SLSU - COLLEGE OF ENGINEERIING

Mapping Dengue Hotspots and Analyzing the Impact of Weather, Sanitation and Water Supply on Disease Spread in the Philippines: A Multi-Year Analysis

Presented by
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CPE15L: Cognate/Professional Course 1

Problem Statement

- Dengue fever remains a significant public health concern in the Philippines, with outbreaks occurring annually and widespread transmission across various regions.
- Despite ongoing efforts to control the disease, the persistence of dengue cases, especially in specific hotspot areas, continues to challenge public health management and response strategies

Problem Statement

- The geographical distribution of dengue cases is influenced by various factors, including weather conditions, sanitation, and water supply.
- Comprehensive understanding of how these factors interact in different regions is lacking.

Problem Statement

Objectives

1. To identify and map the dengue hotspots across different regions in the Philippines, using multi-year data analysis.
2. To analyze the correlation between weather conditions, sanitation, and water supply with the spread of dengue in various regions.
3. To provide actionable insights and recommendations for improving public health awareness, preparedness, and prevention strategies in identified high-risk areas.

Data Sources

DENGUE CASES DATA:

- Dengue cases and deaths data for the years 2016-2021 were obtained from the Humanitarian Data Exchange (HDX) platform. This dataset provides detailed reports on dengue cases and fatalities across various regions per down with dates when it was recorded in the Philippines.
  - https://data.humdata.org/dataset/philippine-dengue-cases-and-deaths

Data Sources

DENGUE CASES DATA:

- Additional, Dengue data by region for 2019-2022 were sourced from the Philippine Statistics Authority's (PSA) Environment Statistics. This dataset includes regional-level statistics on dengue cases.
    - https://psa.gov.ph/statistics/environment-statistics/node/1684061201

Data Sources

WEATHER DATA:

- Historical weather data was obtained from the Climate Change Knowledge Portal by the World Bank. It provides comprehensive climate data, including historical trends for the Philippines, accessible for various timeframes.
    - https://climateknowledgeportal.worldbank.org/country/philippines/climate-data-historical

Data Sources

SANITATION AND WATER SUPPLY DATA:

- Data on regional sanitation situation, and water supply conditions were from the PSA Environment Statistics. Dataset includes situations that may influence disease transmission.
  - https://psa.gov.ph/statistics/environment-statistics/node/1684061201
  - https://psa.gov.ph/statistics/environment-statistics/highlights/component-5-human-settlements-and-environmental-health

Data Sources

GEOSPATIAL DATA:

- Regional boundary geospatial data were obtained using GeoJSON files provided at the following link:
  - https://raw.githubusercontent.com/renatomaaliw3/public_files/master/Data%20Sets/GeoData/gadm41_PHL_1.json
- Region-level geospatial data were extracted from a CSV file:
  - https://raw.githubusercontent.com/ixahh/CPE15L/refs/heads/main/DataSets/PH-REGION-GPD.csv

Data Sources

GEOSPATIAL DATA:

- Province-level geospatial data were obtained from a separate CSV file:
    - https://raw.githubusercontent.com/ixahh/CPE15L/refs/heads/main/DataSets/PH-PROVINCE-GPD.csv

Data Sources

Preprocessing Steps

Preprocessing Steps

INITIAL CLEANUP IN EXCEL:

- Removed unnecessary rows and columns to focus on essential data.
- Standardized column names (e.g., 'Dengue_Cases', 'Sanitation_HH_Total') for consistency.

DATA CLEANING AND TRANSFORMATION IN PYTHON:

- Handling Missing Values: Retained rows with critical data and dropped irrelevant ones.
- Mapping Region Codes to Names: Used a dictionary to map region codes to region names for readability.

Preprocessing Steps

- Filtering Data by Year: Filtered data based on selected year.
- Grouping and Aggregating Data: Summarized data by region (regCode) for total cases and totals for other parameters.
- Re-mapping Region Codes: Applied region name mapping again post-aggregation for easy visualization.

WEATHER DATA PREPROCESSING:

- Grouping by Month and Region: Calculated monthly totals and averages for weather data.
- Sorting Data by Month: Arranged weather data chronologically.

Preprocessing Steps

- Color Palette: Used distinct colors for regions when plotting weather data.

TOP CASES DATA PREPROCESSING:

- Aggregating by Region and Town: Summed cases and deaths by town for identifying top cases.
- Identifying High/Low Cases: Used nsmallest() and nlargest() to find towns with the most and least dengue cases.
- Plotting: Created horizontal bar graphs to visually compare the top 10 towns with highest/lowest cases.

Preprocessing Steps

1. Initial Cleanup in Excel:

	RegC e	RegionNames	Ye	Dengue_ ses	Dengue_ ths	Sanitation_HH_Total	Sanitation_HH_Total_I oved	Sanitation_Improve Total_Values	Sanitation_I mproved_ rcent	Sanitation_ sic	Sanitation_Lim d	Sanitation_Unimp ed	Sanitation_OpenDefecatio	WaterSupply_HH_Total	WaterSupply_HH_Total_Values	WaterSupply_HH_Total_Im ved2	WaterSupply mproved_P ent_Service
2	NCR	National Capital Region	2019	40769	313	3385	3206	3206000	94.7	79.8	14.9	4.9	0	3385	3385000	3381	
3	CAR	Cordillera Administrative Region	2019	12222	28	431	408	408000	94.6	86.2	8.5	4.5	0.9	431	431000	413	
4	I	Ilocos Region	2019	19288	86	1232	1207	1207000	98	82.9	15.1	0	0	1232	1232000	1170	
5	II	Cagayan Valley	2019	16450	116	868	852	852000	98.1	90.2	7.9	0	0	868	868000	848	
6	III	Central Luzon	2019	37143	166	2853	2770	2770000	97.1	88.2	8.9	1.1	1.8	2853	2853000	2819	
7	IV-A	CALABARZON	2019	77034	429	3876	3764	3764000	97.1	88.7	8.4	1.7	1.3	3876	3876000	3787	
8	IV-B	MIMAROPA Region	2019	10621	60	754	694	694000	92	82.9	9.1	1.7	6.4	754	754000	689	
9	V	Bicol Region	2019	11297	149	1300	1104	1104000	84.9	74.2	10.7	3.6	11.5	1300	1300000	1203	
10	VI	Western Visayas	2019	58403	240	1870	1664	1664000	89	83.3	5.7	2.2	8.8	1870	1870000	1704	
11	VII	Central Visayas	2019	31708	231	1883	1721	1721000	91.4	81.4	10	3.4	5.2	1883	1883000	1774	
12	VIII	Eastern Visayas	2019	26157	85	1083	964	964000	89	77.3	11.7	2.1	8.9	1083	1083000	1044	
13	IX	Zamboanga Peninsula	2019	24540	177	851	766	766000	90	83.9	6.1	4.5	5.5	851	851000	789	
14	X	Northern Mindanao	2019	28223	188	1144	1075	1075000	94	80.7	13.3	3.2	2.8	1144	1144000	1075	
15	XI	Davao Region	2019	8369	139	1320	1247	1247000	94.5	79.2	15.3	3.5	2	1320	1320000	1281	
16	XII	SOCCSKSARGEN	2019	19603	139	1156	1072	1072000	92.7	74.2	18.3	4.9	2.4	1156	1156000	1099	
17	XIII	Caraga	2019	8892	63	634	597	597000	94.1	84.9	9.2	2.3	3.6	634	634000	596	
18	BARMM	Bangsamoro Autonomous Region in	2019	6370	11	670	306	306000	45.6	32.7	12.9	38.2	16.1	670	670000	552	
19	NCR	National Capital Region	2020	7338	97	3449	3392	3392000	98.4	79	19.4	1.5	0	3449	3449000	3449	
20	CAR	Cordillera Administrative Region	2020	3729	10	439	428	428000	97.4	86.8	10.6	1.7	0.9	439	439000	424	
21	I	Ilocos Region	2020	7323	60	1252	1239	1239000	99	83	16	0	0	1252	1252000	1244	
22	II	Cagayan Valley	2020	1340	23	883	863	863000	97.7	87.5	10.3	0	0	883	883000	856	
23	III	Central Luzon	2020	16340	139	2923	2870	2870000	98.2	87.2	11.1	1	0.8	2923	2923000	2908	
24	IV-A	CALABARZON	2020	8679	106	3970	3904	3904000	98.3	87.4	10.9	1	0	3970	3970000	3906	
25	IV-B	MIMAROPA Region	2020	5117	33	770	708	708000	92	81	11	3.1	5	770	770000	747	
26	V	Bicol Region	2020	1565	35	1319	1161	1161000	88	76	12.1	3.5	8.4	1319	1319000	1234	
27	VI	Western Visayas	2020	4087	44	1907	1657	1657000	86.9	80.4	6.5	2.1	11.1	1907	1907000	1797	
28	VII	Central Visayas	2020	11165	100	1927	1737	1737000	90.1	75.6	14.6	2	7.9	1927	1927000	1798	
29	VIII	Eastern Visayas	2020	4697	37	1108	1032	1032000	93.1	82	11	1.3	5.6	1108	1108000	1067	
30	IX	Zamboanga Peninsula	2020	2506	28	863	789	789000	91.4	79.8	11.7	2.9	5.7	863	863000	776	
31	X	Northern Mindanao	2020	6109	75	1168	1093	1093000	93.6	82.5	11.2	5.2	1.2	1168	1168000	1149	
32	XI	Davao Region	2020	1972	51	1356	1298	1298000	95.7	72	23.7	3.3	1	1356	1356000	1312	
33	XII	SOCCSKSARGEN	2020	4432	56	1181	1094	1094000	92.6	72.5	20.1	4.8	2.6	1181	1181000	1140	
34	XIII	Caraga	2020	996	25	649	618	618000	95.2	87.1	8.1	2.1	2.7	649	649000	618	
35	BARMM	Bangsamoro Autonomous Region in	2020	1200	7	683	382	382000	55.9	39.3	16.7	24.4	19.6	683	683000	558	
36	NCR	National Capital Region	2021	10368	126	3512	3447	3447000	98.2	86.7	11.2	0.3	0.7	3512	3512000	3475	
37	CAR	Cordillera Administrative Region	2021	652	37	447	437	437000	97.6	86.3	11.1	1.4	0.8	447	447000	422	
38	I	Ilocos Region	2021	8546	96	1270	1262	1262000	99.3	86.4	12.6	0.2	0.4	1270	1270000	1259	
39	II	Cagayan Valley	2021	1490	21	898	879	879000	97.9	86.6	10.7	0.6	0.9	898	898000	881	
40	III	Central Luzon	2021	20692	171	2991	2958	2958000	98.9	92	6.5	0.2	0.7	2991	2991000	2971	
41	IV-A	CALABARZON	2021	8926	159	4082	4030	4030000	98.7	91.8	6.6	0.1	1	4082	4082000	4011	
42	IV-B	MIMAROPA Region	2021	1502	31	787	723	723000	91.9	80.1	10.8	0.9	6.2	787	787000	737	
43	V	Bicol Region	2021	798	41	1338	1246	1246000	93.1	84.6	7.4	0.3	5.7	1338	1338000	1262	
44	VI	Western Visayas	2021	2467	45	1945	1819	1819000	93.5	86.3	6.7	0.3	5.7	1945	1945000	1853	
45	VII	Central Visayas	2021	2604	65	1970	1830	1830000	92.9	78.9	12.7	0.3	6	1970	1970000	1866	
46	VIII	Eastern Visayas	2021	889	21	1134	1059	1059000	93.5	83.8	7.7	0.4	5.5	1134	1134000	1083	

Sheet3 | FINAL DATA SETS | Population | Sheet5 | Notes | DataSet | Summary | Visualizations | WaterSupply-Sur ...

Preprocessing Steps

2. Handling Missing Values

```python
# Merge the region and province dataframes based on the 'regCode' column
x = gdfphRegion.merge(gdfphProvince, on='regCode', how = 'inner')

# Rename 'provDesc' column to 'NAME_1' for consistency across datasets
x = x.rename(columns = {'provDesc' : 'NAME_1'})

# Merge the geographical data with the province-region data
gpdPhFinal = gdfPh.merge(x, on = 'NAME_1', how = 'inner')

# Map 'RegCode' in the dengue data to corresponding region codes
gdfdengData['RegCode'] = gdfdengData['RegCode'].map(regionCode)

# Rename 'RegCode' column to 'regCode' for consistency with other dataframes
gdfdengData = gdfdengData.rename(columns = {'RegCode' : 'regCode'})

# Ensure 'regCode' in the geographical data is of integer type for accurate merging
gpdPhFinal['regCode'] = gpdPhFinal['regCode'].astype(int)


# Merge the dengue data with the geographical data based on 'regCode'
gpdPhFinal = gpdPhFinal.merge(gdfdengData, on = 'regCode', how = 'inner')

# Map region codes in the merged data to region names for easier identification
gpdPhFinal['Region'] = gpdPhFinal['regCode'].map(regionName)

# Drop unnecessary columns from the data to clean it up
phdataSorted = gpdPhFinal.drop(['GID_1', 'GID_0', 'VARNAME_1',
                                'NL_NAME_1', 'TYPE_1', 'ENGTYPE_1',
```

```python
# Further clean the data by removing columns related to sanitation and water supply
phdataCleaned = phdataSorted.drop(['Sanitation_Basic', 'Sanitation_Limited', 'Sanitation_Unimproved',
                                   'Sanitation_OpenDefecation', 'WaterSupply_Basic',
                                   'WaterSupply_Limited', 'WaterSupply_Unimproved',
                                   'WaterSupply_SurfaceWater','Sanitation_Improved_Percent',
                                   'WaterSupply_Improved_Percent_Service'], axis = 1)

# Filter the cleaned data to create separate dataframes for each year
yearDf2019 = phdataCleaned[(phdataCleaned['Year'] == 2019.0)]
yearDf2020 = phdataCleaned[(phdataCleaned['Year'] == 2020.0)]
yearDf2021 = phdataCleaned[(phdataCleaned['Year'] == 2021.0)]
yearDf2022 = phdataCleaned[(phdataCleaned['Year'] == 2022.0)]

# Aggregate (dissolve) the data by region for each year to sum dengue cases by region
regions_dissolved2019 = yearDf2019.dissolve(by='Region', as_index=False)
regions_dissolved2020 = yearDf2020.dissolve(by='Region', as_index=False)
regions_dissolved2021 = yearDf2021.dissolve(by='Region', as_index=False)
regions_dissolved2022 = yearDf2022.dissolve(by='Region', as_index=False)

# Define custom colormaps for each year
cmap_2019 = mcolors.LinearSegmentedColormap.from_list("cmap_2019", ['#F0F8FF', '#0000FF'])  # Light blue to dark blue for 2019
cmap_2020 = mcolors.LinearSegmentedColormap.from_list("cmap_2020", ['#FFFAF0', '#FF4500'])  # Ivory to red for 2020
cmap_2021 = mcolors.LinearSegmentedColormap.from_list("cmap_2021", ['#F0FFF0', '#006400'])  # Honeydew to dark green for 2021
cmap_2022 = mcolors.LinearSegmentedColormap.from_list("cmap_2022", ['#FAF0E6', '#8B008B'])  # Linen to dark magenta for 2022
```

Preprocessing Steps

3. Weather Data Processing

```
# --- Second Graph: Monthly Climatology ---

# Plotting the second graph (Climate Data)
bars = ax2.bar(tempMonth['Category'], tempMonth['Precipitation'], color='lightblue', alpha=0.6, label='Precipitation')

# Creating the secondary axis for temperature
ax2_twin = ax2.twinx()

# Plotting the line graphs for the different temperature types
line_min = ax2_twin.plot(tempMonth['Category'], tempMonth['Average Minimum Surface Air Temperature'], color='r', marker='o', lab
line_mean = ax2_twin.plot(tempMonth['Category'], tempMonth['Average Mean Surface Air Temperature'], color='g', marker='s', label
line_max = ax2_twin.plot(tempMonth['Category'], tempMonth['Average Maximum Surface Air Temperature'], color='y', marker='^', lab

# Adding labels and title to the second graph
ax2.set_xlabel('Month', fontsize=14, fontweight='bold')
ax2_twin.set_ylabel('Temperature (°C)', fontsize=14, fontweight='bold')
ax2.set_ylabel('Precipitation (mm)', fontsize=14, fontweight='bold')
ax2.set_title('Monthly Climatology of Temperature & Precipitation (1991-2020)', fontsize=16, fontweight='bold')

# Combining the legends into one for the second graph
handles, labels = ax2.get_legend_handles_labels()
handles.extend([line_min[0], line_mean[0], line_max[0]])
labels.extend(['Average Minimum Temperature', 'Average Mean Temperature', 'Average Maximum Temperature'])
ax2.legend(handles, labels, loc='upper left', fontsize=12)

# Displaying the second graph's x-axis with rotated labels
ax2.set_xticks(range(1, 13))
ax2.set_xticklabels(['Jan', 'Feb', 'Mar', 'Apr', 'May', 'Jun', 'Jul', 'Aug', 'Sep', 'Oct', 'Nov', 'Dec'], fontsize=12)
ax2.tick_params(axis='x', rotation=45)
```

Preprocessing Steps

4. Top Cases Preprocessing

```
] # Aggregate the data to ensure unique combinations of Year and Region
  aggregated_data = phdataCleaned.groupby(['Year', 'Region'], as_index=False).agg({'Dengue_Cases': 'sum'})

  # Convert 'Year' to integer to remove the decimal
  aggregated_data['Year'] = aggregated_data['Year'].astype(int)

  # Pivot the data for bar graph
  pivot_data = aggregated_data.pivot(index="Year", columns="Region", values="Dengue_Cases")

  # Plot the bar graph
  pivot_data.plot(kind="bar", figsize=(14, 8), colormap="tab20")

  # Adding labels and title
  plt.xlabel("Year", fontsize=12)
  plt.ylabel("Dengue Cases", fontsize=12)
  plt.title("Dengue Cases by Region (2019-2022)", fontsize=14)

  plt.grid(axis='y', linestyle='--', alpha=0.7)

  # Customizing ticks
  plt.xticks(fontsize=10, rotation=0)
  plt.yticks(fontsize=10)

  plt.tight_layout()

  plt.show()
```

```
# Drop the columns "Date" and "Year"
townCases = townCases.drop(columns=["Date", "Year"])

# Group by unique Region and Town, summing Cases and Deaths
aggregated_townCases_df = (
    townCases.groupby(["Region", "Town"], as_index=False)
    .agg({"Cases": "sum", "Deaths": "sum"})
)

# Top 10 towns with the lowest cases across all regions
top_10_lowest = aggregated_townCases_df.nsmallest(10, "Cases")

# Top 10 towns with the highest cases across all regions
top_10_highest = aggregated_townCases_df.nlargest(10, "Cases")

# Create a figure with two horizontal bar graphs side by side
fig, axes = plt.subplots(1, 2, figsize=(16, 8), sharey=False)

# Plotting the top 10 towns with the lowest cases
axes[0].barh(top_10_lowest["Town"], top_10_lowest["Cases"], color="lightcoral")
axes[0].set_title("Top 10 Towns with the Lowest Dengue Cases (2016-2021)", fontsize=1
axes[0].set_xlabel("Cases", fontsize=12)
axes[0].set_ylabel("Town", fontsize=12)  # Label for the Y-axis on the left graph
axes[0].invert_yaxis()  # Align with the left graph
axes[0].tick_params(axis="y", labelsize=10)
```

Visualizations, & Insights

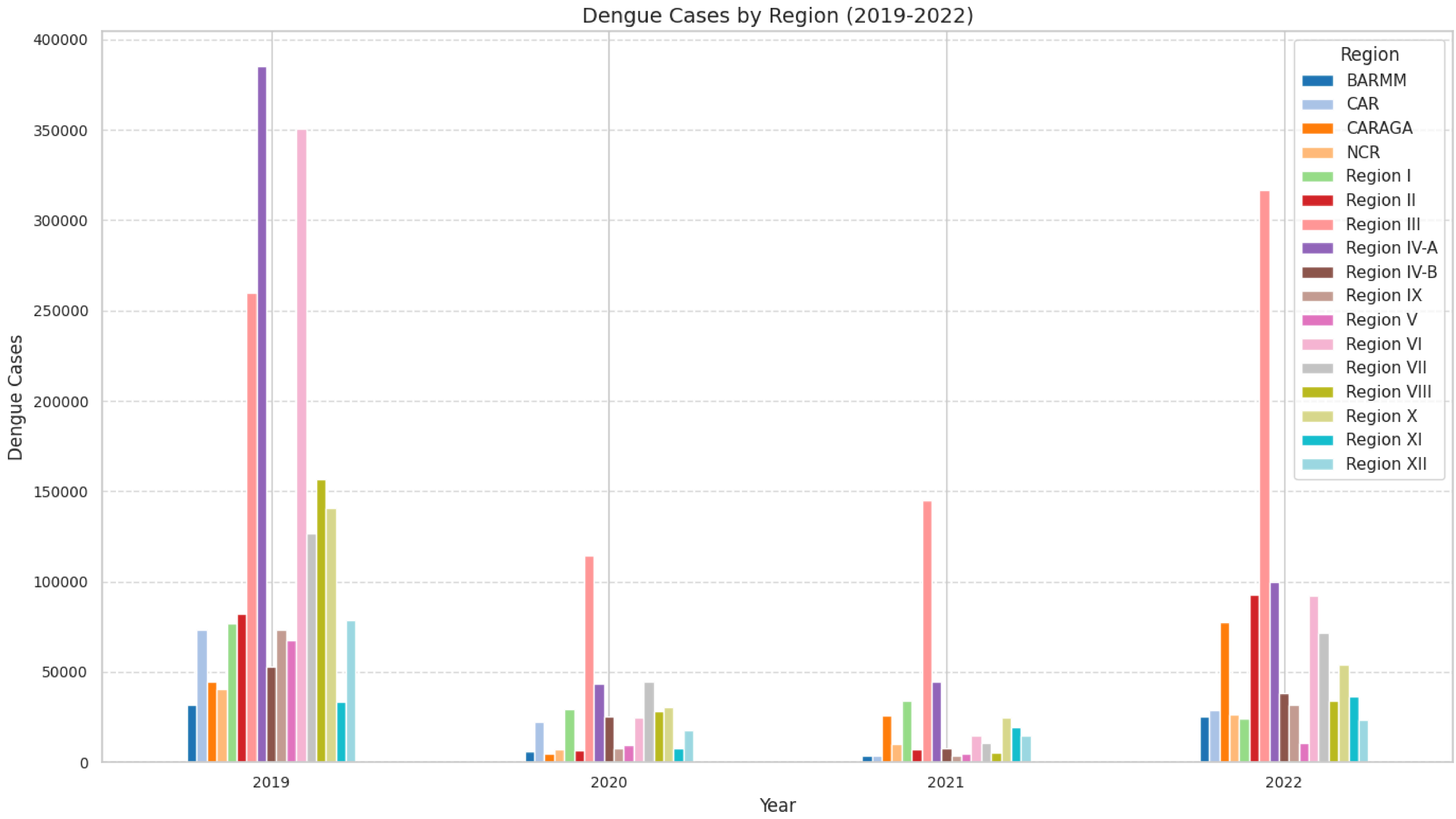


Figure 1. Dengue Cases per Region from 2019-2022

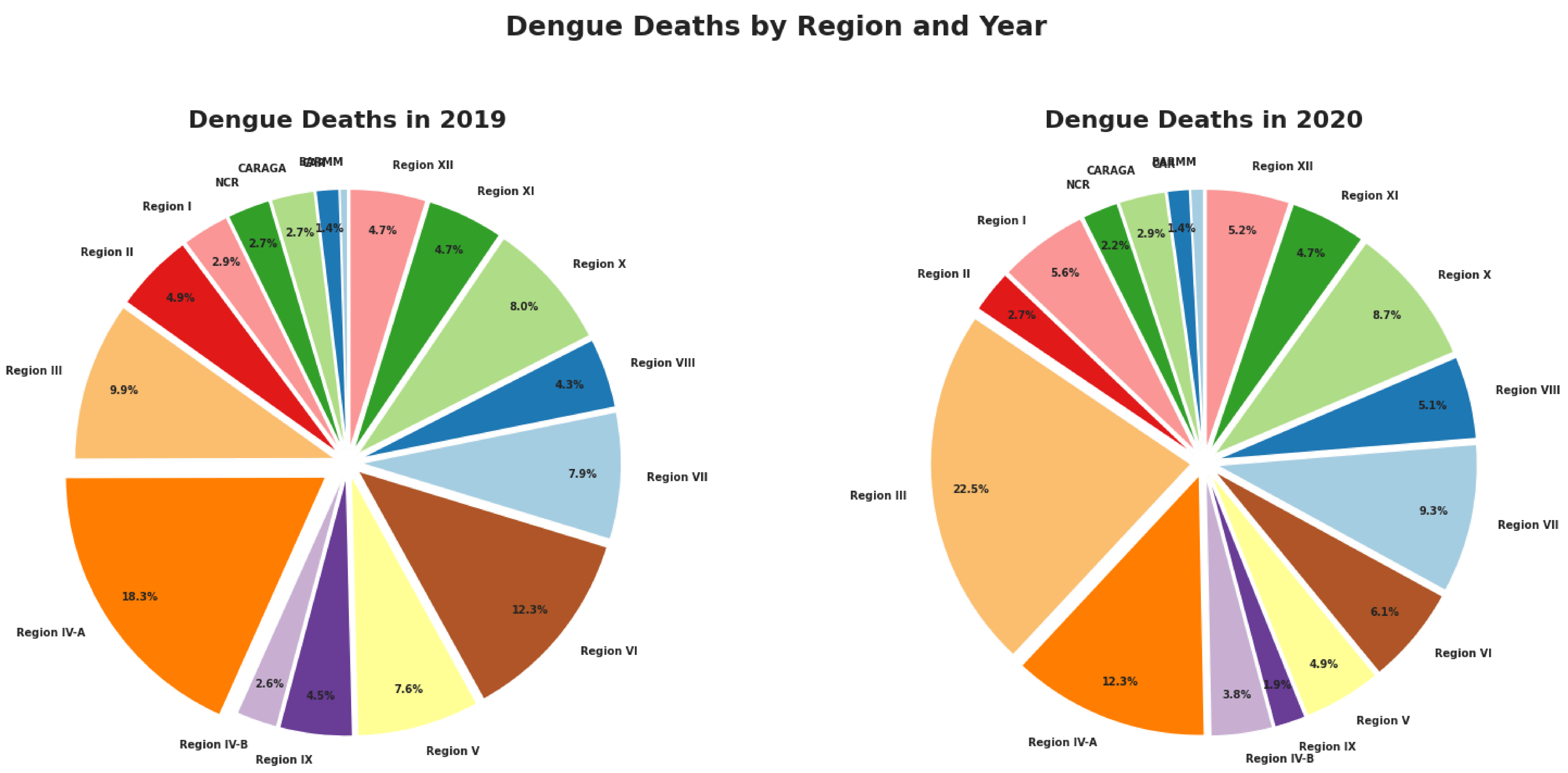


Figure 2. Percentage of Dengue Deaths per Region

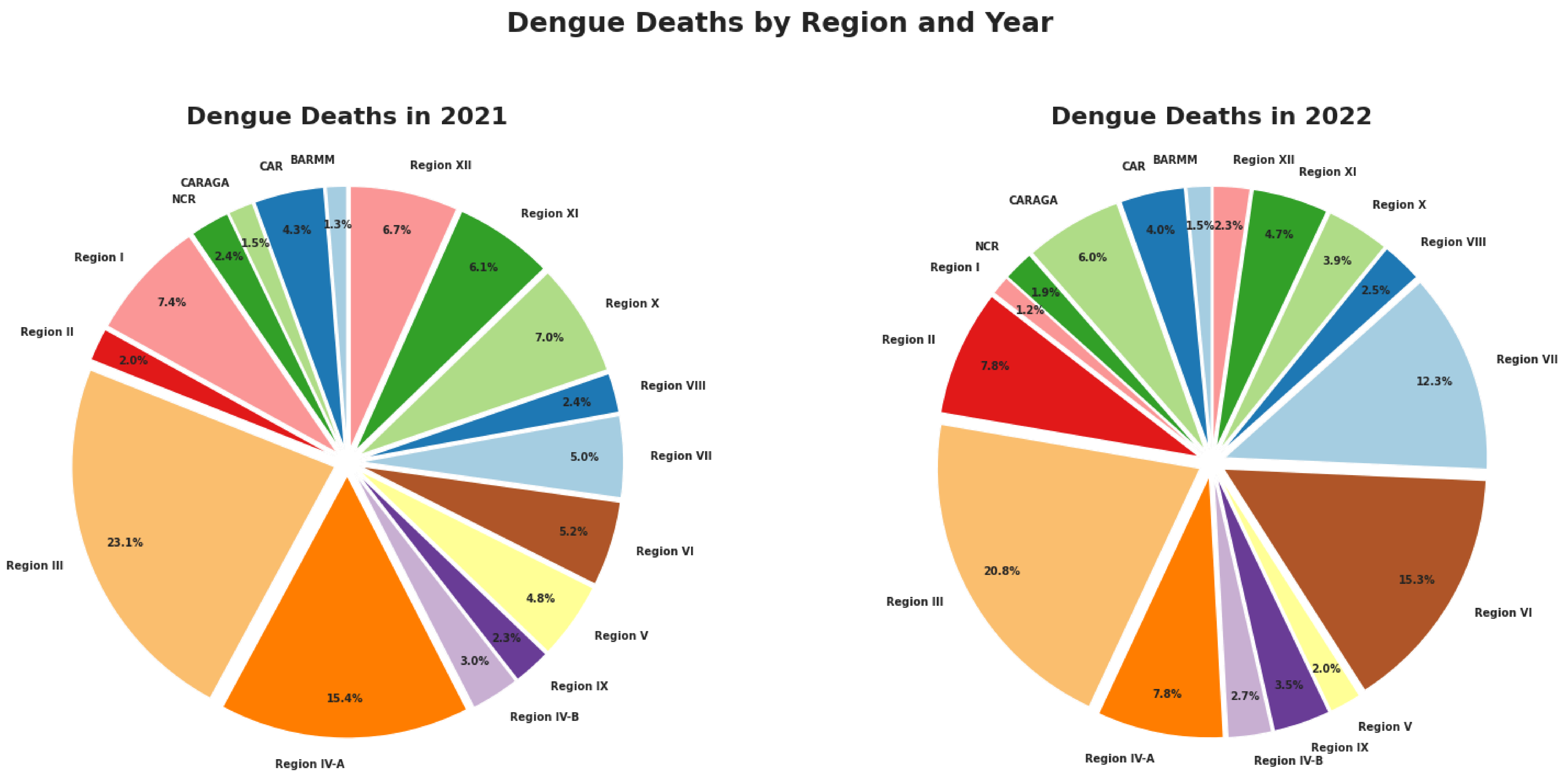


Figure 2. Percentage of Dengue Deaths per Region

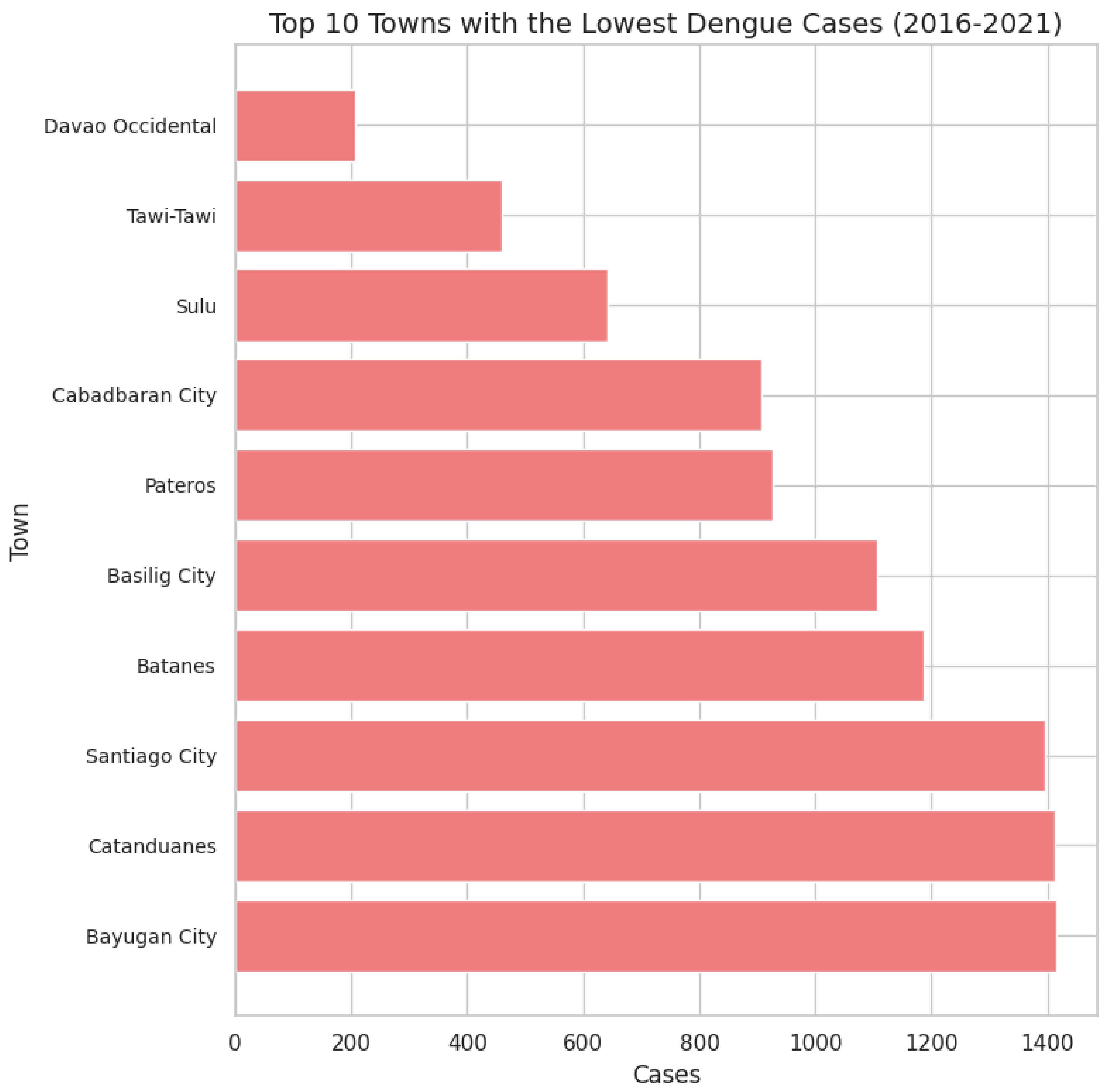


Figure 3. Top 10 Towns/City with the Lowest Total of Dengue Cases from 2016-2021

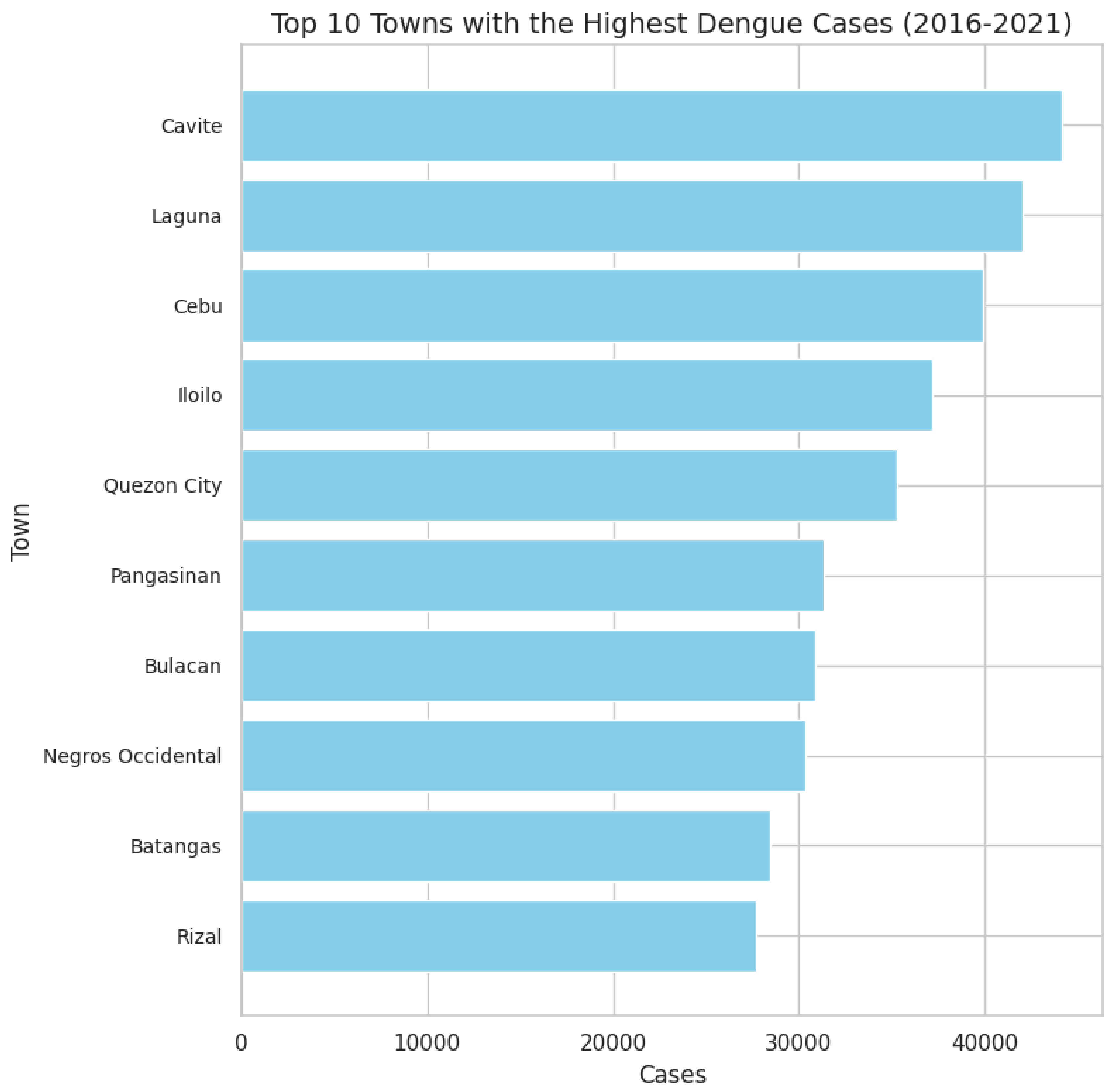


Figure 4. Top 10 Towns/City with the Highest Total of Dengue Cases from 2016-2021

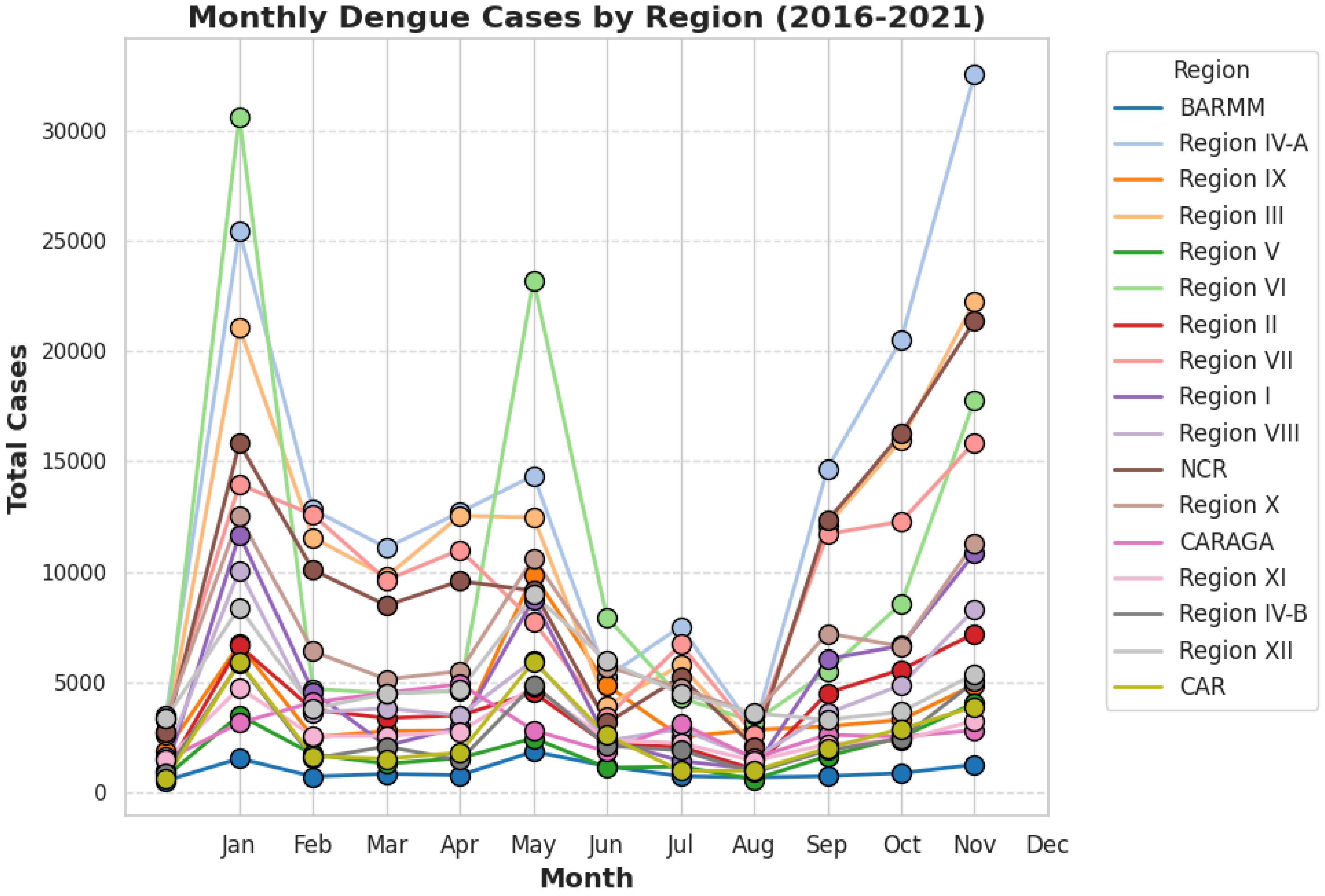


Figure 5. Regional Dengue Cases progression per Month from 2016-2021

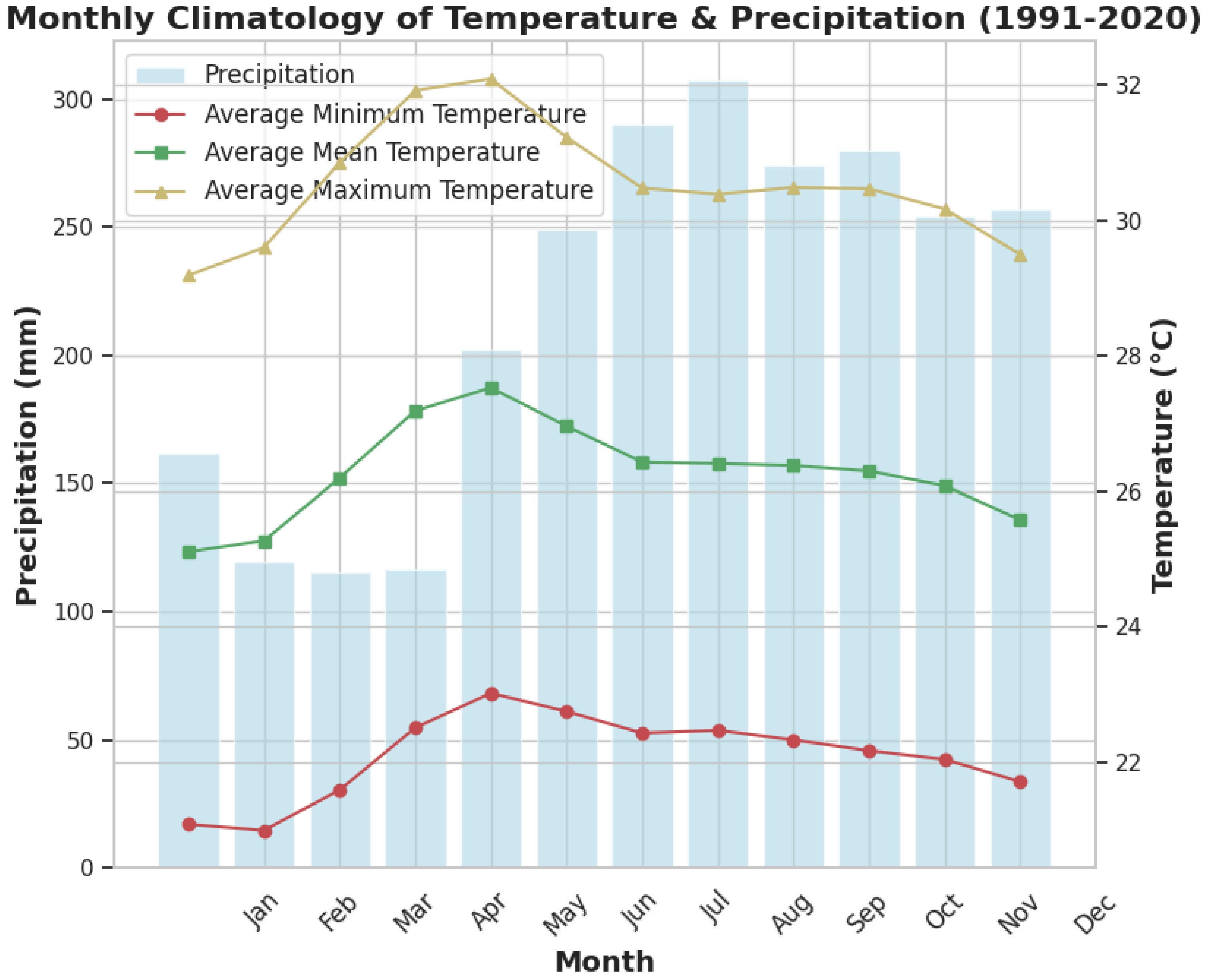


Figure 6. Philippines Monthly Climatology of Temperature & Precipitation from 1991-2020

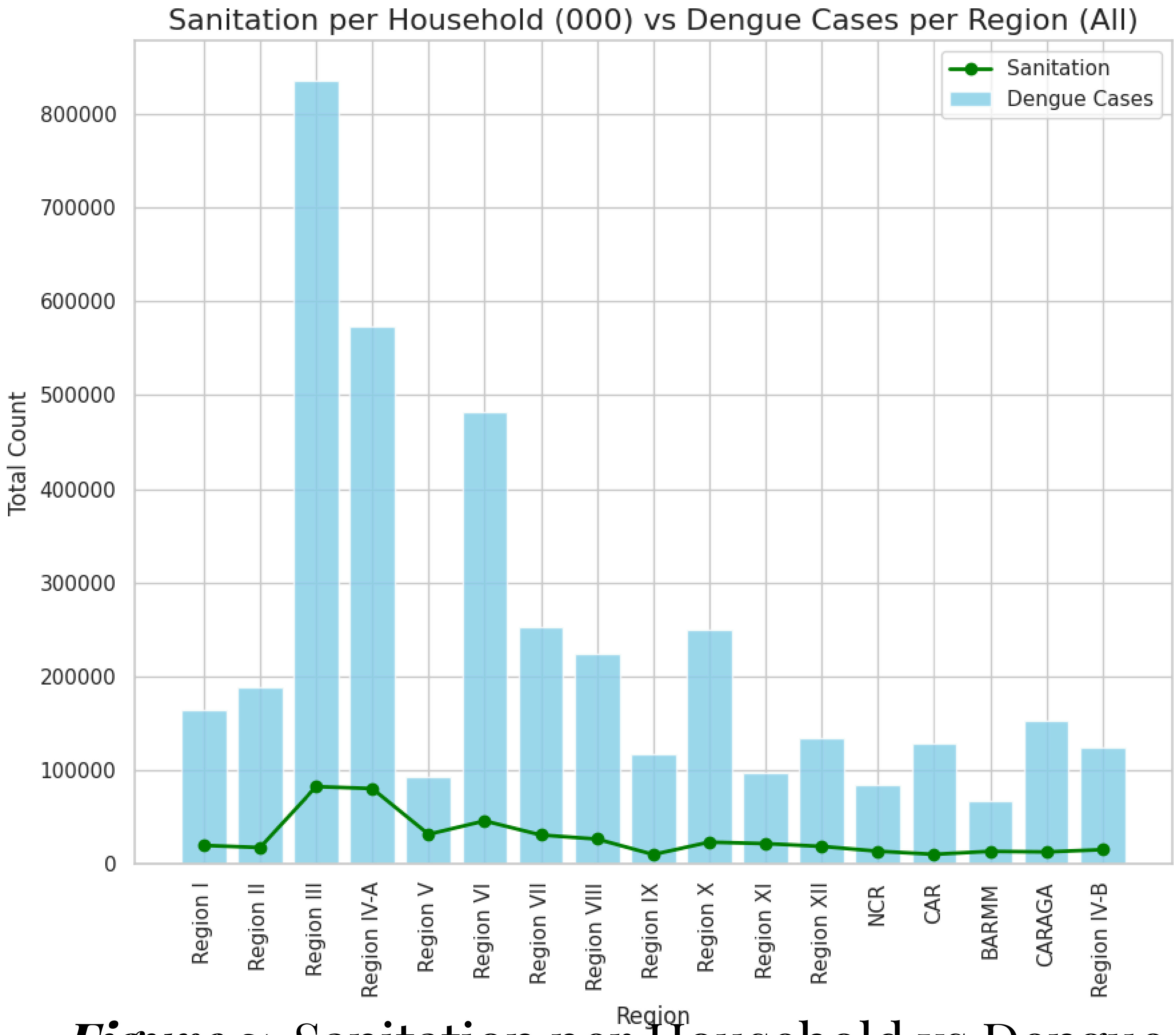


Figure 7. Sanitation per Household vs Dengue Cases per Region

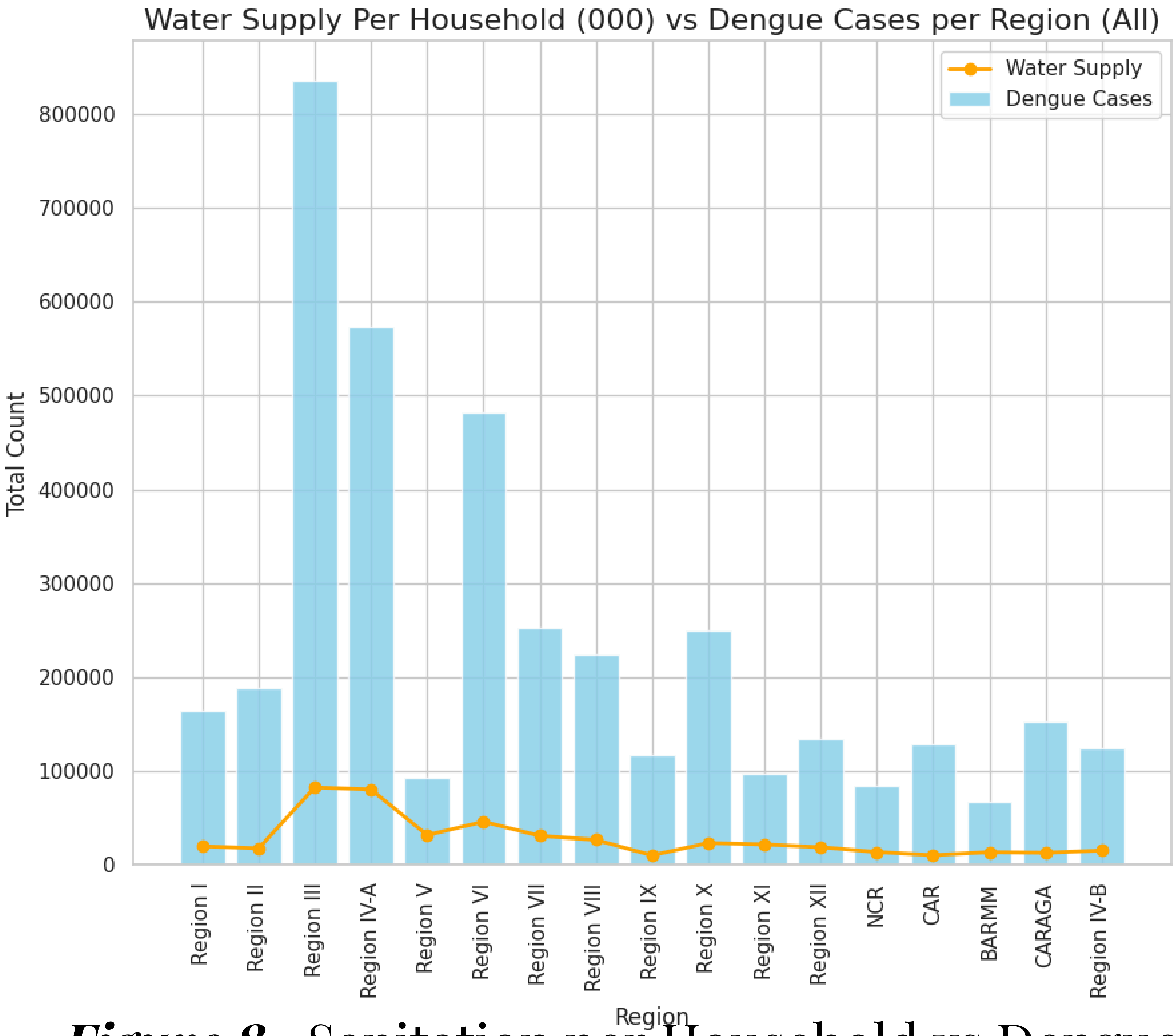
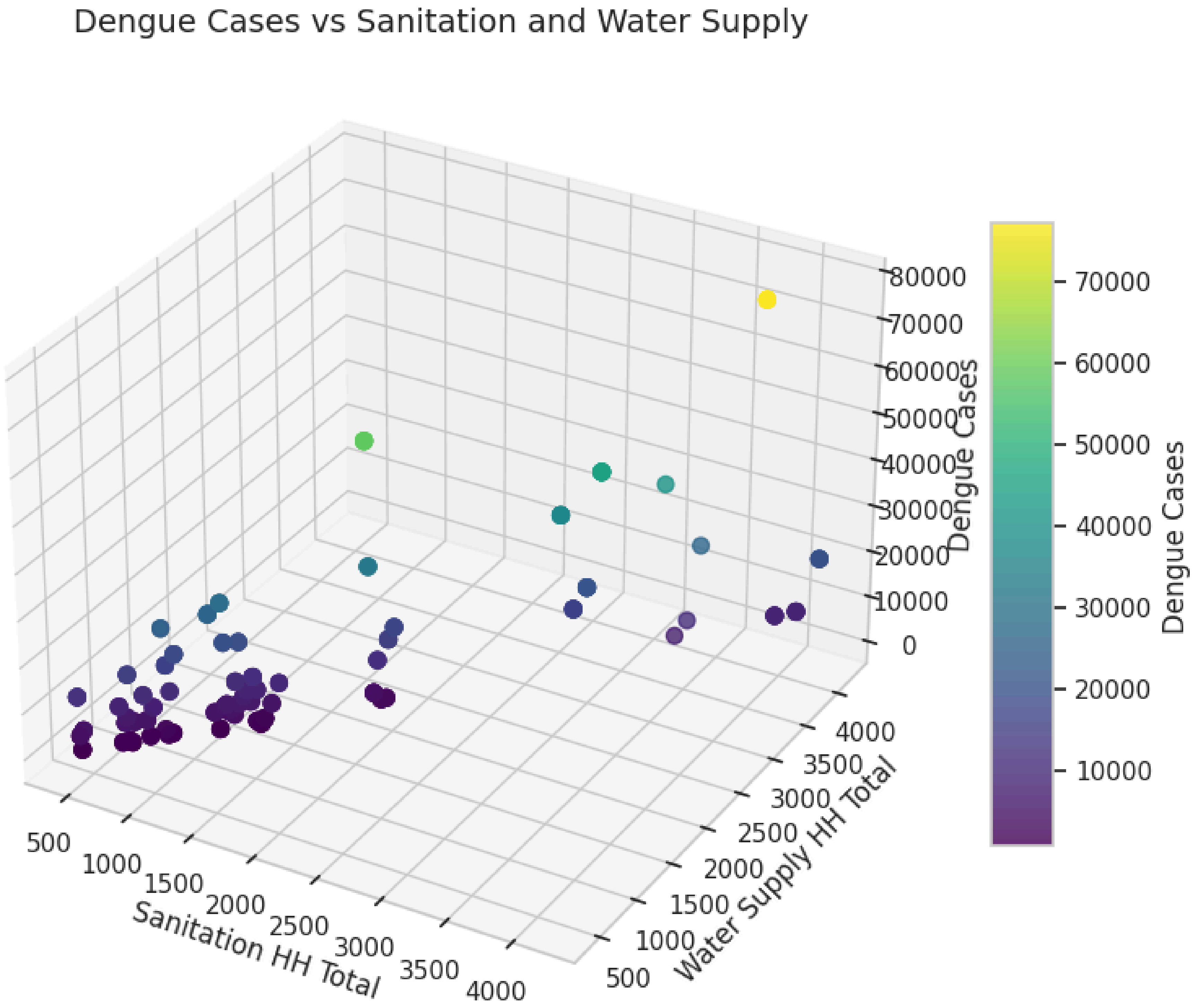
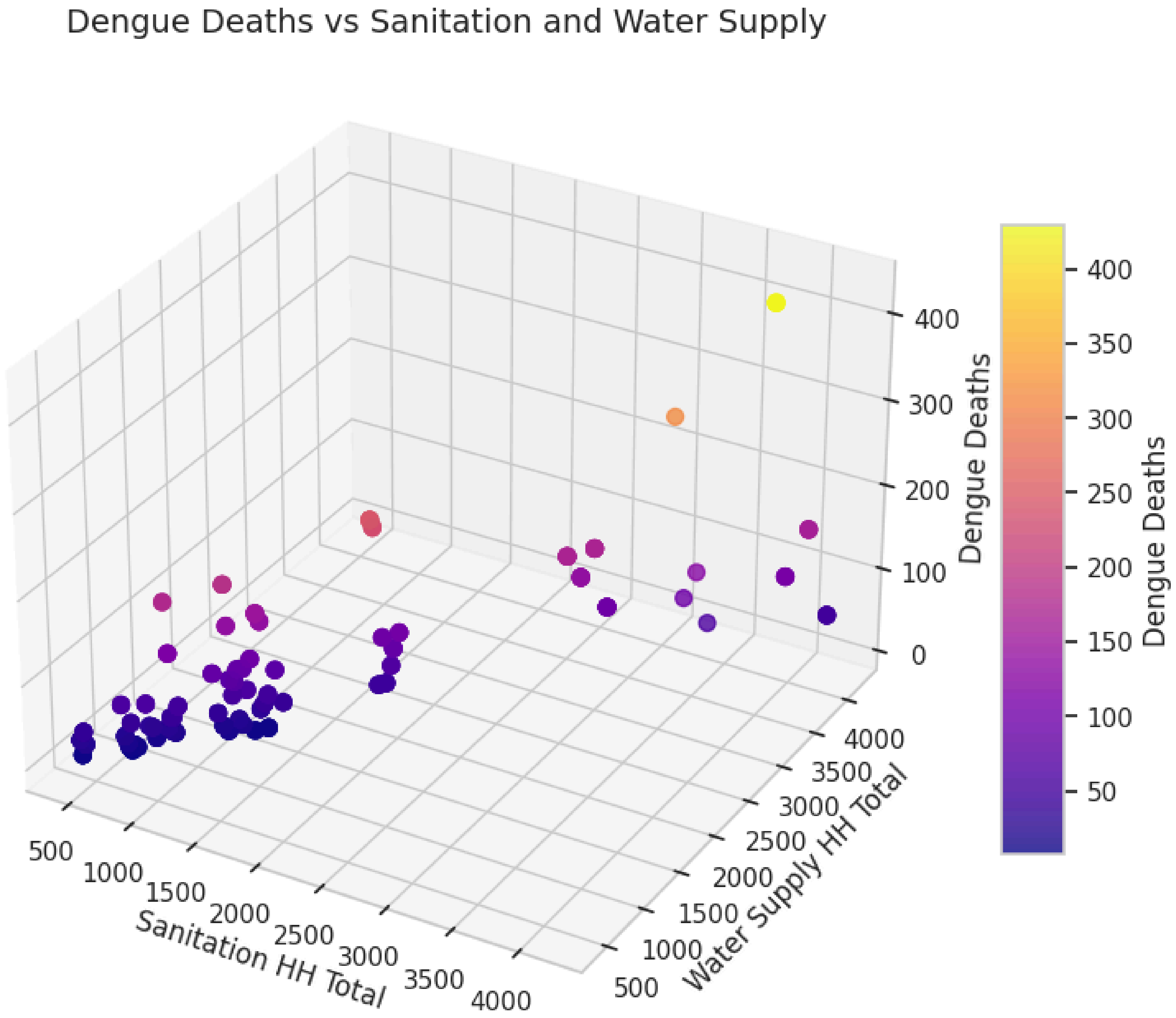
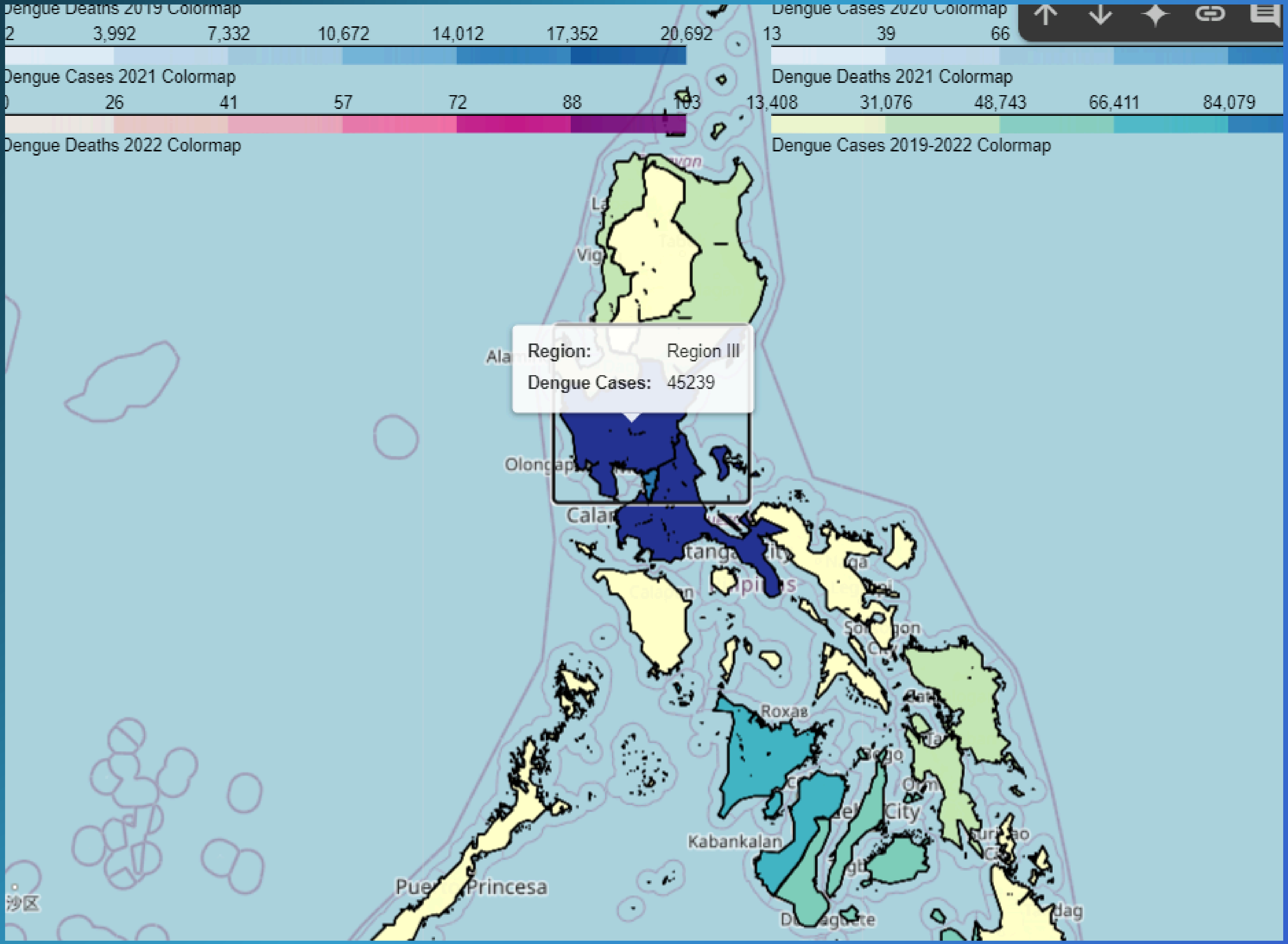


Figure 8. Sanitation per Household vs Dengue Cases per Region

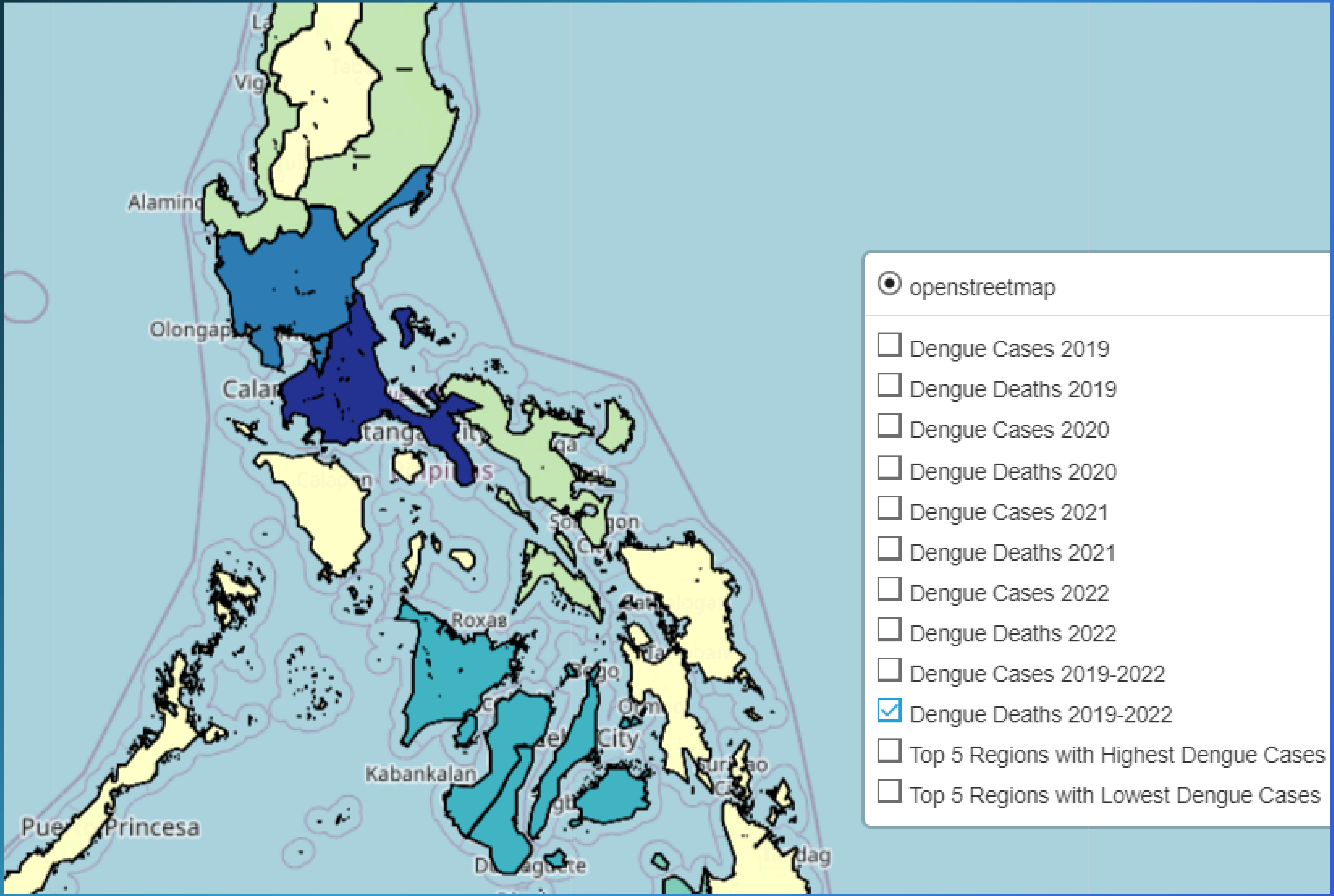

Dengue Cases vs Sanitation and Water Supply
Sanitation HH Total
500
1000
1500
2000
2500
3000
3500
4000
Water Supply HH Total
500
1000
1500
2000
2500
3000
3500
4000
Dengue Cases
0
10000
20000
30000
40000
50000
60000
70000
80000
Dengue Cases
10000
20000
30000
40000
50000
60000
70000


Dengue Deaths vs Sanitation and Water Supply
Sanitation HH Total
500
1000
1500
2000
2500
3000
3500
4000
Water Supply HH Total
500
1000
1500
2000
2500
3000
3500
4000
Dengue Deaths
0
100
200
300
400
Dengue Deaths
50
100
150
200
250
300
350
400



Folium Interactive Maps -

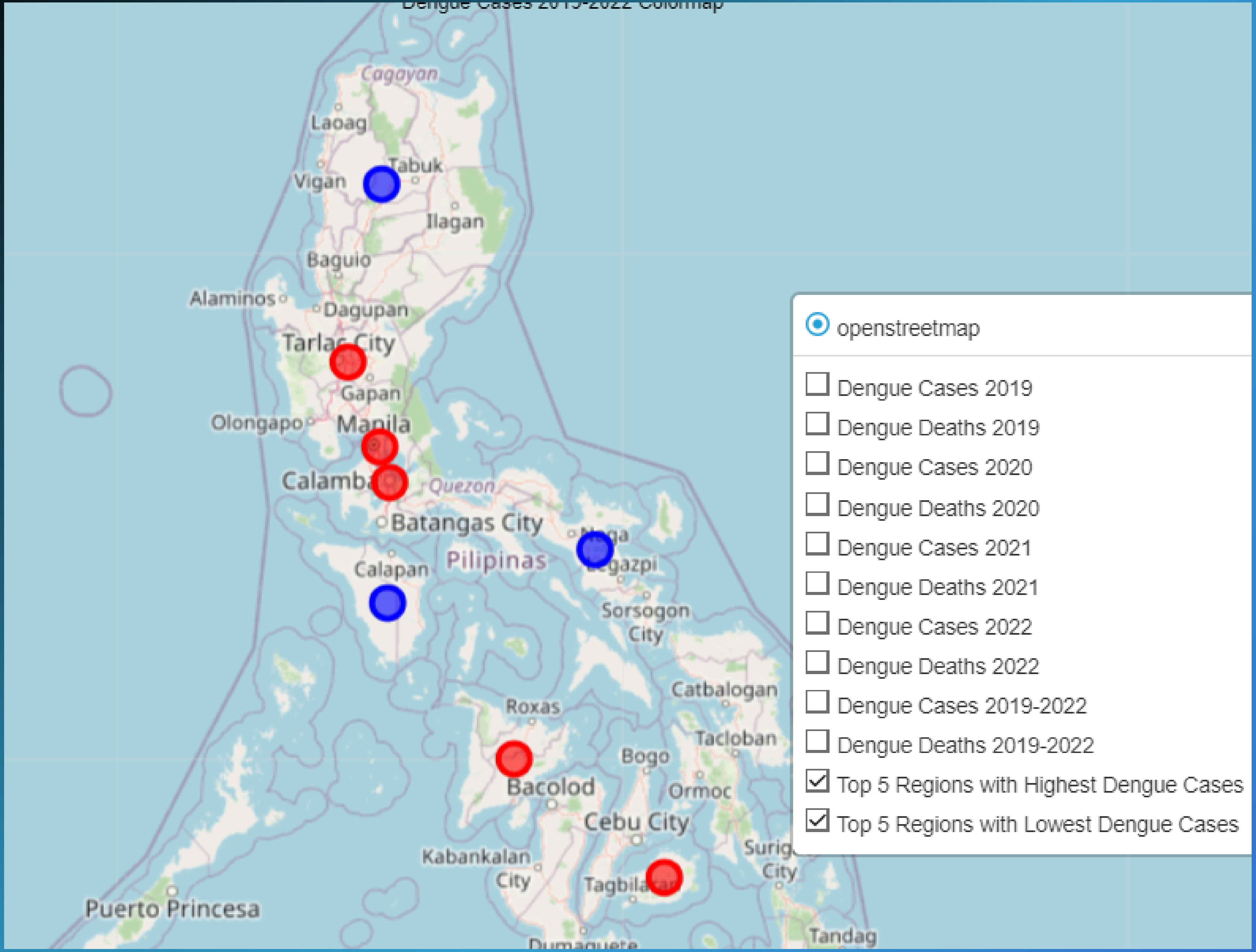
Mapping of Dengue Cases Per Region and Year (2019-2022)



Folium Interactive Maps -

Mapping of Dengue Deaths Per Region and Year

(2019-2022)



Folium Interactive Maps -
Top 5 Regions with the Highest and Lowest Dengue Cases

Results & Discussion

Results & Discussion

- The Top 3 City/Town of those who got the most Dengue Cases from 2016-2021 comes from Cavite, Laguna, and Cebu
- Dengue Cases and Deaths of 2019-2022 are more widespread in Region III, Region IV-A, and Region VI
- Dengue Disease from Years 2016-2021 usually has influx from the months of February, June, and November

Results & Discussion

- When the temperature rises on specific months like February, June, and November there seems to be an influx Dengue contraction.

- Although there is a high level Sanitation per Household in Region IV, Region III, and Region VI dengue is still widespread at their location. Which may be due to the highly urbanized city in this Region.

Results & Discussion

- Having water supply per Household in Region IV, Region III, and Region VI seems to make dengue widespread at their location.

- Due to the highly urbanized cities (in Region IV-A and Region VI) and wide wet farm lands (Region III). Breeds the most mosquitos when the temperature is hot and there is a lot of pollution in the Area.

Conclusions

Dengue cases are most prevalent in Cavite, Laguna, and Cebu, with Regions III, IV-A, and VI showing widespread cases and deaths. Outbreaks peak in February, June, and November, likely due to higher temperatures promoting mosquito breeding. Despite good sanitation levels in these regions, dengue persists, possibly due to urbanization, water supply, and environmental factors. Urbanized cities and wet farmlands create ideal conditions for mosquito breeding, exacerbated by pollution. Addressing these factors is key to controlling the spread of dengue.

Conclusions

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THANK YOU FOR LISTENING!

Link for Python (Google Colab File):
https://colab.research.google.com/drive/1RekrSo8QNSAyqJ5KlCPgonYTN7hEIc7p?usp=sharing

Link for Folium Map & PDF File Download:
https://drive.google.com/drive/folders/1UKKSV25IA934gLa9Xx_c5FYFDKU2n7eH?usp=drive_link

IMPORTANT LINKS: