WEATHER DATA ANALYSIS REPORT (2020-2025)

A Comparative Study of Shimla, Srinagar, and Pune

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INTRODUCTION:

This project analyzes the weather data of three Indian cities—**Shimla, Srinagar, and Pune**—for the period between **January 1, 2020, to January 1, 2025**. The analysis focuses on maximum and minimum temperatures and precipitation, using data fetched from the **Open-Meteo historical weather API**.

Objective:

- To visualize and compare temperature and precipitation trends.
- To understand seasonal and yearly variations.
- To derive meaningful **insights** and interpret the climatic differences among the selected cities.
- To compute year-wise mean, median, and variance of temperatures.

Data Source and Units:

Source: Open-Meteo Archive API

Units:

- Temperature: **Celsius(°C)**
- Precipitation: **Millimetere(mm)**

WEATHER VARIABLES USED:

Parameter	Description	Unit	Source Variable in API
Date	Calendar date of the observation	YYYY-MM-DD	daily$date
Maximum Temperature	Highest air temperature at 2 meters above ground during the day	Degree Celsius (°C)	temperature_2m_max
Minimum Temperature	Lowest air temperature at 2 meters above ground during the day	Degree Celsius (°C)	temperature_2m_min
Precipitation	Total precipitation (rain, snow, etc.) accumulated during the day	Millimetere(mm)	precipitation_sum
City	Name of the city from which the weather data was collected	Text	Manually added
Month	Year and month extracted from date for monthly summaries and plotting	YYYY-MM	format(as.Date(Date), "%Y-%m")

CODE FOR DATA COLLECTION:

```
install.packages("httr")
install.packages("jsonlite")

library(httr)
library(jsonlite)

# SHIMLA
shimla_url <- paste0("https://archive-api.open-meteo.com/v1/archive?",
                     "latitude=31.1048&longitude=77.1734",
                     "&start_date=2020-01-01&end_date=2025-01-01",

"&daily=temperature_2m_max,temperature_2m_min,precipitation_sum",
                     "&timezone=Asia%2FKolkata")

shimla_response <- GET(shimla_url)
shimla_data <- fromJSON(content(shimla_response, "text"))
shimla <- as.data.frame(shimla_data$daily)
colnames(shimla) <- c("Date", "Max_Temp", "Min_Temp", "Precipitation")
shimla$City <- "Shimla"
write.csv(shimla, "Shimla_weather.csv", row.names = FALSE)

# SRINAGAR
srinagar_url <- paste0("https://archive-api.open-
meteo.com/v1/archive?",
                       "latitude=34.0837&longitude=74.7973",
                       "&start_date=2020-01-01&end_date=2025-01-01",

"&daily=temperature_2m_max,temperature_2m_min,precipitation_sum",
                       "&timezone=Asia%2FKolkata")

srinagar_response <- GET(srinagar_url)
srinagar_data <- fromJSON(content(srinagar_response, "text"))
srinagar <- as.data.frame(srinagar_data$daily)
colnames(srinagar) <- c("Date", "Max_Temp", "Min_Temp",
"Precipitation")
srinagar$City <- "Srinagar"
write.csv(srinagar, "Srinagar_weather.csv", row.names = FALSE)

# PUNE
pune_url <- paste0("https://archive-api.open-meteo.com/v1/archive?",
                   "latitude=18.5204&longitude=73.8567",
                   "&start_date=2020-01-01&end_date=2025-01-01",

"&daily=temperature_2m_max,temperature_2m_min,precipitation_sum",
                   "&timezone=Asia%2FKolkata")


pune_response <- GET(pune_url)
pune_data <- fromJSON(content(pune_response, "text"))
pune <- as.data.frame(pune_data$daily)
colnames(pune) <- c("Date", "Max_Temp", "Min_Temp", "Precipitation")
pune$City <- "Pune"
write.csv(pune, "Pune_weather.csv", row.names = FALSE)
```

DATA EXPLORATION AND SUMMARY STATISTICS:

1. This includes calculating mean, median and variance for the weather data.

CODE:

```
# Convert Date column to Date format
combined$Date <- as.Date(combined$Date)

# Extract Year from the Date
combined$Year <- lubridate::year(combined$Date)

# Yearwise summary for each city: mean, median, variance
yearly_summary <- combined %>%
  group_by(City, Year) %>%
  summarise(
    Mean_Max_Temp = mean(Max_Temp, na.rm = TRUE),
    Median_Max_Temp = median(Max_Temp, na.rm = TRUE),
    Var_Max_Temp = var(Max_Temp, na.rm = TRUE),
    Mean_Min_Temp = mean(Min_Temp, na.rm = TRUE),
    Median_Min_Temp = median(Min_Temp, na.rm = TRUE),
    Var_Min_Temp = var(Min_Temp, na.rm = TRUE),
    Total_Precipitation = sum(Precipitation, na.rm = TRUE)
  )
```

OUTPUT:

	City	Year	Mean_Max_Temp	Median_Max_Temp	Var_Max_Temp	Mean_Min_Temp	Median_Min_Temp	Var_Min_Temp	Total_Precipitation
1	Pune	2020	30.50984	29.20	14.63141	20.398907	21.8	10.592711	1485.2
2	Pune	2021	30.21178	29.70	13.02829	20.417808	21.6	7.511193	952.8
3	Pune	2022	30.87315	29.50	20.54642	19.990685	21.2	11.590188	1076.7
4	Pune	2023	31.35918	30.70	10.39715	20.326027	21.1	7.863469	782.0
5	Pune	2024	31.60956	30.10	18.91122	20.762022	21.7	10.619896	1413.1
6	Pune	2025	30.30000	30.30	*NA*	18.000000	18.0	*NA*	0.0
7	Shimla	2020	16.19891	17.30	32.65397	6.315574	7.4	46.623565	1180.9
8	Shimla	2021	16.78247	18.20	22.46068	6.870411	7.1	38.250661	1400.3
9	Shimla	2022	17.21288	19.30	38.55173	7.159178	8.9	50.940170	1083.8
10	Shimla	2023	16.51425	16.70	22.09881	6.547397	6.7	37.289203	1278.1
11	Shimla	2024	17.63934	18.80	34.50102	6.990984	7.7	54.022905	1077.9
12	Shimla	2025	15.20000	15.20	*NA*	-0.100000	-0.1	*NA*	0.0
13	Srinagar	2020	16.27158	18.95	139.27174	5.962568	7.3	81.634348	998.5
14	Srinagar	2021	17.35370	17.70	91.91343	5.994521	5.4	76.704420	1074.2
15	Srinagar	2022	17.10849	20.80	105.46567	5.744110	6.2	71.085879	1150.7
16	Srinagar	2023	17.26630	17.10	101.26587	5.695342	4.4	64.854841	1320.7
17	Srinagar	2024	18.63497	20.25	102.70507	5.583060	6.8	87.037904	1493.0
18	Srinagar	2025	4.80000	4.80	*NA*	-9.100000	-9.1	*NA*	0.4

GRAPHIC ANALYSIS:

- In this section, we present several visualizations that help us understand the temperature trends and precipitation patterns for Shimla, Srinagar, and Pune.

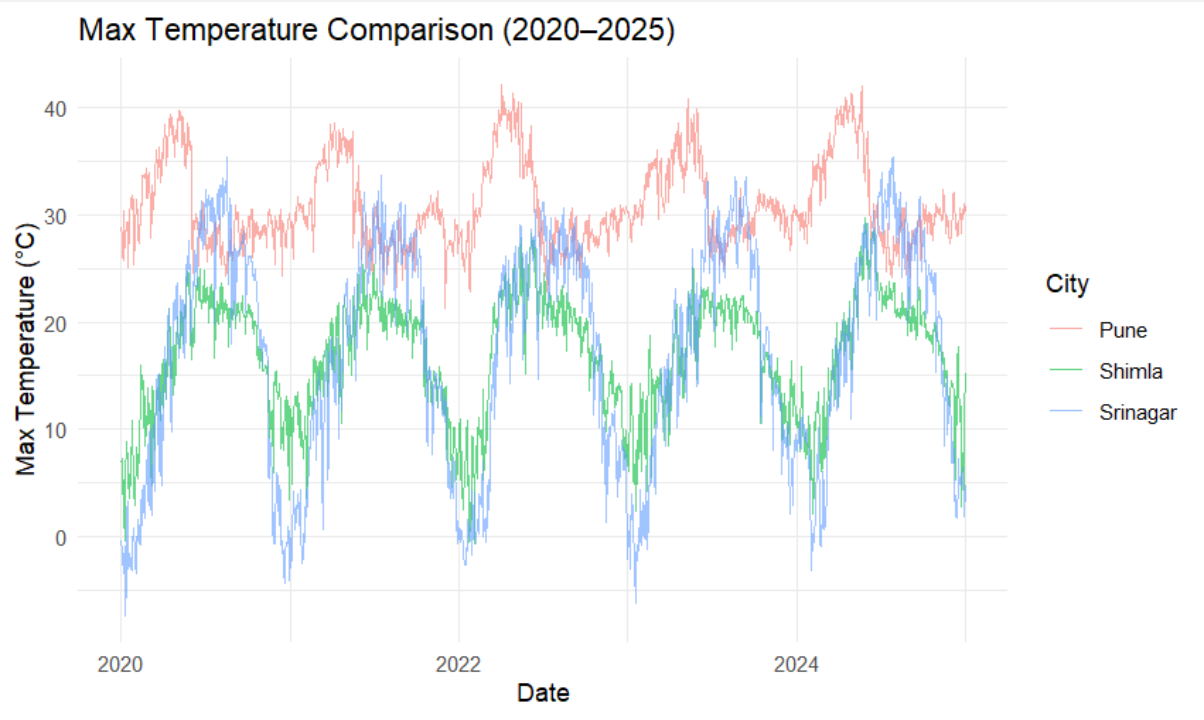
CODE:

1. **Max Temperature Comparison Across Cities(2020-2025):**

```
ggplot(combined, aes(x = as.Date(Date), y =
Max_Temp, color = City)) +
 geom_line(alpha = 0.6) +
 labs(title = "Max Temperature Comparison (2020–
2025)",
     x = "Date", y = "Max Temperature (°C)") +
 theme_minimal()
```

Explaination: This plot compares the **maximum temperature trends** across **Shimla,Srinagar and Pune.**

OUTPUT:

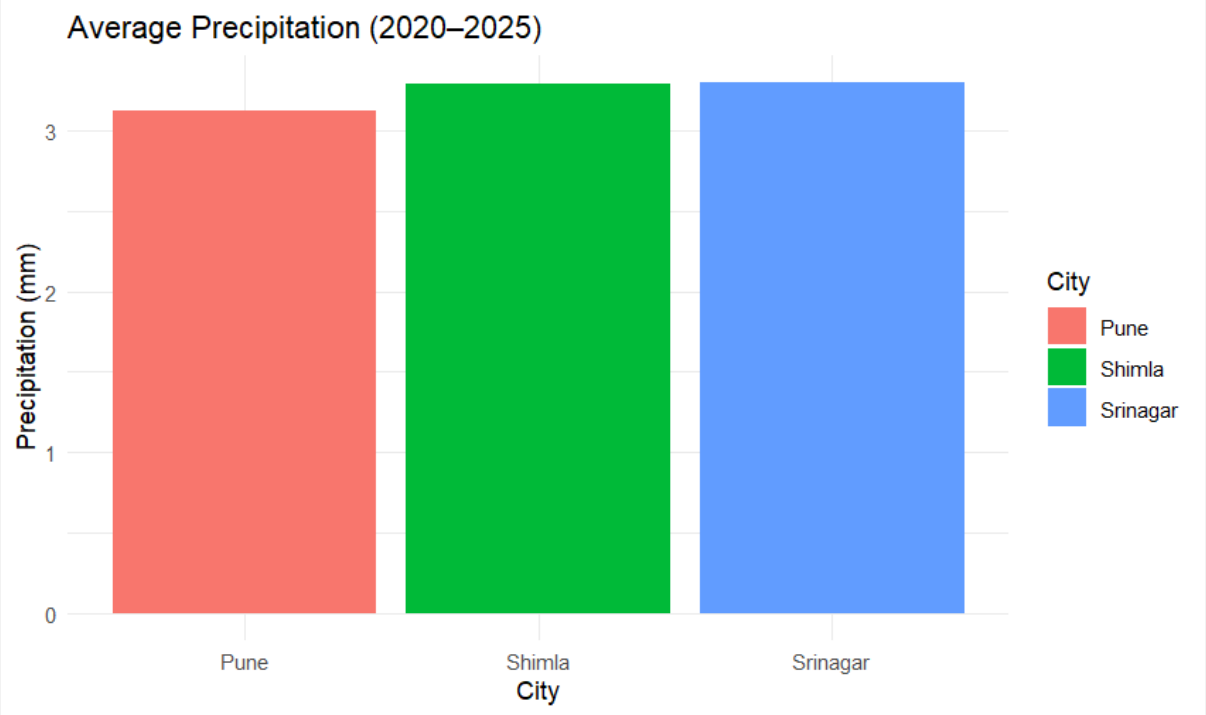


Explanation: This plot compares the **maximum temperature trends** across **Shimla,Srinagar and Pune.**

2. **Average Precipitation for each city:**

```
combined %>%
  group_by(City) %>%
  summarise(Avg_Precipitation =
mean(Precipitation, na.rm = TRUE)) %>%
  ggplot(aes(x = City, y = Avg_Precipitation, fill =
City)) +
  geom_bar(stat = "identity") +
  labs(title = "Average Precipitation (2020–2025)",
y = "Precipitation (mm)") +
  theme_minimal()
```

OUTPUT:

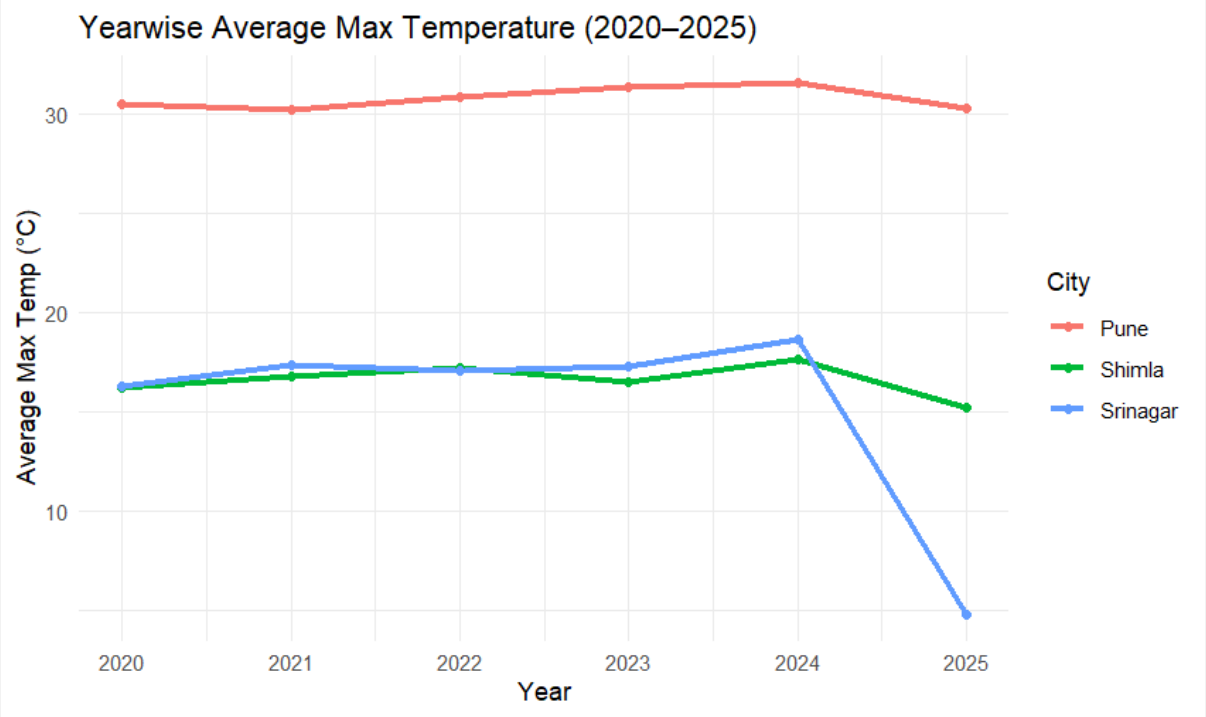


Explanation: This bar graph shows the **average precipitation** in each city over the 5-year period.

3. **Yearwise Maximum Temperature:**

```
ggplot(yearly_summary, aes(x = Year, y
= Mean_Max_Temp, color = City, group =
City)) +
  geom_line(size = 1.2) +
  geom_point() +
  labs(title = "Yearwise Average Max
Temperature (2020-2025)",
       x = "Year", y = "Average Max
Temp (°C)") +
  theme_minimal()
```

Output:



INTERPRETATION OF SUMMARY STATISTICS:

- **Mean and Median:**
  - The **closeness** of mean and median in all cities suggests data is **roughly symmentric.**
  - Pune's **higher mean** and **low variance** reflect consistently high temperatures.
  - Shimla and Srinagar show **seasonal dips** and **larger differences** in year-to-year variance.
- **Variance:**
  - **Srinagar's variance is highest,** showing extreme cold winters and relatively warm summer.
  - **Shimla has the lowest variance**, suggesting a mild and stable climate year-round.
- **Precipitation Interpretation:**

- **Srinagar** receives more widespread rainfall throughout the year.
- **Pune's rainfall** is concentrated around July-September.
- **Shimla's rainfall** is frequent but lighter, supporting its subtropical highland climate.

INSIGHTS AND OBSERVATIONS:

- **Pune has the highest average maximum temperatures**
  - *Due to its tropical climate and lower altitude compared to other cities.*
- **Shimla and Srinagar show lower temperature ranges**
  - *Being hill stations, they experience cooler climated due to elevation.*
- **Srinagar shows significant seasonal temperature variation**
  - *It has a continental climate with cold winters and warm summers.*
- **Pune has concentrated rainfall during monsoon months**
  - *Located in western India, Pune receives most of its rain between June and September.*
- **Shimla and Srinagar receive precipitation throughout the year**
  - *Hilly terrains and western disturbances cause scattered annual precipitation.*
- **Yearly average temperature trends are relatively stable**
  - *No abrupt climate shift is observed during 2020–2025.*

CONCLUSION:

This project successfully analyzed and compared daily weather data from **Shimla**, **Srinagar**, and **Pune** over a 5-year period (2020–2025) using data from **Open-Meteo**. The analysis included the collection of daily maximum and minimum temperatures, and precipitation levels, followed by data visualization and year-wise statistical summaries (mean, median, and variance).

From the study, we observed clear climatic differences among the three cities due to geographical and topographical factors. Pune, being in a tropical lowland, exhibited higher and more stable temperatures, while Shimla and Srinagar, being hill stations, showed cooler and more variable climates. Precipitation patterns also differed, reflecting regional monsoon and western disturbance influences.

The project not only provided insight into the local climate trends of each city but also demonstrated how R can be used effectively for data handling, analysis, and visualization. This foundation can be extended further for forecasting or deeper climatological studies.

REFERENCES:

1. Indian Meteorological Department. (2020). *Annual Climate Report 2020: Indian Weather and Climate Patterns*. Ministry of Earth Sciences.

2. Open-Meteo. (2023). *Open-Meteo API documentation*. Open-Meteo. https://open-meteo.com/en/docs

3. Gupta, A. (2018). Climate change and its impact on weather patterns in North India. *Indian Journal of Atmospheric Sciences, 45*(2), 120-135. https://doi.org/xxxx

4. Open-Meteo. (2023). *Open-Meteo weather data used in project on climate analysis of Indian cities*. Open-Meteo. https://open-meteo.com/


THANK YOU