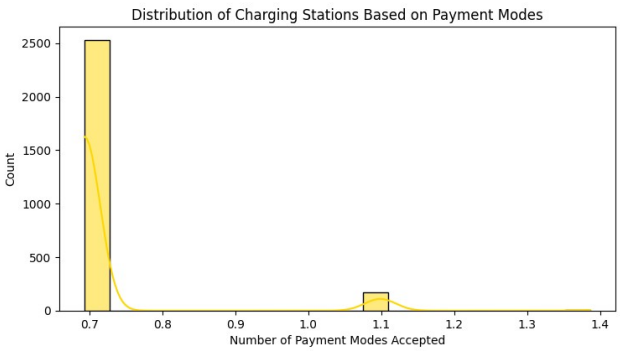
```
# 1. Check the distribution of charging stations across different
cities in India.
city_distribution = df['city'].value_counts()
city_distribution = np.log1p(city_distribution)
axes[0, 0].bar(city_distribution.index, city_distribution.values,
color='skyblue')
axes[0, 0].set_title('Charging Stations Distribution Across Different
Cities')
axes[0, 0].set_ylabel('Number of Charging Stations')
axes[0, 0].tick_params(axis='x', rotation=90)

# 2. Explore the distribution of charging station types.
station_type_distribution = df['station_type'].value_counts()
axes[0, 1].pie(station_type_distribution,
labels=station_type_distribution.index, autopct='%1.1f%%',
startangle=90, colors=sns.color_palette('Set3'))
axes[0, 1].set_title('Distribution of Charging Station Types')

# 3. Explore the distribution of stations that are staffed vs.
unstaffed.
staff_distribution = df['staff'].value_counts()
axes[1, 0].bar(staff_distribution.index, staff_distribution.values,
color='lightcoral')
axes[1, 0].set_title('Distribution of Staffed vs. Unstaffed Charging
Stations')
axes[1, 0].set_ylabel('Number of Charging Stations')

# 4. Analyze the distribution of charging stations based on payment
modes accepted.
payment_modes_distribution = df['payment_modes'].apply(lambda x:
len(str(x).split(', ')) if pd.notnull(x) else 0)
payment_modes_distribution = np.log1p(payment_modes_distribution)
sns.histplot(payment_modes_distribution, bins=20, kde=True,
color='gold', ax=axes[1, 1])
axes[1, 1].set_title('Distribution of Charging Stations Based on
Payment Modes')
axes[1, 1].set_xlabel('Number of Payment Modes Accepted')

# 5. Explore the distribution of charging stations based on the
capacity of power.
df['capacity'] = df['capacity'].replace({'kW': ''}, regex=True)
df['capacity'] = pd.to_numeric(df['capacity'], errors='coerce')
sns.histplot(df['capacity'], bins=20, kde=True,
color='mediumseagreen', ax=axes[2, 0])
axes[2, 0].set_title('Distribution of Charging Stations Based on Power
Capacity (kW)')
axes[2, 0].set_xlabel('Power Capacity (kW)')

# Remove empty subplot
fig.delaxes(axes[2, 1])
```

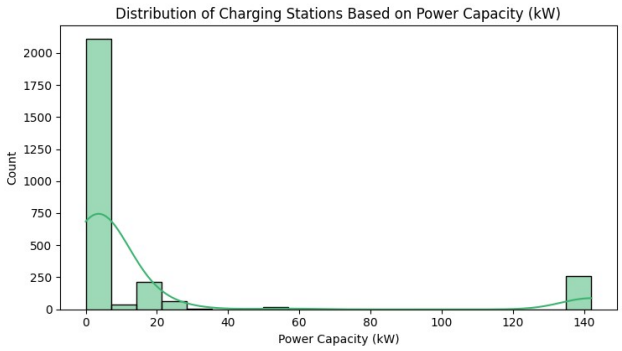
```
# Adjust layout
plt.tight_layout()
plt.show()
```









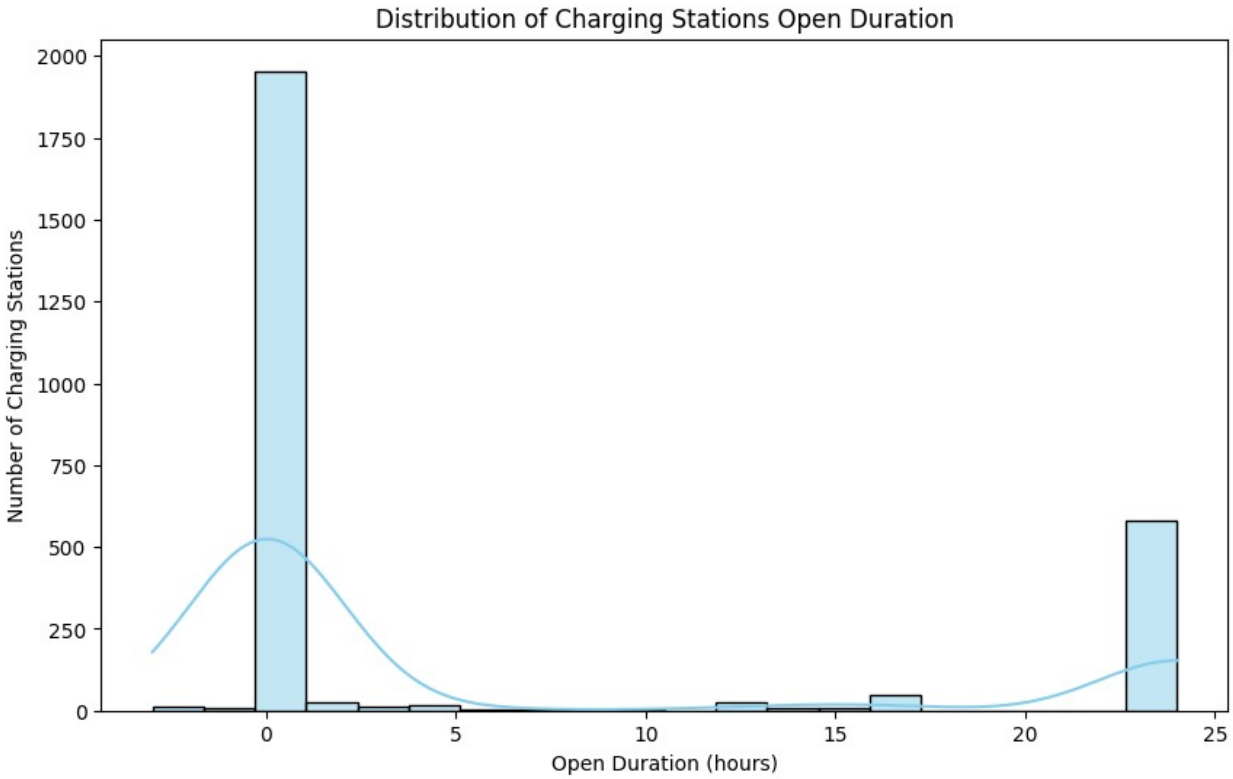


Time Based Analysis

```
# Convert 'open' and 'close' columns to datetime
df['open'] = pd.to_datetime(df['open'])
```

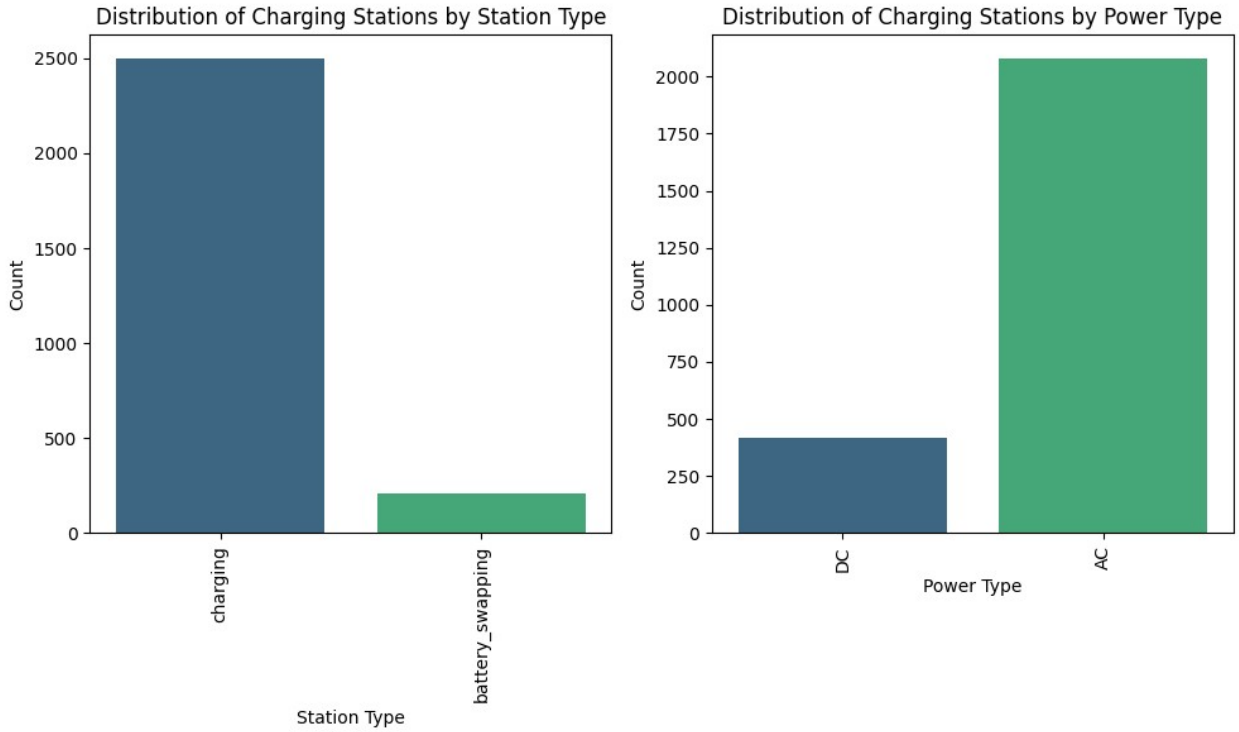
```
df['close'] = pd.to_datetime(df['close'])

# Calculate the time duration for which charging stations are open
df['duration'] = df['close'] - df['open']

# Display the first few rows of the DataFrame with the calculated
duration
print(df[['open', 'close', 'duration']].head())

# Plot the distribution of time durations
plt.figure(figsize=(10, 6))
sns.histplot(df['duration'].dt.total_seconds() / 3600, bins=20,
kde=True, color='skyblue')
plt.title('Distribution of Charging Stations Open Duration')
plt.xlabel('Open Duration (hours)')
plt.ylabel('Number of Charging Stations')
plt.show()
```

```
        open                close        duration
0 2025-03-12 2025-03-12 23:59:59 0 days 23:59:59
1 2025-03-12 2025-03-12 23:59:59 0 days 23:59:59
2 2025-03-12 2025-03-12 23:59:59 0 days 23:59:59
3 2025-03-12 2025-03-12 23:59:59 0 days 23:59:59
4 2025-03-12 2025-03-12 23:59:59 0 days 23:59:59
```



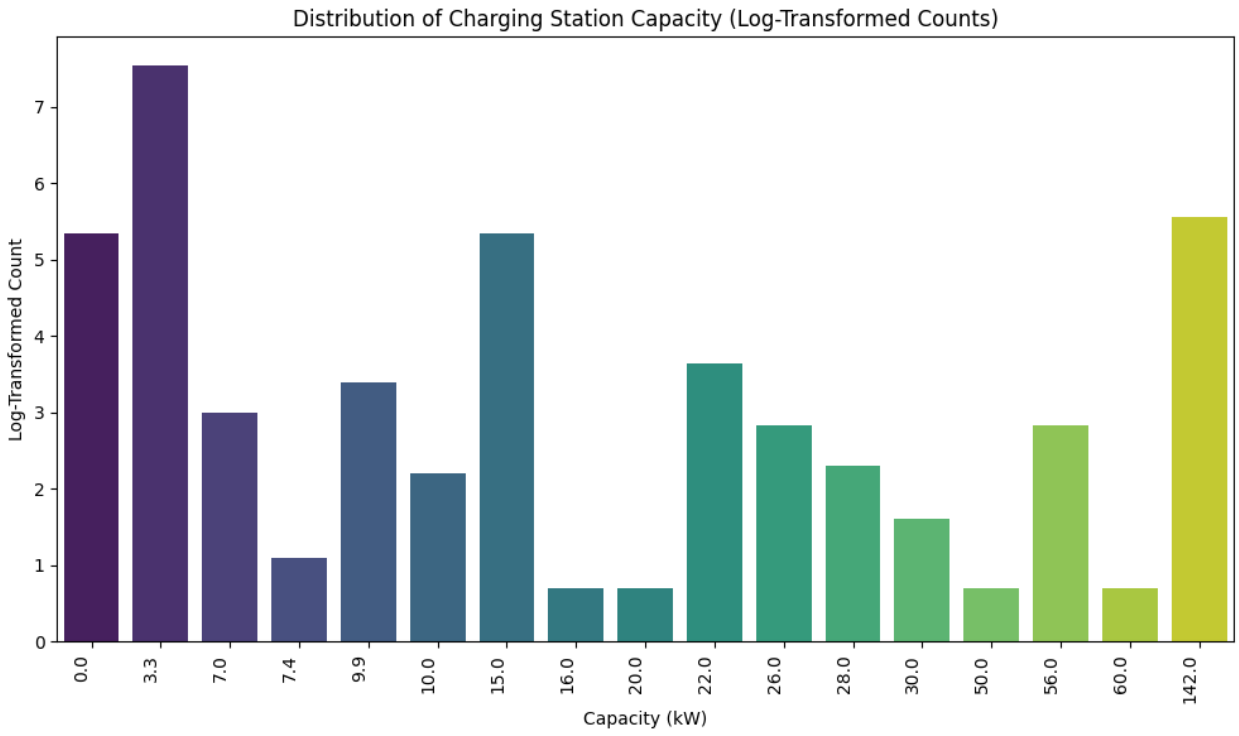
Station Type Vs Power Type

```
# Create subplots for station type and power type
fig, axes = plt.subplots(1, 2, figsize=(10, 6))

# Investigate the distribution of cost per unit across different
station types
sns.countplot(x='station_type', data=df, palette='viridis',
ax=axes[0])
axes[0].set_title('Distribution of Charging Stations by Station Type')
axes[0].set_xlabel('Station Type')
axes[0].set_ylabel('Count')
axes[0].tick_params(axis='x', rotation=90)

# Investigate the distribution of cost per unit across different power
types
sns.countplot(x='power_type', data=df, palette='viridis', ax=axes[1])
axes[1].set_title('Distribution of Charging Stations by Power Type')
axes[1].set_xlabel('Power Type')
axes[1].set_ylabel('Count')
axes[1].tick_params(axis='x', rotation=90)

# Adjust layout
plt.tight_layout()
plt.show()
```



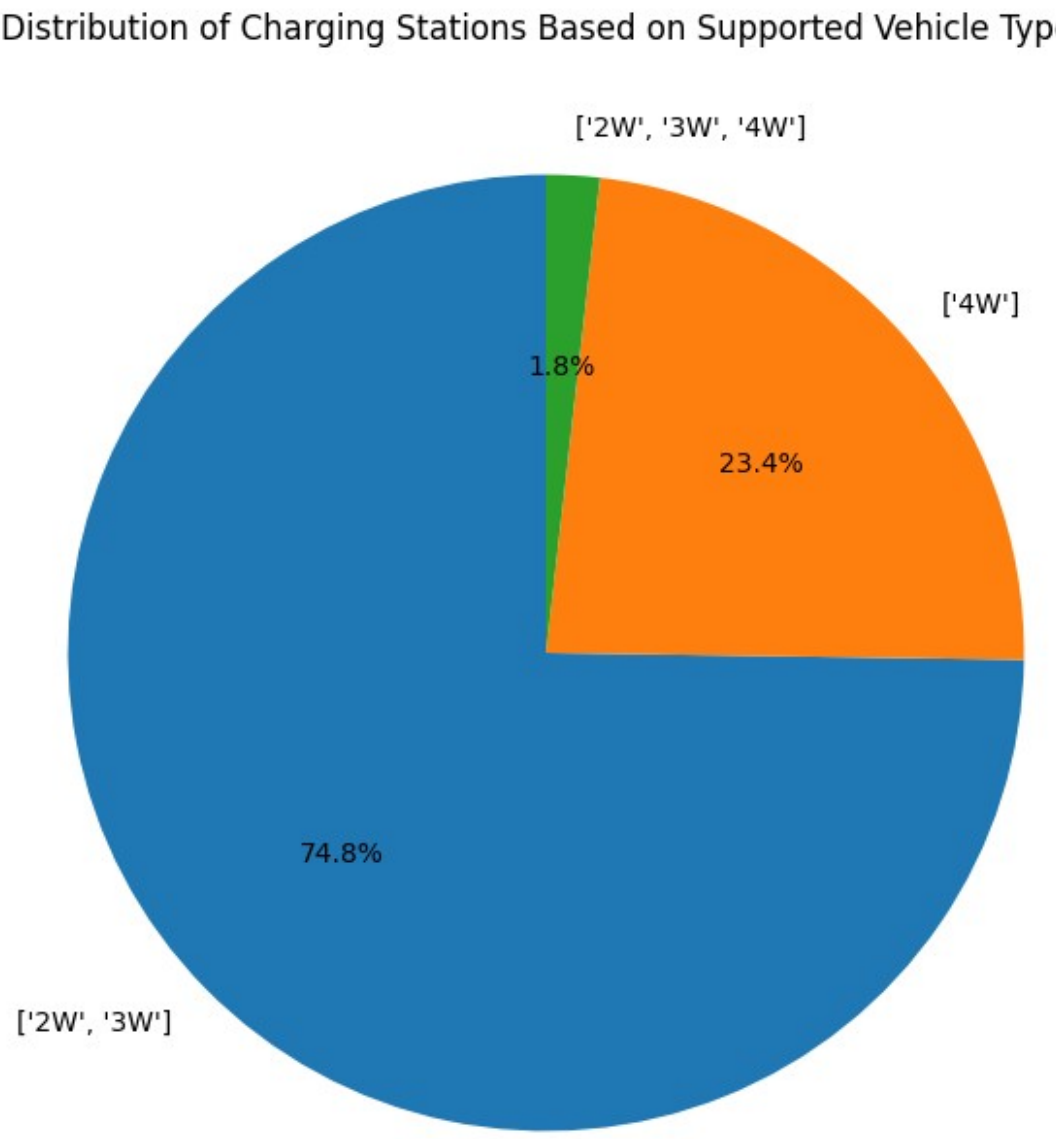
Capacity Analysis

```
capacity_counts = df['capacity'].value_counts()

# Apply logarithm transformation to count values
log_counts = np.log1p(capacity_counts)

# Plot the distribution of charging station capacity with log-
transformed counts
plt.figure(figsize=(10, 6))
sns.barplot(x=log_counts.index, y=log_counts.values,
palette='viridis')
plt.title('Distribution of Charging Station Capacity (Log-Transformed
Counts)')
plt.xlabel('Capacity (kW)')
plt.ylabel('Log-Transformed Count')
plt.xticks(rotation=90, ha='right')

# Adjust layout
plt.tight_layout()
plt.show()
```



Charging Station Vs Vehicle Types

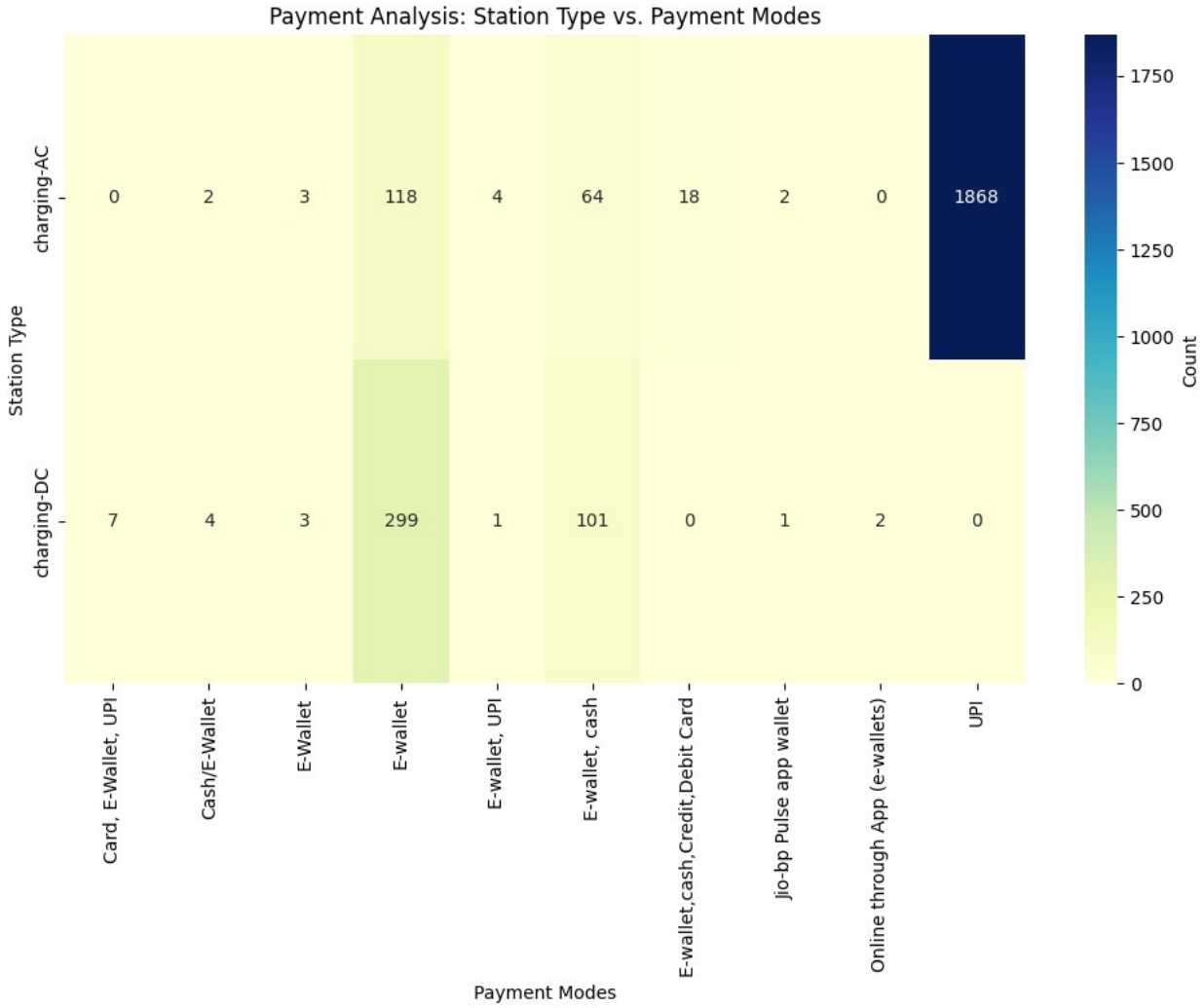
```
# Create a pie chart for the distribution of charging stations based
on supported vehicle types
vehicle_type_counts = df['vehicle_type'].value_counts()

plt.figure(figsize=(10, 8))
plt.pie(vehicle_type_counts, labels=vehicle_type_counts.index,
autopct='%1.1f%%', startangle=90)
plt.title('Distribution of Charging Stations Based on Supported
Vehicle Types')

# Show the plot
plt.show()
```



Payment Mode Analysis

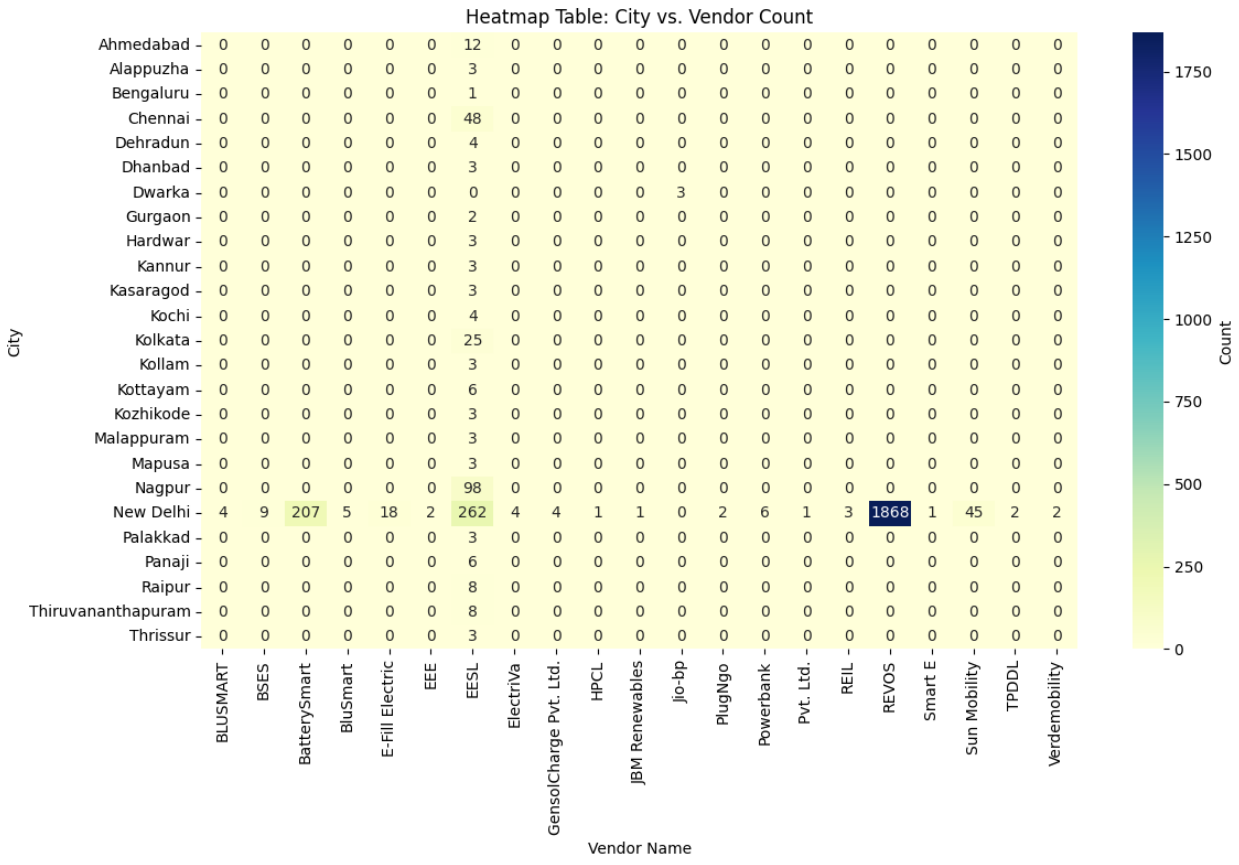
```
# Create a pivot table for payment analysis
payment_pivot = df.pivot_table(index=['station_type', 'power_type'],
columns='payment_modes', values='vehicle_type', aggfunc='count',
fill_value=0)

# Create a heatmap
```

```
plt.figure(figsize=(10, 8))
sns.heatmap(payment_pivot, annot=True, fmt='d', cmap='YlGnBu',
cbar_kws={'label': 'Count'})
plt.title('Payment Analysis: Station Type vs. Payment Modes')
plt.xlabel('Payment Modes')
plt.ylabel('Station Type')

# Adjust layout
plt.tight_layout()
plt.show()
```



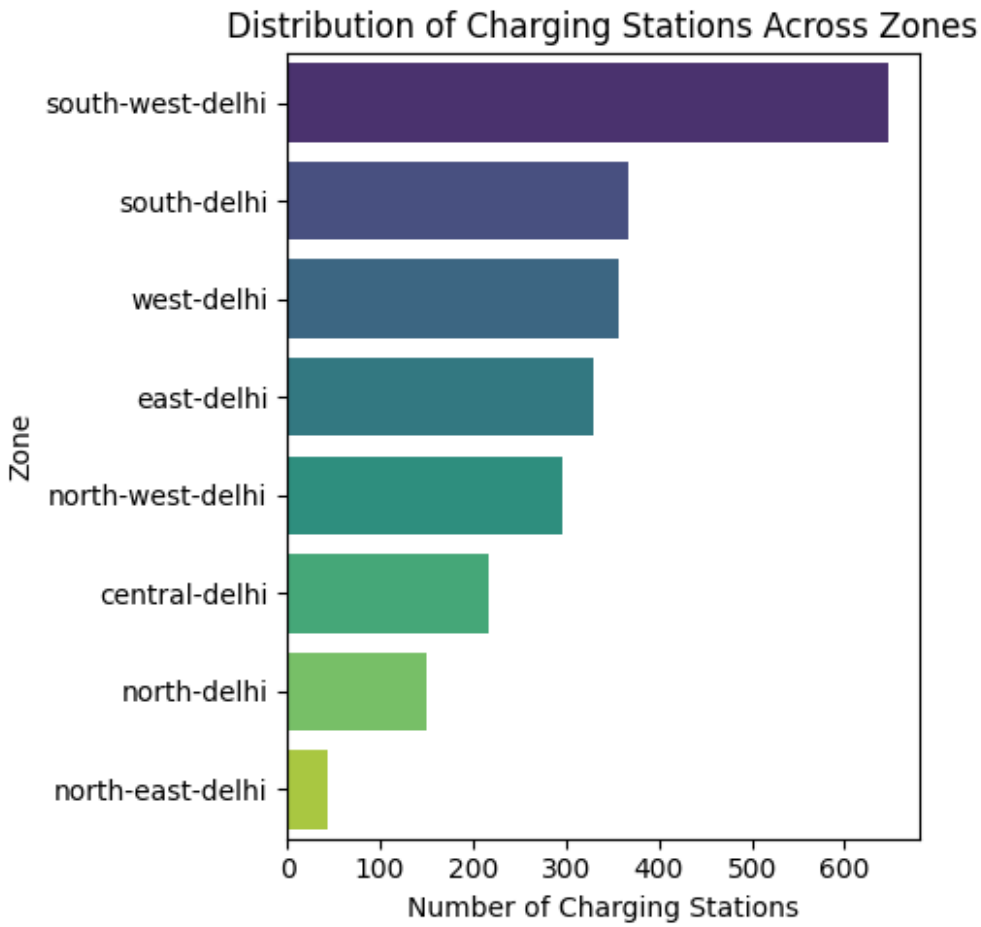
Vendor Analysis

```
# Create a pivot table for city and vendor count
city_vendor_pivot = df.pivot_table(index='city',
columns='vendor_name', values='uid', aggfunc='count', fill_value=0)

# Create a heatmap table
plt.figure(figsize=(12, 8))
sns.heatmap(city_vendor_pivot, annot=True, cmap='YlGnBu',
cbar_kws={'label': 'Count'}, fmt='g')
plt.title('Heatmap Table: City vs. Vendor Count')
plt.xlabel('Vendor Name')
plt.ylabel('City')

# Adjust layout
plt.tight_layout()
plt.show()
```



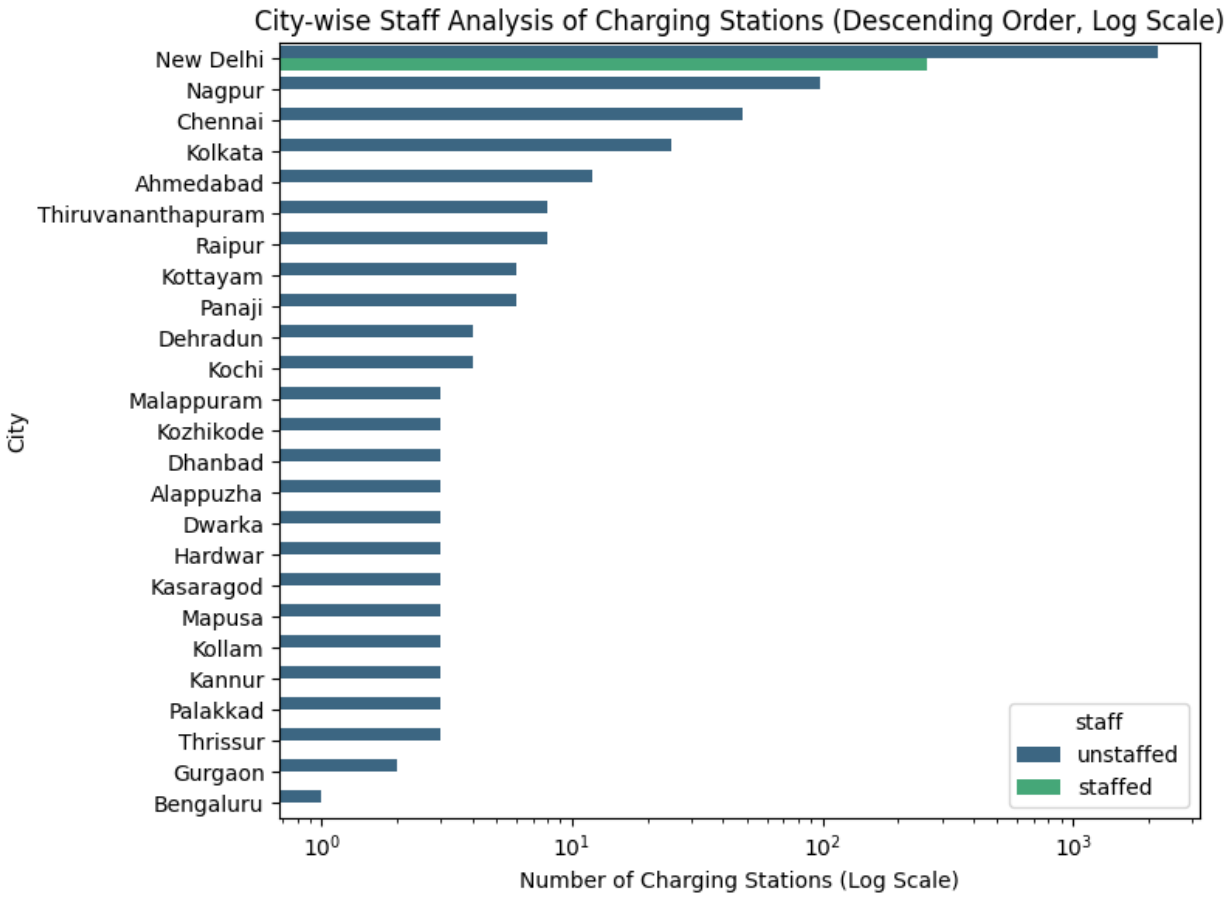
Zone Wise Analysis

```
# Calculate the counts for each zone
zone_counts = df['zone'].value_counts()

# Sort the zones based on the counts
sorted_zones = zone_counts.sort_values(ascending=False).index

# Create a horizontal bar plot for the distribution of charging
stations across different zones
plt.figure(figsize=(5, 5))
sns.countplot(y='zone', data=df, order=sorted_zones,
palette='viridis')
plt.title('Distribution of Charging Stations Across Zones')
plt.ylabel('Zone')
plt.xlabel('Number of Charging Stations')

# Adjust layout
plt.tight_layout()
plt.show()
```



Staff Analysis

```
# Calculate the total number of charging stations in each city
city_station_counts = df.groupby('city')['uid'].count().reset_index()

# Sort the cities in descending order based on the total number of
charging stations
sorted_cities = city_station_counts.sort_values(by='uid',
ascending=False)['city']

# Create a horizontal count plot for the distribution of staffed and
unstaffed charging stations across different cities
plt.figure(figsize=(8, 6))
sns.countplot(y='city', hue='staff', data=df, order=sorted_cities,
palette='viridis')

# Apply a logarithmic scale to the x-axis
plt.xscale('log')

plt.title('City-wise Staff Analysis of Charging Stations (Descending
Order, Log Scale)')
plt.ylabel('City')
plt.xlabel('Number of Charging Stations (Log Scale)')

# Adjust layout
plt.tight_layout()
plt.show()
```



Geospatial Analysis With Folium

```
import folium
from folium.plugins import MarkerCluster


# Create a map centered around the mean latitude and longitude
map_center = [df['latitude'].mean(), df['longitude'].mean()]
charging_map = folium.Map(location=map_center, zoom_start=5)

# Create a MarkerCluster to group nearby markers
marker_cluster = MarkerCluster().add_to(charging_map)

# Add markers for each charging station
for index, row in df.iterrows():
    popup_text = f"<b>{row['name']}</b><br>Vendor:
{row['vendor_name']}<br>Contact: {', '.join(map(str,
row['contact_numbers']))}"
    folium.Marker([row['latitude'], row['longitude']],
```

```
popup=popup_text).add_to(marker_cluster)

charging_map
```

```
<folium.folium.Map at 0x2642d097610>
```