In [7]:
```
import pandas as pd
df = pd.read_csv('../AirIndia_Analysis/Updated.csv')
df.head()
```

Out[7]:

	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2,307
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3,578
2	Air India	AI 641	Mumbai	18:55	Bengaluru	20:25	01 h 30 m	5,783
3	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9,458
4	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17,018

In [8]:
```
df.info()
df.describe()
df.columns
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 77 entries, 0 to 76
Data columns (total 8 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   FlightName     77 non-null     object
 1   FlightCode     77 non-null     object
 2   DepartingCity  77 non-null     object
 3   DepartingTime  77 non-null     object
 4   ArrivingCity   77 non-null     object
 5   ArrivingTime   77 non-null     object
 6   Duration       77 non-null     object
 7   Price          77 non-null     object
dtypes: object(8)
memory usage: 4.9+ KB
```

Out[8]:
```
Index(['FlightName', 'FlightCode', 'DepartingCity', 'DepartingTime',
       'ArrivingCity', 'ArrivingTime', 'Duration', 'Price'],
      dtype='object')
```

In [9]:
```
null_counts = df.isnull().sum()
null_percentage = (null_counts / len(df)) * 100

print("Null Counts:\n", null_counts)
print("\nNull Percentage:\n", null_percentage)

df = df.loc[:, null_percentage < 30]

df = df.dropna(thresh=len(df.columns) - 2)

df = df.dropna()
```

```
Null Counts:
 FlightName       0
FlightCode       0
DepartingCity    0
DepartingTime    0
ArrivingCity     0
ArrivingTime     0
Duration         0
Price            0
dtype: int64

Null Percentage:
 FlightName       0.0
FlightCode       0.0
DepartingCity    0.0
DepartingTime    0.0
ArrivingCity     0.0
ArrivingTime     0.0
Duration         0.0
Price            0.0
dtype: float64
```

In [10]:
```
df['Price'] = df['Price'].astype(str)

df['Price'] = df['Price'].str.replace(',', '', regex=True)
```

In [11]:
```
df['Price']
```

Out[11]:
```
0      2307
1      3578
2      5783
3      9458
4     17018
      ...
72     5472
73     5472
74     5472
75     5472
76     5472
Name: Price, Length: 77, dtype: object
```

In [12]:
```
print(df['Price'].dtype)
```

```
object
```

In [13]:
```
df['Price'] = pd.to_numeric(df['Price'], errors='coerce')
```

In [14]:
```
print(df['Price'].dtype)
```

```
int64
```

In [15]:
```
df['Price']
```

Out[15]:
```
0      2307
1      3578
2      5783
3      9458
4     17018
      ...
72     5472
73     5472
74     5472
75     5472
76     5472
Name: Price, Length: 77, dtype: int64
```

In [16]:
```
df = df.sort_values(by='Price', ascending=True)
```

In [17]:
```
df
```

Out[17]:

	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2307
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3578
5	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621
6	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621
42	Air India	AI 864	Mumbai	07:00	New Delhi	09:15	02 h 15 m	4745
...	...	...	...	...	...	...	...	...
22	Air India	AI 506	New Delhi	09:40	Bengaluru	12:30	02 h 50 m	8233
3	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9458
32	Air India	AI 808	Bengaluru	21:00	New Delhi	23:55	02 h 55 m	10711
4	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17018
11	Air India	AI 642	Bengaluru	21:25	Mumbai	23:20	01 h 55 m	20581

77 rows × 8 columns

In [18]:
```
df.to_csv("airindia_cleaned.csv", index=False)
```

In [19]:
```
df['Dep_Time'] = pd.to_datetime(df['DepartingTime'], errors='coerce')

df['Year'] = df['Dep_Time'].dt.year
df['Month'] = df['Dep_Time'].dt.month

print(df[['DepartingTime', 'Year', 'Month']].head())
```

```
  DepartingTime  Year  Month
0         03:55  2025      4
1         16:40  2025      4
5         09:20  2025      4
6         09:20  2025      4
42        07:00  2025      4
```

```
C:\Users\amogh\AppData\Local\Temp\ipykernel_9488\2476565692.py:1: UserWarning: Could not infer format, so each e
lement will be parsed individually, falling back to `dateutil`. To ensure parsing is consistent and as-expected,
please specify a format.
  df['Dep_Time'] = pd.to_datetime(df['DepartingTime'], errors='coerce')
```

In [20]:
```
df
```

Out[20]:

	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price	Dep_Time	Year	Month
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2307	2025-04-16 03:55:00	2025	4
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3578	2025-04-16 16:40:00	2025	4
5	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621	2025-04-16 09:20:00	2025	4
6	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621	2025-04-16 09:20:00	2025	4
42	Air India	AI 864	Mumbai	07:00	New Delhi	09:15	02 h 15 m	4745	2025-04-16 07:00:00	2025	4
...	...	...	...	...	...	...	...	...	...	...	...
22	Air India	AI 506	New Delhi	09:40	Bengaluru	12:30	02 h 50 m	8233	2025-04-16 09:40:00	2025	4
3	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9458	2025-04-16 06:45:00	2025	4
32	Air India	AI 808	Bengaluru	21:00	New Delhi	23:55	02 h 55 m	10711	2025-04-16 21:00:00	2025	4
4	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17018	2025-04-16 09:20:00	2025	4
11	Air India	AI 642	Bengaluru	21:25	Mumbai	23:20	01 h 55 m	20581	2025-04-16 21:25:00	2025	4

77 rows × 11 columns

In [21]:
```
duplicate_count = df.duplicated(subset=['FlightCode']).sum()
print("Number of duplicate FlightCode rows:", duplicate_count)

duplicates = df[df.duplicated(subset=['FlightCode'], keep=False)]
print(duplicates)
```

```
Number of duplicate FlightCode rows: 15
   FlightName FlightCode DepartingCity DepartingTime ArrivingCity  \
5   Air India     AI 604     Bengaluru         09:20       Mumbai
6   Air India     AI 604     Bengaluru         09:20       Mumbai
42  Air India     AI 864        Mumbai         07:00    New Delhi
43  Air India     AI 864        Mumbai         07:00    New Delhi
44  Air India     AI 864        Mumbai         07:00    New Delhi
47  Air India     AI 623        Mumbai         10:25    New Delhi
48  Air India     AI 623        Mumbai         10:25    New Delhi
64  Air India     AI 560     New Delhi         07:10    Hyderabad
65  Air India     AI 560     New Delhi         07:10    Hyderabad
66  Air India     AI 560     New Delhi         07:10    Hyderabad
40  Air India     AI 814     New Delhi         22:30       Mumbai
39  Air India     AI 814     New Delhi         22:30       Mumbai
13  Air India     AI 803     New Delhi         06:10    Bengaluru
14  Air India     AI 803     New Delhi         06:10    Bengaluru
72  Air India     AI 559     Hyderabad         06:15    New Delhi
73  Air India     AI 559     Hyderabad         06:15    New Delhi
55  Air India     AI 764     New Delhi         17:05      Kolkata
54  Air India     AI 764     New Delhi         17:05      Kolkata
27  Air India     AI 501     Bengaluru         13:15    New Delhi
28  Air India     AI 501     Bengaluru         13:15    New Delhi
61  Air India     AI 768       Kolkata         15:25    New Delhi
60  Air India     AI 768       Kolkata         15:25    New Delhi
58  Air India     AI 401     New Delhi         06:55      Kolkata
57  Air India     AI 401     New Delhi         06:55      Kolkata
8   Air India     AI 622     Bengaluru         12:05       Mumbai
9   Air India     AI 622     Bengaluru         12:05       Mumbai
20  Air India     AI 512     New Delhi         19:15    Bengaluru
21  Air India     AI 512     New Delhi         19:15    Bengaluru

   ArrivingTime   Duration  Price            Dep_Time  Year  Month
5         11:35  02 h 15 m   4621 2025-04-16 09:20:00  2025      4
6         11:35  02 h 15 m   4621 2025-04-16 09:20:00  2025      4
42        09:15  02 h 15 m   4745 2025-04-16 07:00:00  2025      4
43        09:15  02 h 15 m   4745 2025-04-16 07:00:00  2025      4
44        09:15  02 h 15 m   4745 2025-04-16 07:00:00  2025      4
47        12:40  02 h 15 m   4745 2025-04-16 10:25:00  2025      4
48        12:40  02 h 15 m   4745 2025-04-16 10:25:00  2025      4
64        09:20  02 h 10 m   4750 2025-04-16 07:10:00  2025      4
65        09:20  02 h 10 m   4750 2025-04-16 07:10:00  2025      4
66        09:20  02 h 10 m   4750 2025-04-16 07:10:00  2025      4
40        00:45  02 h 15 m   4780 2025-04-16 22:30:00  2025      4
39        00:45  02 h 15 m   4780 2025-04-16 22:30:00  2025      4
13        09:00  02 h 50 m   5240 2025-04-16 06:10:00  2025      4
14        09:00  02 h 50 m   5240 2025-04-16 06:10:00  2025      4
72        08:45  02 h 30 m   5472 2025-04-16 06:15:00  2025      4
73        08:45  02 h 30 m   5472 2025-04-16 06:15:00  2025      4
55        19:15  02 h 10 m   5492 2025-04-16 17:05:00  2025      4
54        19:15  02 h 10 m   5492 2025-04-16 17:05:00  2025      4
27        15:55  02 h 40 m   5881 2025-04-16 13:15:00  2025      4
28        15:55  02 h 40 m   5881 2025-04-16 13:15:00  2025      4
61        18:10  02 h 45 m   6063 2025-04-16 15:25:00  2025      4
60        18:10  02 h 45 m   6063 2025-04-16 15:25:00  2025      4
58        09:00  02 h 05 m   6374 2025-04-16 06:55:00  2025      4
57        09:00  02 h 05 m   6374 2025-04-16 06:55:00  2025      4
8         14:00  01 h 55 m   6721 2025-04-16 12:05:00  2025      4
9         14:00  01 h 55 m   6721 2025-04-16 12:05:00  2025      4
20        22:35  03 h 20 m   7183 2025-04-16 19:15:00  2025      4
21        22:35  03 h 20 m   7183 2025-04-16 19:15:00  2025      4
```

In [22]:
```
df.drop_duplicates(subset=['FlightCode'], inplace=True)

df.reset_index(drop=True, inplace=True)
```

In [23]:
```
df
```

Out[23]:

	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price	Dep_Time	Year	Month
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2307	2025-04-16 03:55:00	2025	4
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3578	2025-04-16 16:40:00	2025	4
2	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621	2025-04-16 09:20:00	2025	4
3	Air India	AI 864	Mumbai	07:00	New Delhi	09:15	02 h 15 m	4745	2025-04-16 07:00:00	2025	4
4	Air India	AI 866	Mumbai	09:00	New Delhi	11:20	02 h 20 m	4745	2025-04-16 09:00:00	2025	4
...	...	...	...	...	...	...	...	...	...	...	...
57	Air India	AI 506	New Delhi	09:40	Bengaluru	12:30	02 h 50 m	8233	2025-04-16 09:40:00	2025	4
58	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9458	2025-04-16 06:45:00	2025	4
59	Air India	AI 808	Bengaluru	21:00	New Delhi	23:55	02 h 55 m	10711	2025-04-16 21:00:00	2025	4
60	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17018	2025-04-16 09:20:00	2025	4
61	Air India	AI 642	Bengaluru	21:25	Mumbai	23:20	01 h 55 m	20581	2025-04-16 21:25:00	2025	4

62 rows × 11 columns

In [25]:
```
df.to_csv("../AirIndia_Analysis/airindia_cleaned.csv", index=False)
```

In [26]:
```
df
```

Out[26]:

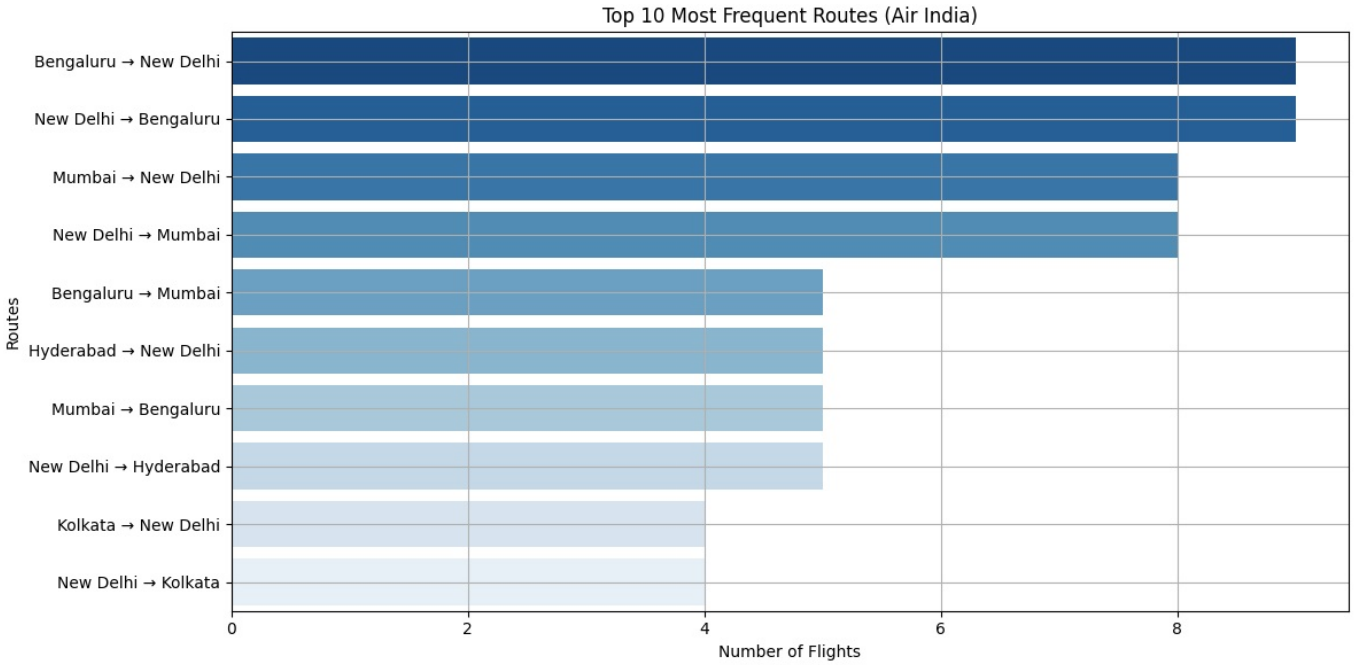
	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price	Dep_Time	Year	Month
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2307	2025-04-16 03:55:00	2025	4
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3578	2025-04-16 16:40:00	2025	4
2	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621	2025-04-16 09:20:00	2025	4
3	Air India	AI 864	Mumbai	07:00	New Delhi	09:15	02 h 15 m	4745	2025-04-16 07:00:00	2025	4
4	Air India	AI 866	Mumbai	09:00	New Delhi	11:20	02 h 20 m	4745	2025-04-16 09:00:00	2025	4
...	...	...	...	...	...	...	...	...	...	...	...
57	Air India	AI 506	New Delhi	09:40	Bengaluru	12:30	02 h 50 m	8233	2025-04-16 09:40:00	2025	4
58	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9458	2025-04-16 06:45:00	2025	4
59	Air India	AI 808	Bengaluru	21:00	New Delhi	23:55	02 h 55 m	10711	2025-04-16 21:00:00	2025	4
60	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17018	2025-04-16 09:20:00	2025	4
61	Air India	AI 642	Bengaluru	21:25	Mumbai	23:20	01 h 55 m	20581	2025-04-16 21:25:00	2025	4

62 rows × 11 columns

In [28]:

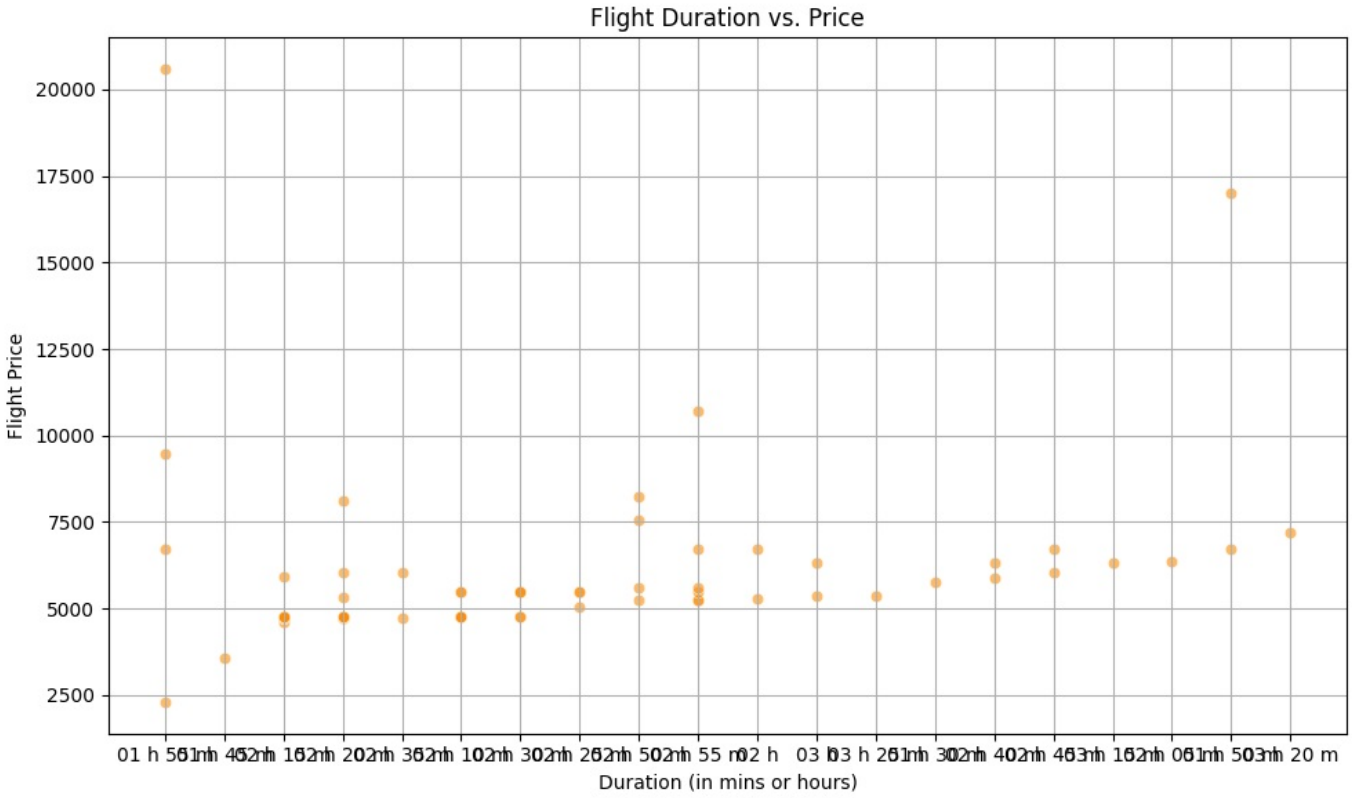
```
import matplotlib.pyplot as plt
import seaborn as sns

route_counts = df.groupby(['DepartingCity', 'ArrivingCity']).size().reset_index(name='Count')
top_routes = route_counts.sort_values(by='Count', ascending=False).head(10)

plt.figure(figsize=(12,6))
sns.barplot(data=top_routes, x='Count', y=top_routes['DepartingCity'] + " → " + top_routes['ArrivingCity'], pal
plt.title('Top 10 Most Frequent Routes (Air India)')
plt.xlabel('Number of Flights')
plt.ylabel('Routes')
plt.grid(True)
plt.tight_layout()
plt.show()
```

```
C:\Users\amogh\AppData\Local\Temp\ipykernel_9488\3017008856.py:8: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `y` variable
to `hue` and set `legend=False` for the same effect.

  sns.barplot(data=top_routes, x='Count', y=top_routes['DepartingCity'] + " → " + top_routes['ArrivingCity'], pa
lette='Blues_r')
```

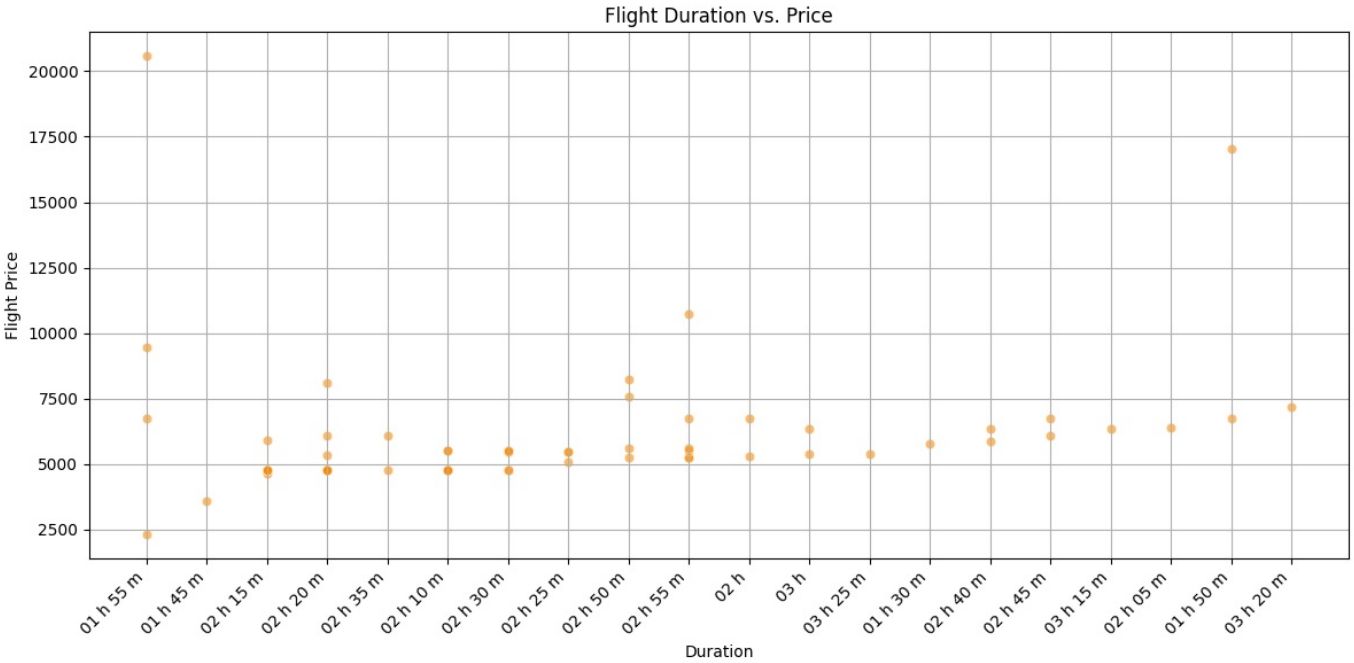


In [29]:

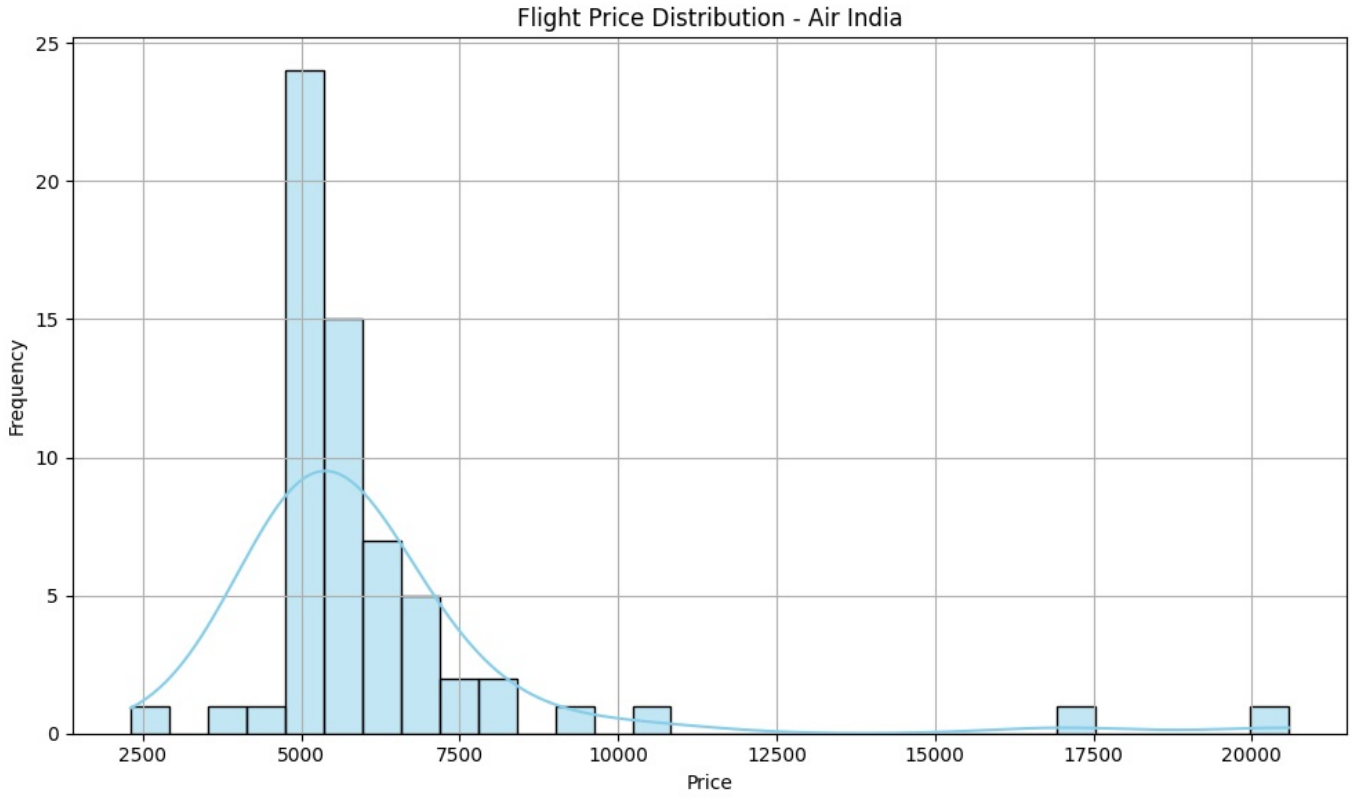
```
plt.figure(figsize=(10,6))
sns.scatterplot(data=df, x='Duration', y='Price', alpha=0.6, color='darkorange')
plt.title('Flight Duration vs. Price')
plt.xlabel('Duration (in mins or hours)')
plt.ylabel('Flight Price')
plt.grid(True)
plt.tight_layout()
plt.show()
```



In [30]:
```
plt.figure(figsize=(12,6))
sns.scatterplot(data=df, x='Duration', y='Price', alpha=0.6, color='darkorange')
plt.title('Flight Duration vs. Price')
plt.xlabel('Duration')
plt.ylabel('Flight Price')
plt.xticks(rotation=45, ha='right')  # Rotate labels for better readability
plt.grid(True)
plt.tight_layout()
plt.show()
```



In [31]:
```
plt.figure(figsize=(10,6))
sns.histplot(df['Price'], bins=30, kde=True, color='skyblue')
plt.title('Flight Price Distribution - Air India')
plt.xlabel('Price')
plt.ylabel('Frequency')
plt.grid(True)
plt.tight_layout()
plt.show()
```



In [32]:
```
df
```

Out[32]:

	FlightName	FlightCode	DepartingCity	DepartingTime	ArrivingCity	ArrivingTime	Duration	Price	Dep_Time	Year	Month
0	Air India	AI 621	Mumbai	03:55	Bengaluru	05:50	01 h 55 m	2307	2025-04-16 03:55:00	2025	4
1	Air India	AI 607	Mumbai	16:40	Bengaluru	18:25	01 h 45 m	3578	2025-04-16 16:40:00	2025	4
2	Air India	AI 604	Bengaluru	09:20	Mumbai	11:35	02 h 15 m	4621	2025-04-16 09:20:00	2025	4
3	Air India	AI 864	Mumbai	07:00	New Delhi	09:15	02 h 15 m	4745	2025-04-16 07:00:00	2025	4
4	Air India	AI 866	Mumbai	09:00	New Delhi	11:20	02 h 20 m	4745	2025-04-16 09:00:00	2025	4
...	...	...	...	...	...	...	...	...	...	...	...
57	Air India	AI 506	New Delhi	09:40	Bengaluru	12:30	02 h 50 m	8233	2025-04-16 09:40:00	2025	4
58	Air India	AI 603	Mumbai	06:45	Bengaluru	08:40	01 h 55 m	9458	2025-04-16 06:45:00	2025	4
59	Air India	AI 808	Bengaluru	21:00	New Delhi	23:55	02 h 55 m	10711	2025-04-16 21:00:00	2025	4
60	Air India	AI 639	Mumbai	09:20	Bengaluru	11:10	01 h 50 m	17018	2025-04-16 09:20:00	2025	4
61	Air India	AI 642	Bengaluru	21:25	Mumbai	23:20	01 h 55 m	20581	2025-04-16 21:25:00	2025	4

62 rows × 11 columns

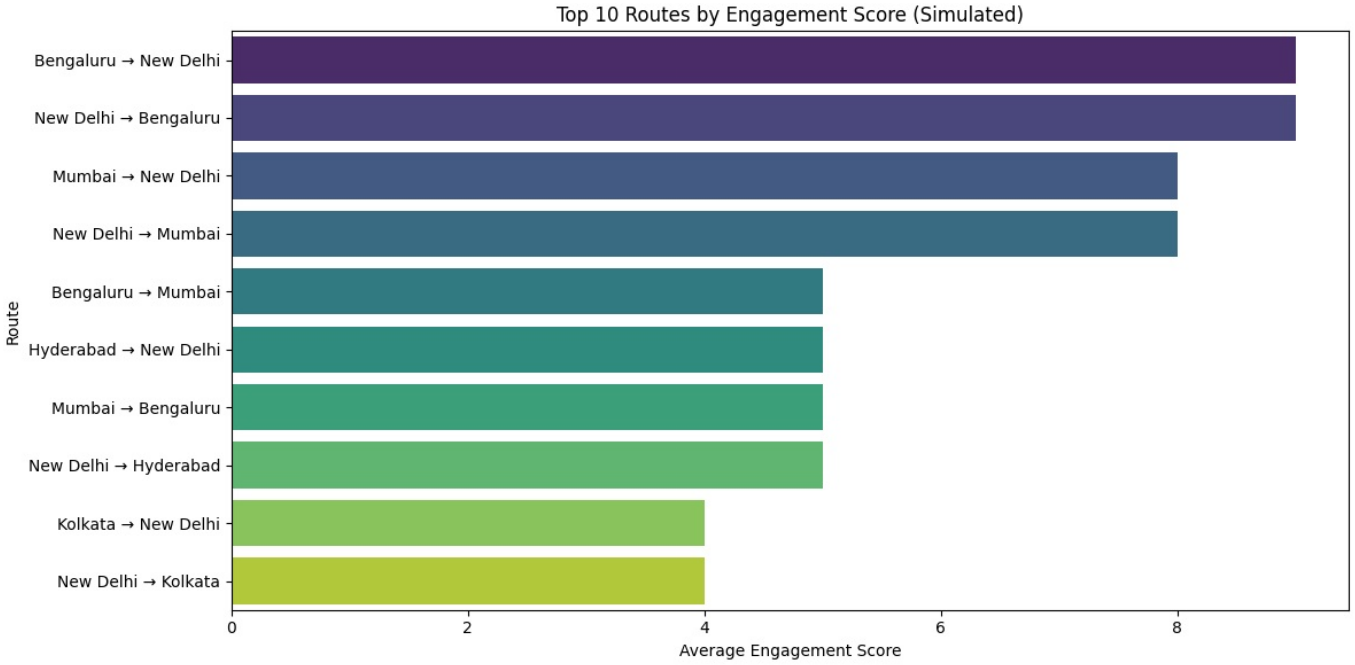
In [34]:
```
df['Route'] = df['DepartingCity'] + ' → ' + df['ArrivingCity']

route_popularity = df['Route'].value_counts().to_dict()

df['Engagement_Score'] = df['Route'].map(route_popularity)
```

In [35]:
```
df['Engagement_Score']
```

Out[35]:
```
0     5
1     5
2     5
3     8
4     8
     ..
57    9
58    5
59    9
60    5
61    5
Name: Engagement_Score, Length: 62, dtype: int64
```

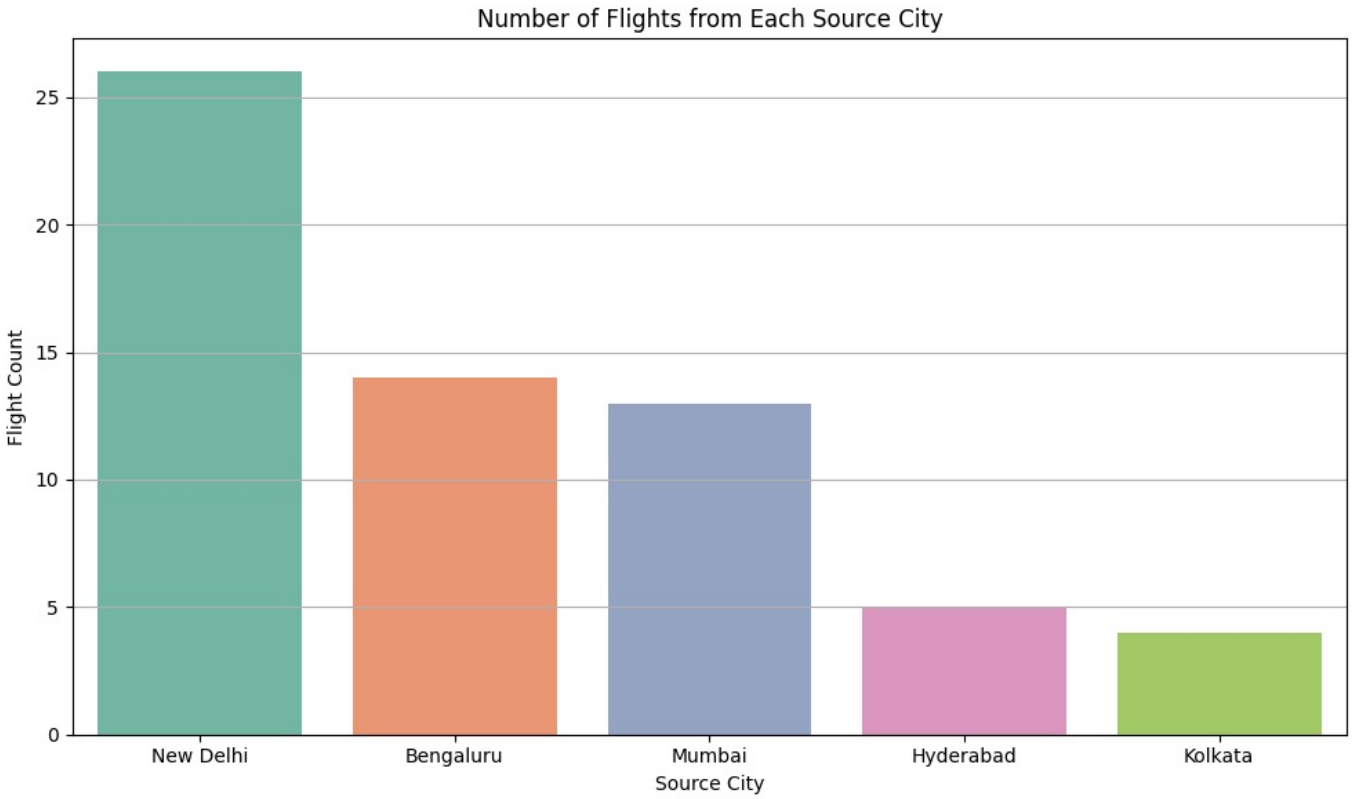
In [36]:
```
top_engagement = df.groupby('Route')['Engagement_Score'].mean().reset_index()
top_engagement = top_engagement.sort_values(by='Engagement_Score', ascending=False).head(10)

plt.figure(figsize=(12,6))
sns.barplot(data=top_engagement, x='Engagement_Score', y='Route', palette='viridis')
plt.title('Top 10 Routes by Engagement Score (Simulated)')
plt.xlabel('Average Engagement Score')
plt.ylabel('Route')
plt.tight_layout()
plt.show()
```

```
C:\Users\amogh\AppData\Local\Temp\ipykernel_9488\1961782606.py:5: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `y` variable
to `hue` and set `legend=False` for the same effect.

  sns.barplot(data=top_engagement, x='Engagement_Score', y='Route', palette='viridis')
```

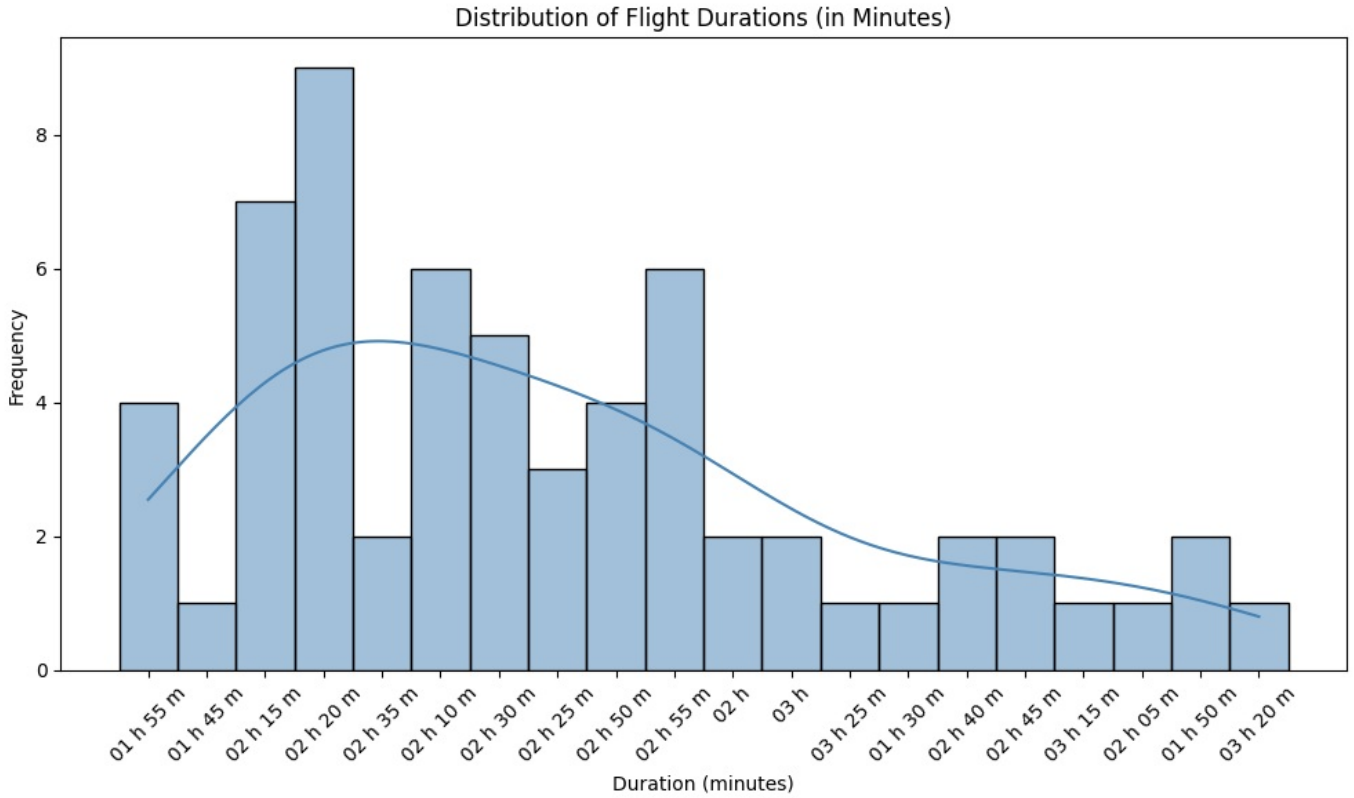


In [37]:
```
plt.figure(figsize=(10,6))
sns.countplot(data=df, x='DepartingCity', order=df['DepartingCity'].value_counts().index, palette='Set2')
plt.title('Number of Flights from Each Source City')
plt.xlabel('Source City')
plt.ylabel('Flight Count')
plt.grid(True, axis='y')
plt.tight_layout()
plt.show()
```

```
C:\Users\amogh\AppData\Local\Temp\ipykernel_9488\2438509347.py:2: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `x` variable
to `hue` and set `legend=False` for the same effect.

  sns.countplot(data=df, x='DepartingCity', order=df['DepartingCity'].value_counts().index, palette='Set2')
```

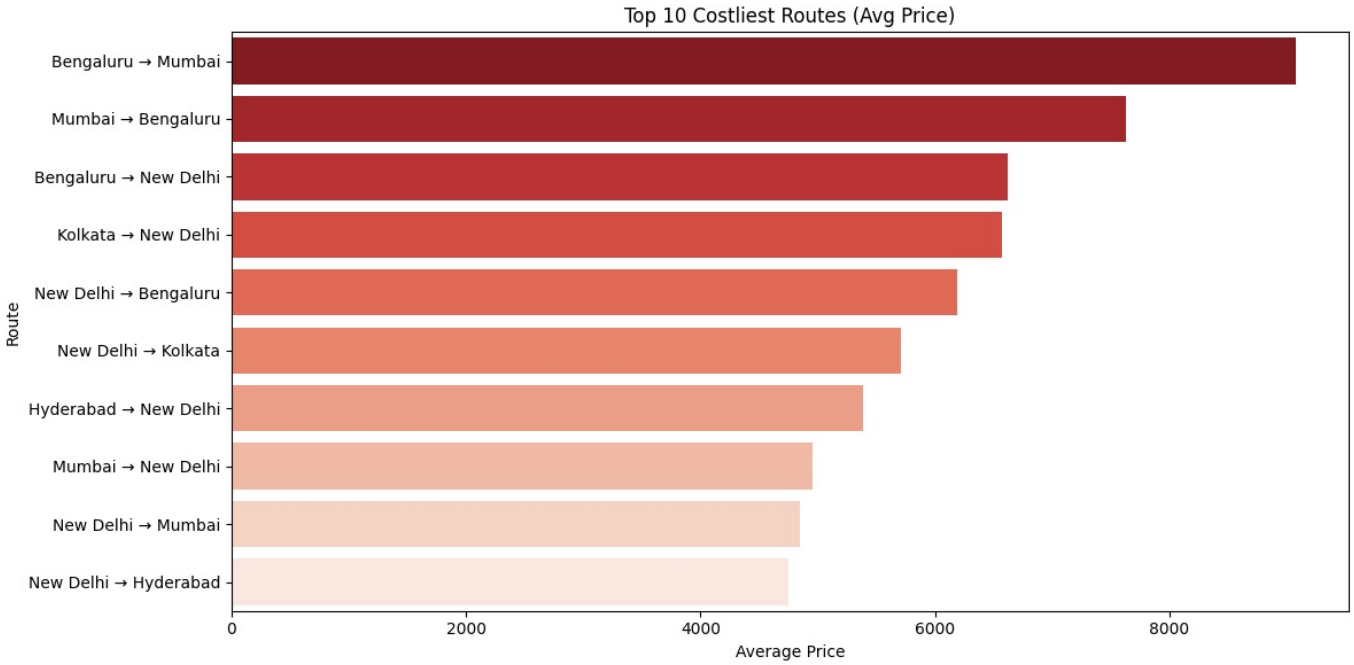


In [43]:
```
import matplotlib.pyplot as plt
import seaborn as sns

plt.figure(figsize=(10,6))
sns.histplot(df['Duration'], bins=30, kde=True, color='steelblue')
plt.title('Distribution of Flight Durations (in Minutes)')
plt.xlabel('Duration (minutes)')
plt.ylabel('Frequency')
plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```



In [44]:
```
top_costly_routes = df.groupby('Route')['Price'].mean().reset_index().sort_values(by='Price', ascending=False).

plt.figure(figsize=(12,6))
sns.barplot(data=top_costly_routes, x='Price', y='Route', palette='Reds_r')
plt.title('Top 10 Costliest Routes (Avg Price)')
plt.xlabel('Average Price')
plt.ylabel('Route')
plt.tight_layout()
plt.show()
```

```
C:\Users\amogh\AppData\Local\Temp\ipykernel_9488\2005828086.py:4: FutureWarning:

Passing `palette` without assigning `hue` is deprecated and will be removed in v0.14.0. Assign the `y` variable
to `hue` and set `legend=False` for the same effect.

  sns.barplot(data=top_costly_routes, x='Price', y='Route', palette='Reds_r')
```



Focus on Affordable Pricing

Optimize Flight Duration

Promote High-Engagement Routes

Improve Customer Experience

Highlight Popular Source & Destination Pairs

In [ ]: