

# **ANALYSING SATELLITE DATA ON FIRE INCIDENTS IN PUNJAB AND HARYANA AND ITS IMPACT ON DELHI'S AIR HEALTH**



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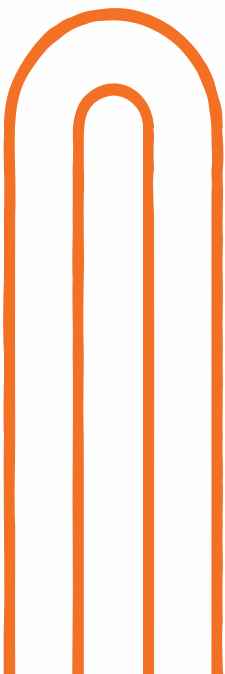
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## SUGGESTED CITATION

Balyan, Palak. (2024). Tracking Fire incident by using satellite for Punjab and Haryana and AQI variation in NCR cities. Climate Trends.



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## Executive Summary:

From 2019 to 2023, both Haryana and Punjab experienced fluctuations in fire incidents, with notable reductions in 2022 and 2023. Haryana's fire counts dropped from 14,122 in 2019 to 7,959 in 2023, with fire activity consistently higher from September to December, though the last four months saw a 48% reduction over five years. Punjab followed a similar trend, with fires peaking at 95,048 in 2020 and decreasing to 52,722 in 2023, but the post-monsoon period remains the most fire prone.

Delhi's air quality was significantly impacted by these fire incidents. On days without fires, the city's AQI averaged 175 ("Moderate"). However, during the same stubble burning season, AQI increased to 233 ("Poor"), and on days when fires exceeded climatological averages, AQI spiked to 337 ("Very Poor"). Fire incident in Punjab and Haryana contributed to a 103-unit increase in Delhi's AQI, underscoring the urgent need for coordinated fire management and air quality interventions across states.

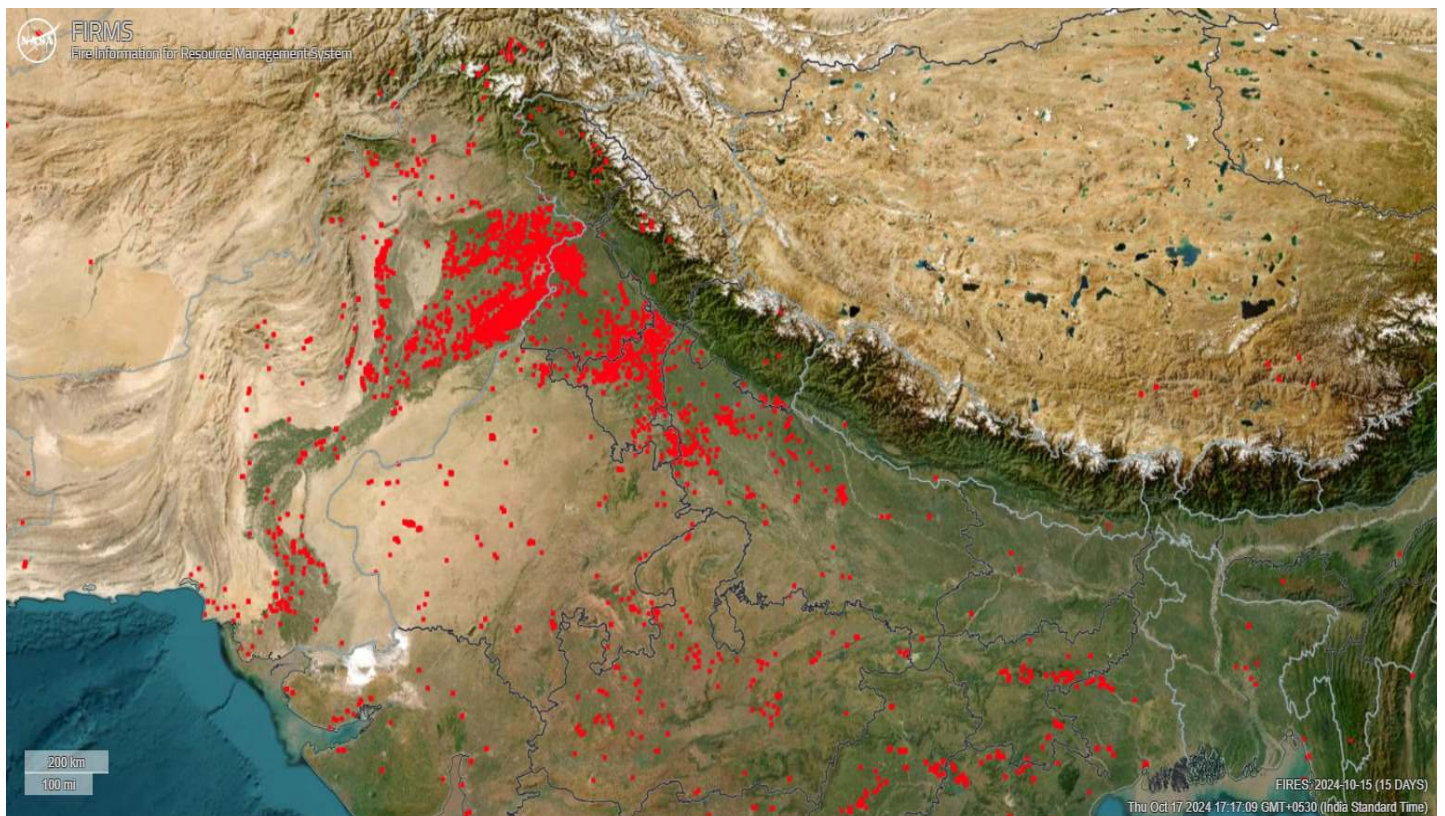
## Background:

Fire incidents and air quality are pivotal environmental factors that impact human health, ecosystems, and regional climate. The use of satellite data to monitor fire incidents and analyse Air Quality Index (AQI) variations provides valuable insights for environmental management and public health. This study employs VIIRS S-NPP (Visible Infrared Imaging Radiometer Suite - Suomi National Polar-orbiting Partnership) 375-meter fire data to track fire incidents, alongside AQI data for NCR cities, over the period from September 1 to December 31 for the years 2019 to 2023.

## Methodology:

### Fire Incident Tracking Using VIIRS S-NPP Data

The Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (S-NPP) satellite offers advanced capabilities for detecting and monitoring fire incidents. VIIRS provides high-resolution fire data with a spatial resolution of 375 meters, which allows for precise detection of active fire locations and intensity. The data is derived from thermal infrared measurements, enabling the identification of fires even through cloud cover and in various lighting conditions. By analysing fire incidents from September 1 to December 31 across the years 2019 to 2023, the study aims to capture seasonal variations and long-term trends in fire activity. This period encompasses critical months in the Indian subcontinent, where climatic transitions and agricultural practices, such as stubble burning, can significantly influence fire patterns.



**Figure-1:** Showing Fire incident of between 1-Oct to 15th Oct,2024 in the Punjab and Hayana region.

## Air Quality Index (AQI) Variation in NCR Cities

The National Capital Region (NCR) of India, including major cities like Delhi, Gurgaon, Noida, and Faridabad, faces significant air quality challenges. The AQI provides a composite measure of air pollution based on various pollutants, including particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), nitrogen dioxide (NO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>), carbon monoxide (CO), and ozone (O<sub>3</sub>). The Central Pollution Control Board (CPCB), Government of India releases daily AQI bulletin displaying the AQI status for all the cities with operational Continuous Ambient Air Quality Monitoring Station (CAAQMS). The bulletin is revised on daily basis in the CPCB website after 4.00 PM. We selected the 11 cities which are Ambala, Agra, Chandigarh, Delhi, Faridabad, Ghaziabad, Gurugram, Hisar, Noida, Rohtak and Sonipat.

The study period from September 1 to December 31 is particularly relevant for AQI analysis as it includes the transition from the monsoon season to winter. During this time, NCR cities often experience increased pollution levels due to factors such as vehicular emissions, industrial activities, and agricultural practices, including stubble burning in neighbouring regions.

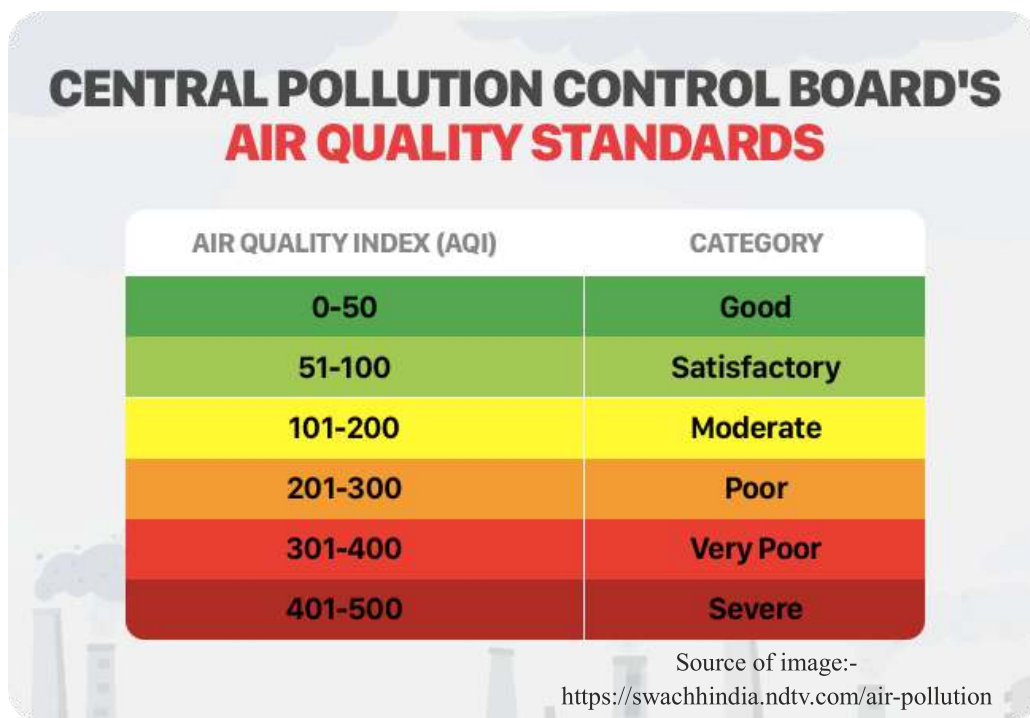


Figure-2: Showing AQI range and category.

## Result:

### Percentage of Days according to Air Quality Index in NCR Cities from 2019 to 2023:

From September to December each year between 2019 and 2023, air quality trends in Agra, Delhi, Faridabad, Ghaziabad, and Gurugram reveal a general decline in air quality. In Agra, the number of "Good" AQI days decreased by approximately 79%, from 19 days in 2019 to just 4 days in 2023, while "Satisfactory" days increased by about 91%, from 35 to 67, indicating some improvement despite fluctuations in "Poor" and "Very Poor" days. Delhi consistently faced high pollution levels, with "Very Poor" days increasing by 55% from 29 in 2019 to 45 in 2023, and "Severe" days fluctuating, showing persistent air quality challenges. In Faridabad, "Poor" AQI days rose by approximately 43%, from 28 in 2019 to 40 in 2023, while "Good" AQI days decreased by about 92%. Ghaziabad saw a rise of around 86% in "Poor" AQI days from 22 in 2019 to 41 in 2023, with a notable decrease of 100% in "Good" days. Gurugram experienced a decrease in "Good" days by about 100%, and an increase in "Mode" AQI days by approximately 55%, with fluctuating levels in "Poor" and "Very Poor" categories. Overall, the data reflects a trend of worsening air quality across these cities during the last quarter of each year.

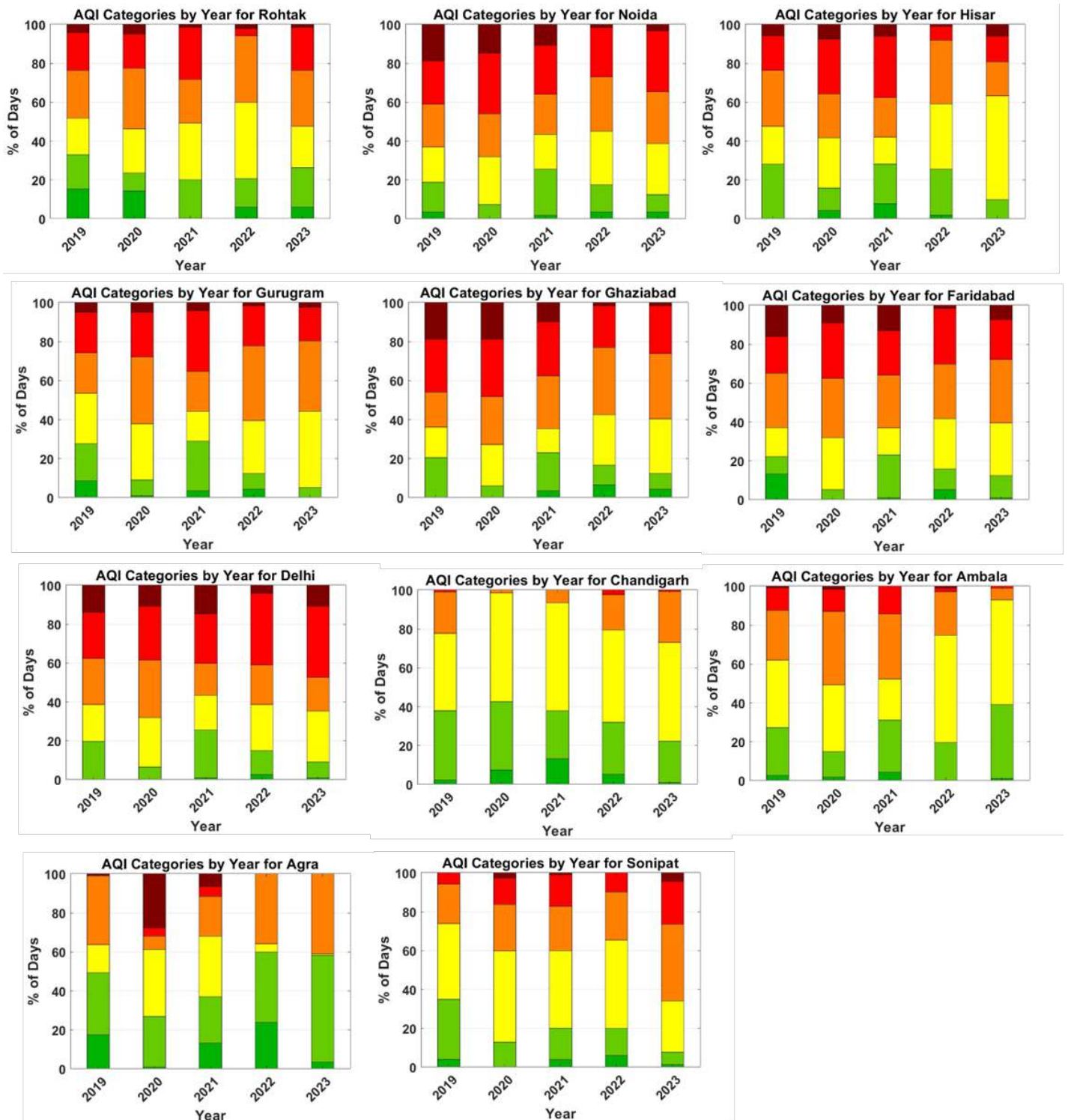


Figure-3: Percentage of days in AQI variations of 11 cities of NCR during Sep to Dec from 2019 to 2023.

### Fire count based on District in Haryana and Punjab:

#### For Haryana:

From 2019 to 2023, Haryana's districts exhibited varied trends in fire counts from September to December. Ambala experienced a decrease of about 37%, indicating reduced fire activity. Bhiwani and Faridabad saw significant increases of 75% and 76%, respectively, suggesting a notable rise in incidents. Fatehabad also had a reduction of around 44%, while Gurgaon experienced a dramatic 275% increase, reflecting a substantial rise in fire activity. Hisar and Jhajjar showed increases of 71% and 365%, respectively, highlighting marked surges in fire counts. Conversely, Kaithal and Karnal saw substantial reductions of 78% and 86%, respectively, indicating major decreases in fire incidents. Kurukshetra's fire counts dropped by 74%, and Yamunanagar experienced a decrease of about 49%. In contrast, Jind had a moderate decrease of 19%, and Mewat saw a dramatic 1100% increase, pointing to a significant rise in fire incidents. Overall, these changes underscore a complex pattern of fluctuating fire activity across Haryana's districts.

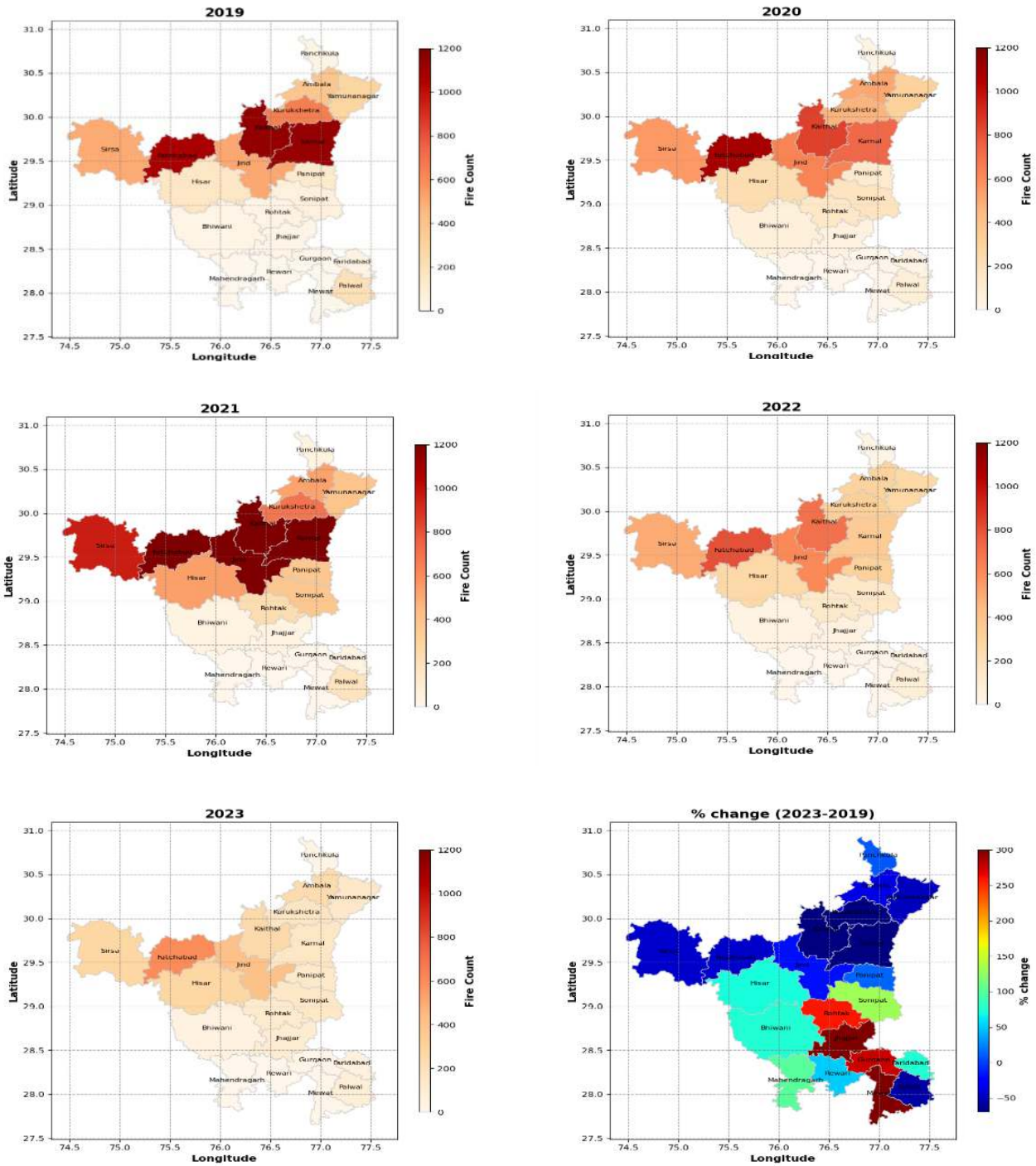


Figure-4: District wise Fire Count of Haryana during Sep to Dec.

**Key highlights from the fire counts in Haryana from September to December between 2019 and 2023 are:**

- Jhajjar experienced the most dramatic increase, with fire counts rising by about 365%, indicating a significant surge in fire activity.
- Gurgaon and Mehat saw substantial increases of 275% and 1100%, respectively, reflecting notable rises in fire incidents.
- Karnal and Kaithal had significant decreases of approximately 86% and 78%, respectively, showing major reductions in fire activity.

**For Punjab:**

From 2019 to 2023, Punjab exhibited a general trend of reduced fire activity across most districts during September to December. Significant reductions were observed in districts such as Gurdaspur, Hoshiarpur, Muktsar, and Patiala, with decreases ranging from 25% to over 70%, reflecting a major decline in fire counts. Moderate reductions were seen in areas like Bathinda, Faridkot, and Jalandhar, with decreases between 22% and 45%, indicating a general decrease in fire activity.

Meanwhile, some districts, such as Amritsar and Sangrur, experienced only minor reductions, and a few areas, including Sahibzada Ajit Singh Nagar, showed minimal or slight increases. Overall, this suggests a notable decrease in fire incidents across Punjab, with varying degrees of change in different districts.

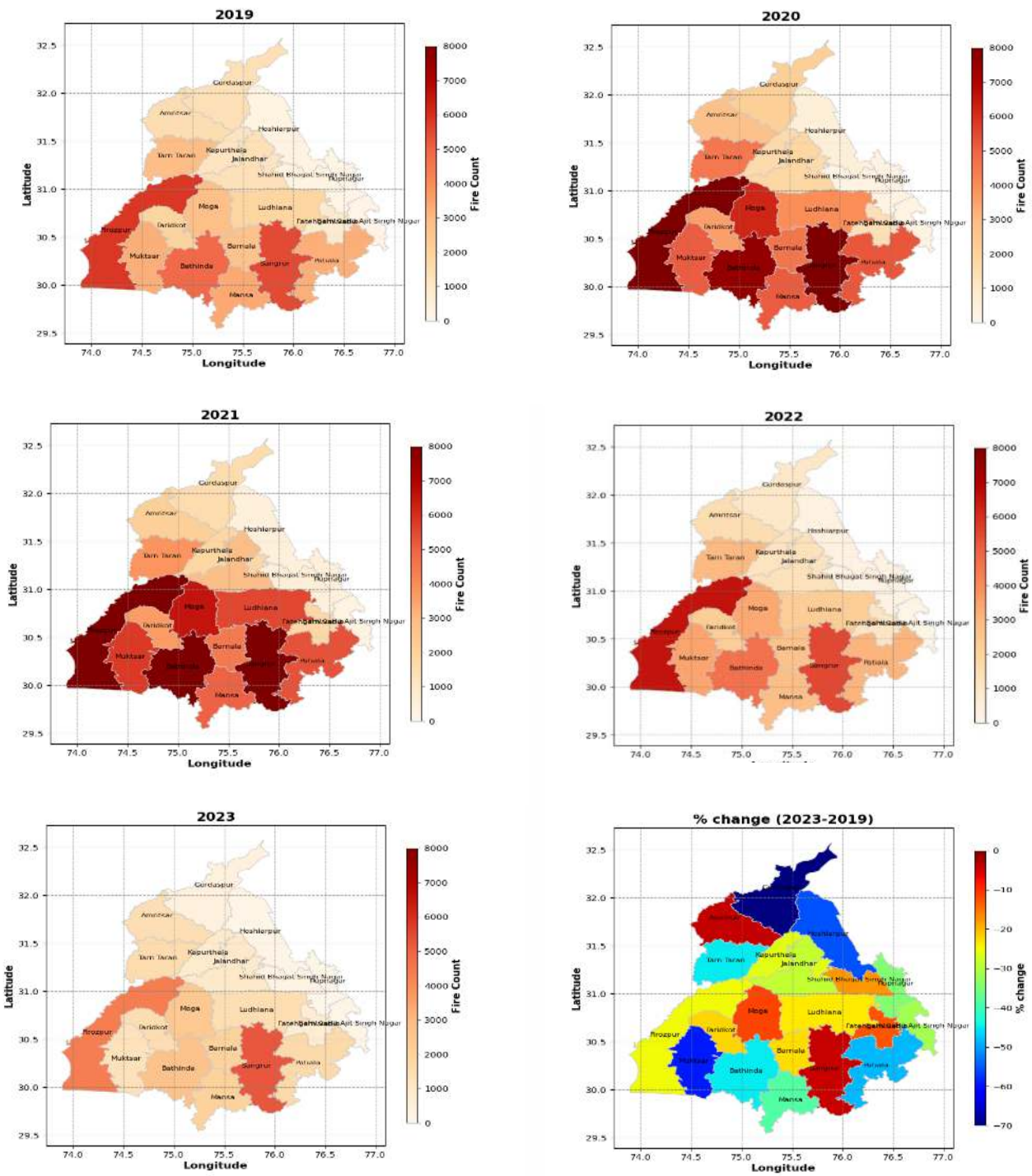


Figure-5: District wise fire count of Punjab during Sep to Dec.

**Key highlight from the fire counts in Punjab from September to December between 2019 and 2023 are:**

- Significant reductions in fire counts were observed in districts like Gurdaspur and Muktsar, with decreases of up to 71%.
- Moderate decreases were noted in districts such as Bathinda and Faridkot, with reductions ranging from 22% to 45%.
- Some districts, including Amritsar and Sangrur, saw minimal reductions, while a few, like Sahibzada Ajit Singh Nagar, experienced slight increases in fire counts.



## Comparison between peak Vs Other seasons:

### For Punjab:

The data reveals a distinct seasonal pattern in fire activity, with the period from September to December consistently experiencing more fires than the earlier part of the year. For example, in 2019, the fire count increased from 22,950 (January to August) to 45,600 (September to December), showing nearly a 100% increase. This trend is even more dramatic in 2020, where the fire count jumped from 18,246 in the first eight months to a staggering 76,802 in the final four months more than four times higher. The years 2020 and 2021 stand out as particularly intense fire seasons. In 2021, fire counts rose from 16,309 (January to August) to a high of 78,721 (September to December), making it the year with the highest fire count in the dataset. The dramatic increase in fire counts during this period suggests a strong influence of seasonal climatic conditions, possibly driven by extended droughts or agricultural burning.

In contrast, 2022 saw a relative decrease in fire activity, with 47,173 fires in the second half of the year, down significantly from the 78,721 fires recorded in 2021. Similarly, in 2023, fire counts were lower in both periods, with 21,117 fires in the first eight months and 31,605 in the last four months a decrease compared to previous years. This reduction could indicate improved fire management practices or more favourable climatic conditions in recent years. Despite this downward trend in 2022 and 2023, the data shows that fire activity remains a persistent problem, particularly in the second half of each year, highlighting the ongoing need for effective fire management and prevention strategies.

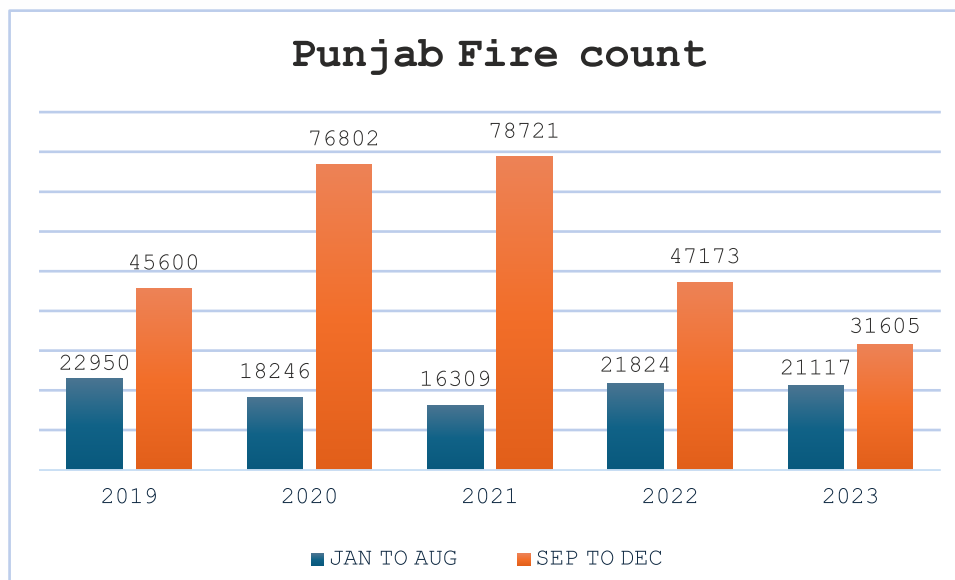


Figure-6: Bar plot of Punjab Fire Count.

### Key Highlights:

- From 2019 to 2023, the overall fire counts were 68,550 in 2019, 95,048 in 2020, 95,030 in 2021, 47,173 in 2022, and 52,722 in 2023.
- The period from September to December consistently experiences higher fire counts compared to January to August.
- In 2019, fire counts nearly doubled from the first eight months to the last four months.
- In 2020, the fire count more than quadrupled during the last four months compared to the first eight months.
- 2021 saw the most significant increase, with fire counts rising by over 380% in the last four months compared to the first eight months.
- 2022 showed a decrease in fire activity during the last four months compared to 2021, with a reduction of around 40%.
- 2023 also experienced a decrease in fire counts compared to previous years, with a reduction of approximately 60% in the last four months compared to 2021.
- Despite reductions in 2022 and 2023, fire activity remains notably higher in the latter part of each year, indicating a persistent problem that underscores the need for effective fire management and prevention strategies.
- In Punjab, the fire problem is not confined to the September to December period, as fire incidents also occur throughout the rest of the months.
- From 2019 to 2023, the fire count during January to August decreased by approximately 8%, while the count from September to December saw a reduction of about 31%.

## For Haryana:

The data reveals a distinct seasonal pattern in fire activity for Haryana, with the period from September to December consistently experiencing more fires than the earlier part of the year. For example, in 2019, the fire count increased from 7,694 (January to August) to 6,428 (September to December), showing a significant seasonal shift. This trend is even more pronounced in 2020, where the fire count rose from 4,609 in the first eight months to 6,195 in the final four months. The years 2020 and 2021 stand out as particularly intense fire seasons. In 2021, fire counts increased from 5,918 (January to August) to a high of 10,695 (September to December), making it one of the highest periods for fire counts in the dataset. The dramatic increase in fire counts during this period suggests a strong influence of seasonal climatic conditions, possibly driven by extended droughts or agricultural burning.

In contrast, 2022 saw a relative decrease in fire activity, with 4,985 fires in the second half of the year, down from 10,695 fires recorded in 2021. Similarly, in 2023, fire counts were lower in both periods, with 4,620 fires in the first eight months and 3,339 in the last four months a decrease compared to previous years. This reduction could indicate improved fire management practices or more favourable climatic conditions in recent years. Despite this downward trend in 2022 and 2023, the data shows that fire activity remains a persistent problem, particularly in the second half of each year, highlighting the ongoing need for effective fire management and prevention strategies.

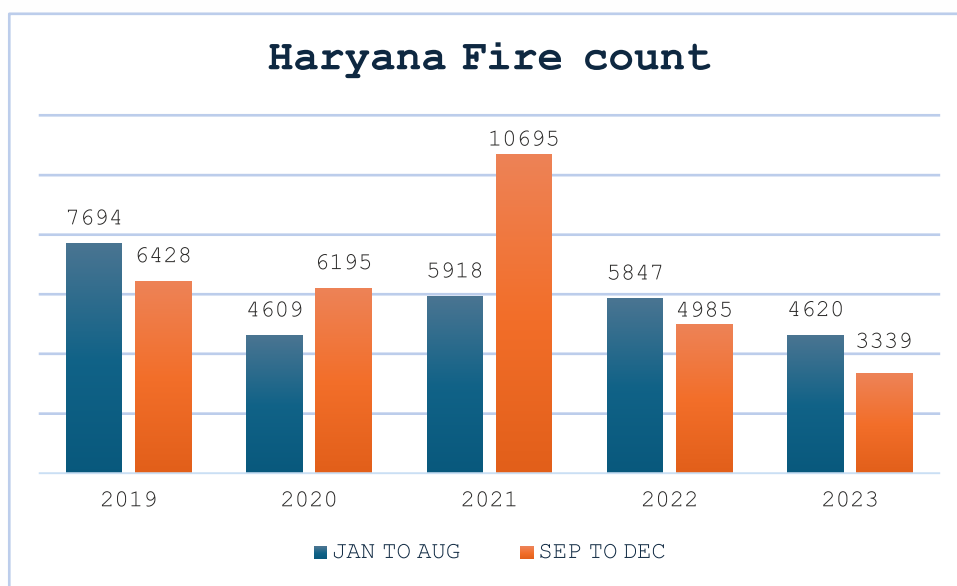


Figure-7: Bar plot of Haryana Fire Count.

## Key Highlights:

- From 2019 to 2023, the overall fire counts in Haryana were 14,122 in 2019, 10,804 in 2020, 16,613 in 2021, 10,832 in 2022, and 7,959 in 2023.
- The period from September to December consistently experiences higher fire counts compared to January to August.
- In 2019, fire counts decreased slightly from 7,694 (January to August) to 6,428 (September to December).
- In 2020, the fire count was higher in the latter part of the year, increasing from 4,609 (January to August) to 6,195 (September to December).
- 2021 saw a significant rise, with fire counts increasing from 5,918 (January to August) to 10,695 (September to December).
- 2022 showed a decrease in fire activity in the last four months, with a reduction from 10,695 (2021) to 4,985.
- In 2023, fire counts also experienced a reduction, with a decrease from 10,695 (2021) to 3,339 (September to December), reflecting a reduction of approximately 68% in the latter part of the year.
- Despite the reductions in 2022 and 2023, fire activity remains notably higher in the latter part of each year, indicating a persistent issue that underscores the need for effective fire management and prevention strategies in Haryana.
- The data shows that fire incidents are not confined to the September to December period but occur throughout the rest of the year as well.
- For Haryana data, the fire count during January to August decreased by approximately 40% from 2019 to 2023, while the count from September to December saw a reduction of about 48% over the same period.

## Impact of fire count on Delhi AQI

The analysis of fire count data from Punjab and Haryana reveals a strong correlation between fire incidents in these regions and the increase in air pollution levels in Delhi. Specifically, the fire count serves as a critical contributing factor to the rise in the Air Quality Index (AQI) in Delhi, particularly during the stubble burning season. Fire incidents, primarily resulting from agricultural practices such as crop residue burning, introduce significant quantities of particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>) into the atmosphere. These pollutants, combined with the prevailing wind patterns, travel to Delhi, leading to a sharp increase in AQI. The findings indicate that as the fire count in neighbouring states rises, there is a corresponding deterioration in air quality, with AQI values in Delhi frequently moving into the 'Poor,' 'Very Poor,' and 'Severe' categories.

From September to December between 2019 and 2023, the impact of fire incidents on Delhi's air quality is significant. On days without any fire incidents, Delhi's AQI averages 175, classified as "Moderate," and these days make up only 5% of the period. The baseline AQI, based on climatological averages for fire activity during this season, is 233, which falls under the "Poor" category. When fire incidents occur but remain below climatological averages, the AQI is 229 and categorized as "Poor," occurring on 72% of the days. However, when fire counts exceed the climatology, Delhi's AQI surges to 337, placing it in the "Very Poor" category, and this is seen on 21% of the days. This demonstrates a clear correlation between increased fire activity and deteriorating air quality in Delhi.

This trend is particularly alarming because it suggests that high fire counts can increase AQI by more than 103 units, making Delhi's air increasingly harmful to public health. This correlation underscores the importance of addressing the agricultural burning practices in the surrounding regions, as they directly influence the air quality in Delhi. Without mitigation strategies, such as providing alternatives to stubble burning, the annual air quality crisis in the region will persist, leading to severe health implications for millions of residents.

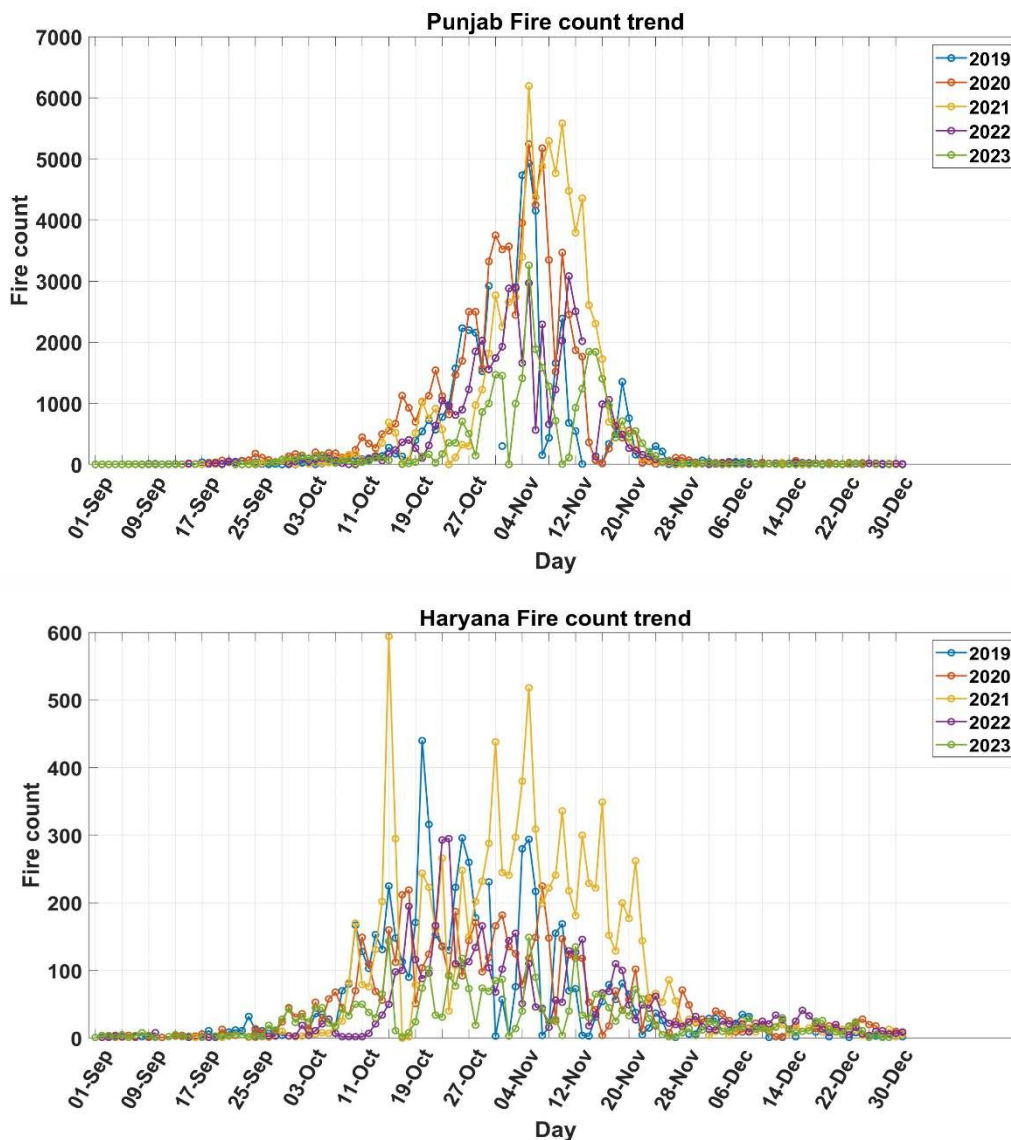
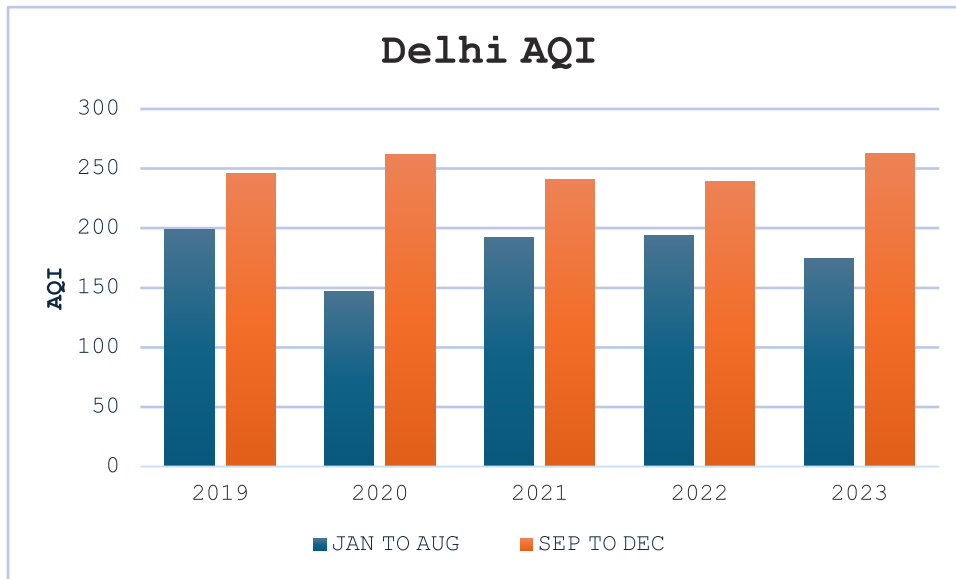
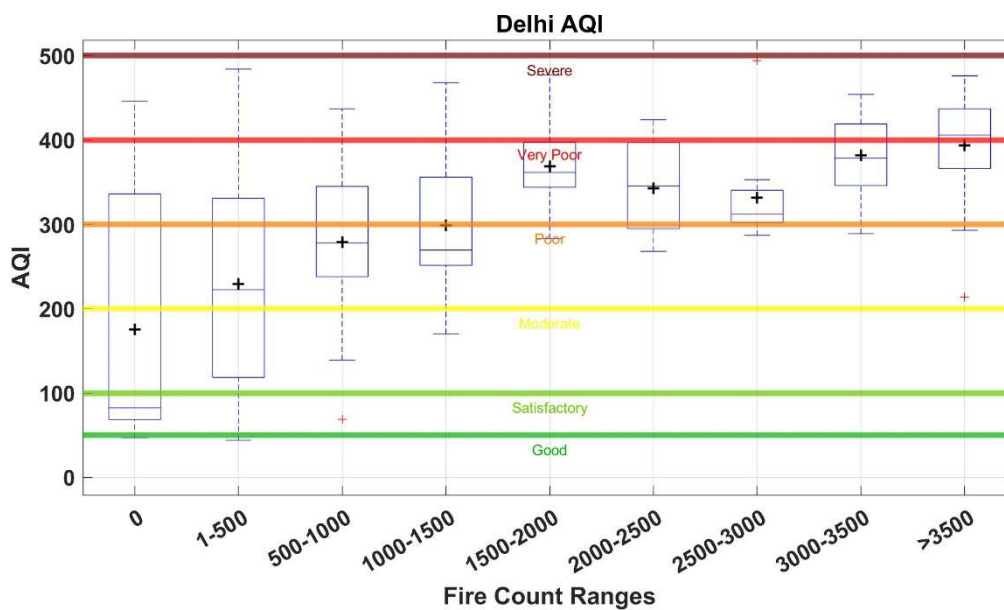


Figure-8: Fire Count variations during Sep to Dec for Punjab and Haryana.



**Figure-9:** Bar plot of Delhi AQI from 2019 to 2023



**Figure-10:** AQI variations in different ranges of Fire incident from 2019 to 2023 during Sep to Dec

**Key Highlights:**

- Delhi's AQI averages 175 on days with no fire incidents, classified as "Moderate," accounting for 5% of the observed days.
- The baseline AQI during the stubble burning season is 233, indicating "Poor" air quality.
- On days when fire incidents occur but are below climatological averages, AQI remains 229 ("Poor"), accounting 72% of the days.
- When fire incidents exceed climatological averages, AQI jumps to 337, classified as "Very Poor," affecting 21% of the days.
- Our analysis reveals a notable impact of fire incidents in Punjab and Haryana on air quality in Delhi. Specifically, it was found that each fire incident in these neighbouring states contributes to an increase in Delhi's Air Quality Index (AQI) by approximately 103 units.



