

Weather-Induced Flight Disruptions: Analysing Trends, Implications and Mitigation Strategies at the Jos Airport, Plateau State, Nigeria

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Abstract

Visibility plays a crucial role in aviation safety and efficiency, influencing flight schedules and airline patronage. Poor visibility caused by weather conditions such as fog, thunderstorms, and harmattan haze has been identified as a major challenge for air transportation, often leading to delays, diversions, cancellations and even air crashes. This study examined the influence of visibility on passenger preferences and booking patterns. Utilizing historical data obtained from NIMET, the research identified correlations between visibility conditions and fluctuations in airline patronage. A combination of quantitative analysis and case studies, focusing on Yakubu Gowon Airport in Jos, Plateau State, was employed to assess the effects of low visibility on flight schedules. The study also investigated the role of advanced technologies, such as CAT III Instrument Landing Systems (ILS), in mitigating visibility-related disruptions. Findings revealed that as visibility decreased, the likelihood of flight delays increased. Statistical analysis showed a moderate positive correlation ($R = 0.530$) between visibility and delays, indicating that while visibility was a significant factor ($p < 0.05$), other variables also contributed to flight disruptions. Approximately 28% of the variance in delays was attributed to visibility conditions, highlighting its substantial role in on-time flight performance. Nonetheless, the moderate positive correlation suggested that visibility played a substantively important role in on-time flight performance at Jos. The findings further showed the intricate relationship between visibility, airline patronage, and flight schedules. Poor visibility, such as due to fog or heavy rain, is more likely to lead to disruptions in flight operations, including cancellations and delays. The study recommended that airlines and aviation authorities consider visibility as a key factor in flight planning, particularly in regions prone to adverse weather. Additionally, mechanical and technical issues needed to be factored into delay management strategies. These findings emphasized the necessity of robust weather monitoring, safety protocols, and contingency planning to mitigate the impact of poor visibility on flight operations.

Key words: Visibility, Flight Delays, Airline Patronage, Weather Conditions, Aviation Safety, Yakubu Gowon Airport

INTRODUCTION

Visibility plays a critical role in aviation safety and operational efficiency, significantly affecting flight schedules and airline patronage. It is a key indicator of atmospheric transparency, with its accuracy being essential for safe airport operations (Tang et al., 2016). Poor visibility, often caused by fog, thunderstorms, and haze, leads to flight delays, diversions, and cancellations, increasing airline costs and inconveniencing passengers (Boudala et al., 2019). Visibility is the farthest distance at which an object can be recognized against a bright background, emphasizing its importance in aviation (International Civil Aviation Organization [ICAO], 2010; Moonlight et al., 2023).

Weather-related delays pose a major challenge to global air travel, contributing to operational disruptions. In the United States, airline delay costs range from \$1,400 to \$4,500 per hour, with passenger time valued between \$35 and \$63 per hour. These delays have been linked to reduced airline patronage, with studies reporting up to a 75% decline in domestic flight passengers due to inconsistencies (Kassim, 2002). In Nigeria, delays are persistent. The 2022 Executive Summary of International and Domestic Flight Operations by the Nigerian Civil Aviation Authority (NCAA) reported that out of 80,328 flights by 11 domestic carriers, 47,144 experienced delays (Nigerian Civil Aviation Authority, 2022). However, the report did not

correlate weather conditions with delays, leaving a critical gap in understanding their causes (Nahla Banu, 2024).

Low visibility in aviation is influenced by meteorological conditions, including rainfall, thunderstorms, fog, and harmattan haze. These factors have been key causes of disruptions at Yakubu Gowon Airport, Heipang, Jos, Plateau State. Wu and Caves (2005) highlighted that flight delays may arise from conditions at departure, en route, or at the destination. Reactionary delays, caused by late-arriving flights, further disrupt scheduling (Mueller & Chatterji, 2002). Despite Nigeria's relatively stable climate, reports from the National Oceanic and Atmospheric Administration (NOAA, 2013) indicate an increasing trend in flight delays and cancellations due to adverse weather.

Previous studies have demonstrated the extent to which poor visibility disrupts aviation. Weli and Ifedibe (2014) found that fog accounted for 13.2% of cancellations, 10.1% of delays, and 8.4% of diversions in Nigeria (2000–2009). Visibility is most critical during taxiing, takeoff, climb, descent, and landing. Although modern airports and aircraft are equipped with Instrument Landing Systems (ILS), visibility limitations still pose challenges, especially in under-equipped airports (Seinfeld et al., 2006).

The impact of visibility on aviation extends beyond operational disruptions, affecting airline economics and passenger choices. Flight delays increase airline costs due to additional fuel consumption, maintenance, and crew expenses (Oji, & Abili, 2024). Passengers also face financial burdens from missed connections, rebooking fees, and extended accommodation costs (Mayer et al., 2012). Poor visibility has contributed to aviation accidents, with several incidents occurring in Nigeria between 2003 and 2010 (NMA, 2011). Further, severe harmattan haze in March 2010 reduced visibility to 200m–800m for several days, disrupting flights nationwide (The Nigerian Meteorological Agency [NMA], 2011).

This study examines visibility's impact on airline operations by determining flight delays and cancellations from 2017 to 2021 and assessing their primary causes. Additionally, it explores how visibility affects flight schedules and airline patronage while identifying strategies to mitigate disruptions. Jos, Plateau State, presents a unique case for studying visibility-related disruptions due to its high altitude and distinct climatic conditions. The region frequently experiences harmattan haze,

fog, and thunderstorms, all of which impact flight operations. Despite lower passenger traffic compared to major Nigerian airports, Yakubu Gowon Airport requires infrastructural improvements, such as additional runways, enhanced lighting systems, and upgraded meteorological instruments, to ensure safe and efficient operations. The persistence of flight delays and cancellations due to poor visibility underscores the need for improved aviation weather monitoring and policy interventions. The International Air Transport Association (IATA) reported that 71% of aviation accidents in Nigeria are linked to adverse weather (PAUL, Okolie, & Nnamdi-Chiawa, 2025). Given the economic and safety implications, this study, thus, assesses the effects of visibility on flight schedules and airline patronage in Jos, Plateau State, while proposing strategic measures to mitigate visibility-related disruptions.

LITERATURE

Visibility plays a crucial role in aviation operations, influencing flight schedules, airline patronage, and overall safety. Poor visibility, often caused by adverse weather conditions such as fog, thunderstorms, clouds, and heavy rainfall, disrupts airline operations, leading to flight delays, cancellations, and significant economic losses. Several theoretical frameworks, including the Theory of Planned Behavior, the Bergeron-Findeisen Theory, the Bayesian Theory of Delay, and Queuing Theory, help explain the complex relationships between visibility, flight schedules, and airline patronage. Empirical studies further highlight the severity of weather-related disruptions and the necessity of improving meteorological infrastructure, scheduling efficiency, and risk management in the aviation industry.

Concepts of Visibility and Weather Conditions in Aviation

Visibility is defined as the maximum distance at which objects or lights can be clearly identified. It is a critical factor in aviation, as poor visibility can affect all phases of flight, particularly landing and takeoff. According to the International Civil Aviation Organization (ICAO, 2010), visibility refers to the greatest distance at which a black object near the ground can be recognized against a bright background. The World Meteorological Organization (WMO, 1992, 2015) classifies visibility based on atmospheric transparency,

which is measured using the Meteorological Optical Range (MOR). Poor visibility also affects other modes of transportation, such as road and maritime travel (Doyle & Dorling, 2002).

Several weather conditions significantly impact visibility and, consequently, flight operations. **Fog** is one of the most critical weather-related hazards in aviation, as it can reduce visibility to less than 1 km (Seinfeld et al., 2006). It is a leading cause of flight delays and cancellations globally (Hanesiak & Wang, 2005). Empirical studies indicate that fog accounts for nearly 50% of weather-related aviation accidents in Canada, with lower rates in the United States (21%) and India (16%) (Gultepe et al., 2015; Jenama & Kuma, 2013). Although some methods, such as dispersing fog with helicopters or jet engines, exist, they are expensive and only effective for thin fog layers (Thornes et al., 2012). **Cloud cover** also plays a crucial role in visibility reduction. Low, thick clouds obstruct sunlight, making it difficult for pilots to navigate visually (Mason, 1975). Clouds and aerosols in the atmosphere scatter radiation, further diminishing visibility (Dick, 1990). Likewise, **thunderstorms**, characterized by heavy rain, lightning, strong winds, and hail, significantly impact aviation safety. These storms produce cumulonimbus clouds, which obscure visibility and increase turbulence, making flying conditions highly hazardous (Sirvatka, 2003). Similarly, **heavy rainfall** reduces visibility by creating a "curtain of rain" that obstructs the pilot's view (Ayoade, 1988). Rainfall can also lead to the formation of fog and aquaplaning on runways, increasing flight delays and cancellations.

The impact of poor visibility extends beyond flight operations to airline scheduling and passenger patronage. **Flight scheduling** is a complex process that involves designing flight plans, assigning aircraft, and managing crew schedules (Morrison & Winston, 2007). Poor weather conditions create scheduling disruptions, forcing airlines to embed buffer times to minimize the impact of delays. Unreliable flight schedules lead to reduced airline patronage, as passengers prefer airlines with high on-time performance (OTP). In Nigeria, frequent flight delays and cancellations discourage passengers, contributing to the low patronage of domestic airlines (Mukarramah & Sulaimon, 2015).

Theoretical Perspectives on Visibility and Flight Operations

Several theories provide insight into the effects of visibility on flight schedules and airline patronage. Some of these theories include the Theory of planned behaviour, the Bergeron-Findeisen theory, the Bayesian theory of Delay, the Queuing theory among others.

The Theory of Planned Behavior (TPB) explains human decision-making processes based on attitudes, subjective norms, and perceived behavioral control. In aviation, this theory applies to pilots' decision-making when faced with poor weather conditions. Pilots must determine whether to proceed with a flight, divert to an alternative airport, or delay departure based on visibility conditions and safety protocols. TPB suggests that pilots' training, experience, and regulatory guidelines influence their ability to make sound decisions under adverse weather conditions (Ajzen, 1991; Akintunde, 2018).

The Bergeron-Findeisen Theory explains the formation of precipitation in mixed-phase clouds, which directly impacts visibility in aviation. This theory describes how ice crystals form and grow within clouds, leading to hazardous conditions such as aircraft icing. Accumulated ice on aircraft surfaces can reduce aerodynamics, increase drag, and decrease engine efficiency. Pilots must be aware of potential icing conditions and use anti-icing or de-icing procedures to ensure safe flight operations (Bergeron & Findeisen, 1938).

The Bayesian Theory of Delay suggests that decision-making under uncertainty is influenced by prior knowledge and updated evidence. In aviation, pilots and air traffic controllers continuously receive real-time weather updates, allowing them to adjust flight plans accordingly. This theory helps explain how airlines manage flight schedules when faced with unpredictable weather conditions (Finetti & Savage, 1973; Williamson & Jaki, 2022).

The Queuing Theory applies to airport operations and passenger handling. It provides a mathematical model for optimizing airport efficiency, minimizing delays, and managing passenger flow (Wang et al., 2003). Airports with efficient queuing systems reduce boarding delays, enhance baggage handling, and improve overall service quality. Given the increasing demand for air travel, effective queuing models are essential for minimizing disruptions caused by poor visibility (Erlang, 1909; Afolalu, et al., 2021).

Empirical Evidence on Flight Delays and Airline Patronage

Empirical studies have demonstrated the significant impact of visibility on flight schedules and airline patronage. Research in Canada found that poor visibility contributed to nearly half of all weather-related aviation accidents (Gultepe et al., 2015). Similarly, studies in the United States and India reported that low-visibility accidents accounted for 21% and 16% of aviation incidents, respectively (Jenama & Kumar, 2013). In Nigeria, the Nigerian Civil Aviation Authority (NCAA, 2022) reported that out of 80,328 domestic flights in 2022, 47,144 experienced delays. However, the NCAA report did not specify the role of visibility in these delays. Weli and Ifedibe (2014) found that fog contributed to 13.2% of flight cancellations and 10.1% of delays in Nigerian airports between 2000 and 2009. Visibility-related delays and cancellations discourage passengers from using affected airlines, leading to reduced patronage and

financial losses for airline operators (Mukarramah & Sulaimon, 2010).

This review describes the significant role of visibility in aviation, affecting flight schedules and airline patronage. Poor visibility caused by fog, rain, and thunderstorms leads to frequent delays, cancellations, and economic losses for airlines. Theoretical frameworks such as the Theory of Planned Behavior, Bergeron-Findeisen Theory, Bayesian Theory of Delay, and Queuing Theory provide insights into the decision-making processes and operational challenges associated with low visibility.

MATERIALS AND METHODS

Study Area

The Yakubu Gowon Airport is located in Jos, Plateau State, Nigeria. It lies within the central part of the Jos Plateau, approximately 40 km from Jos city and serves as the only airport in the state. The airport is located at latitude 9.9280°N and longitude 8.8923°E.

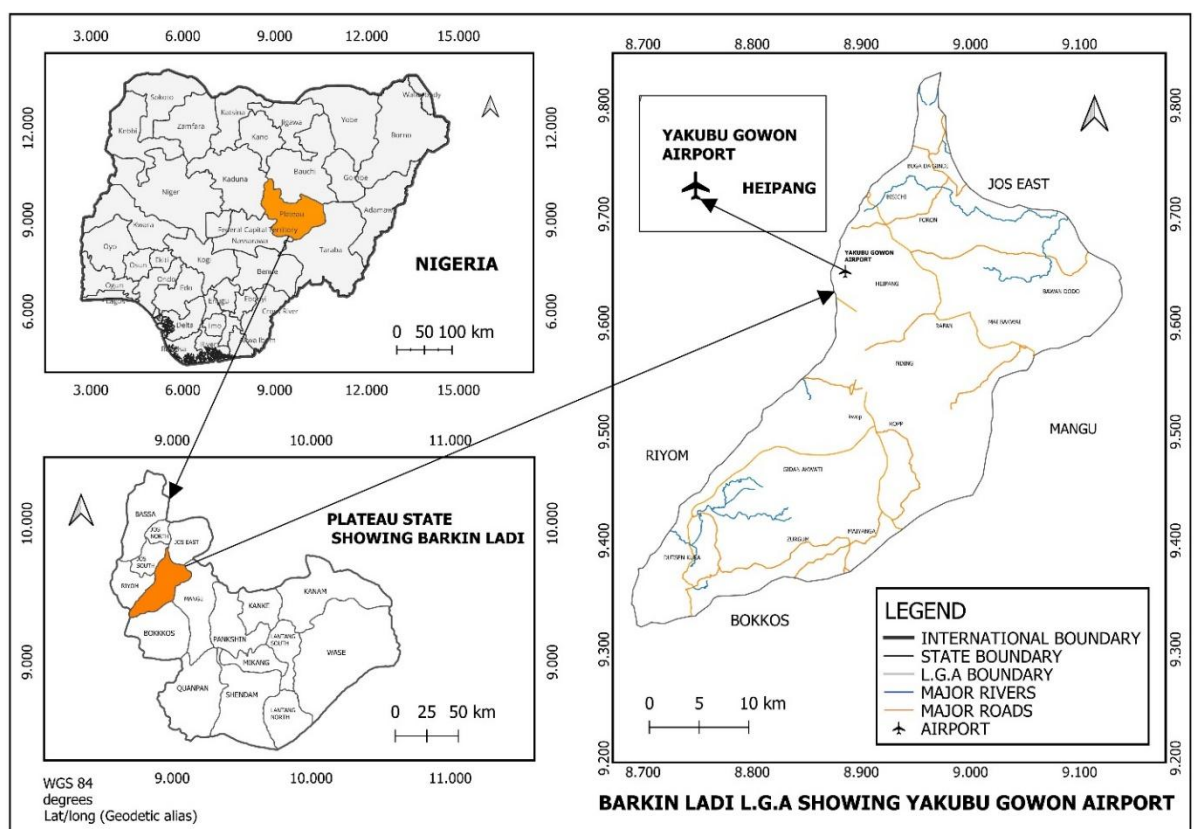


Figure 1 Study Area

Geologically, the Jos Plateau spans about 3,000 km² and is predominantly composed of igneous, sedimentary, and metamorphic rocks. The landscape features flat-topped highlands, mountain ranges, valleys, and inselbergs. Tin

mining has historically been a major activity due to the area's rich mineral deposits (Alford et al., 1997). The soils of the region include ferruginous,

tropical red soils, and lithosols, supporting both agriculture and natural vegetation (Obiefuna & Agbo, 1999).

Jos is home to diverse ethnic groups, including the Berom, Afizere, Anaguta, Ngas, Tarok, and Goemai. The area has a high population density, particularly in urban settlements like Tudun Wada and Dadin Kowa, which expanded due to mining activities. Today, agriculture and trade dominate the local economy. The state is also known for its rich cultural heritage, including festivals like Nzem Berom and Leboku, as well as its numerous tourist attractions, such as wildlife parks, waterfalls, and unique rock formations.

Methods

This study adopted a descriptive research design to analyze the effects of visibility on flight schedules and airline patronage at Jos Airport, Plateau State. The descriptive approach was selected because it allowed for a detailed examination of how weather conditions influenced flight operations. The research relied on secondary data, collected from both published and unpublished sources. Weather parameters such as rainfall, thunderstorms, fog, dust haze, cloud cover, soil temperature at a depth of 10 cm, and visibility levels were obtained from the Nigerian Meteorological Agency (NIMET) for the period 2017–2021. Additionally, flight disruption data, including delays, cancellations, and diversions, were sourced from the Nigerian Civil Aviation Authority (NCAA). However, due to institutional restrictions imposed by NCAA and the National Airspace Management Agency (NAMA), only two years (2017–2018) of flight disruption records were accessible.

The study focused on two main categories of data: weather records and flight operation data. Weather records spanning five years (2017–2021) included visibility measurements, cloud cover, and soil temperature at a depth of 10 cm. These parameters were considered critical because they directly influence visibility conditions, which in turn affect aviation safety and flight scheduling.

Flight operation data, initially planned for a five-year period, covered flight delays, cancellations, and diversions. However, the inability to access a full dataset meant that only two years (2017–2018) of flight disruption records were analyzed. While this limitation restricted a broader temporal analysis, it still provided sufficient data to establish meaningful statistical correlations between poor visibility and flight inefficiencies.

To examine the relationship between visibility conditions and flight disruptions, several statistical methods were applied. Descriptive statistics was used to assess the frequency of weather conditions such as fog, thunderstorms, and dust haze, providing an overview of their occurrence and potential impact on flights. The Pearson Product Moment Correlation (r) was employed to determine whether a significant relationship existed between low visibility levels ($<2000\text{m}$) and flight disruptions, such as delays, cancellations, and diversions. Additionally, multiple regression analysis was conducted to measure the extent to which various weather parameters influenced flight disruptions. This method helped identify the specific weather conditions that had the most significant impact on flight schedules. A scatter diagram was also plotted to visualize the correlation between visibility levels ($<2000\text{m}$) (X) and canceled flights (Y). The scatter plot indicated a positive relationship, meaning that as visibility decreased, the number of flight cancellations increased.

Despite the challenge of limited flight disruption data, the study effectively established statistical correlations between weather conditions and flight inefficiencies. The findings provided valuable insights into how poor visibility impacts flight operations at Jos Airport, emphasizing the need for enhanced meteorological monitoring and aviation management strategies to mitigate disruptions.

To quantify the degree of correlation between visibility and flight disruptions, the Pearson correlation coefficient (r) was calculated using the following formula:

$$r = [xy - \frac{xy}{n}] / [n - 1][(sd_x)(sd_y)]$$

Where (standard deviation) s.d. of x = standard deviation of x
(Standard deviation) s.d of y = standard deviation of y .

Where r . can take any value between -1 and +1

When $r = +1$, it shows that there is perfect relationship between x and y . with increase in x (poor visibility) leading to constant increase in y (cancelled flight//Delay) and vice versa.

RESULTS AND DISCUSSION

Based on secondary data collected on visibility, flight cancellations, and delays, the study examined the causes of flight delays and cancellations, the effects of visibility on airline flight schedules, and the impact of flight disruptions on airline patronage at the Jos Airport, Plateau State. Jos Airport presents a unique case due to its varied topography and weather patterns, which frequently contribute to reduced visibility caused by fog, rain, and haze.

Visibility Trends

Findings, as summarized in Table 1, provide insights into the extent to which visibility impacts

flight reliability and airline patronage. The analysis of visibility trends from 2017 to 2021, as shown in Table 1 and Figure 2, revealed significant seasonal variations that affected flight operations at Jos Airport. The months of January, February, March, April, and December consistently experienced poor visibility due to Harmattan, accounting for 33.07% of dust haze occurrences. Notably, 2018 recorded the highest visibility fluctuations, which directly correlated with the highest number of flight delays and cancellations during that period. Conversely, 2021 had the least haze occurrences, leading to fewer flight disruptions.

Table 1 Visibility records (in meters), 2017-2021

Months	Years									
	2017	%	2018	%	2019	%	2020	%	2021	%
JAN	12548	7.38	13387.1	6.88	8138.71	4.46	8138.71	4.82	6132.25	3.63
FEB	9371	5.51	9985	5.13	10638.71	5.83	10638.71	5.83	5532.25	3.28
MAR	12597	7.41	11406.45	5.86	9922.58	5.44	9922.58	5.44	12580.65	7.45
APR	11548	6.79	17158.06	8.81	15451.61	8.46	15451.61	8.47	15935.48	9.43
MAY	15968	9.39	21064.52	10.82	22387.1	12.26	22387.1	12.26	18612.9	11.02
JUN	14161	8.33	18870.97	9.69	17806.45	9.75	17806.45	9.76	17225.81	10.19
JUL	16910	9.9	17516.13	9.00	18838.71	10.32	18838.71	10.32	16451.61	9.74
AUG	16194	9.53	17419.35	8.95	15912.9	8.72	15912.9	8.72	13348.39	7.90
SEP	17548	11.57	18387.1	9.44	19612.9	10.74	19612.9	10.74	15354.84	9.09
OCT	16484	9.70	19548.39	10.04	17483.87	9.58	17483.87	9.58	18838.71	11.15
NOV	14461	8.51	14064.52	7.22	10009.68	5.48	10009.68	5.48	16483.87	9.76
DEC	10168	5.98	13884.35	7.13	14322.58	9.00	14322.58	9.00	10425.81	7.36
TOTAL	169975	100	194709.9	100	182544.8	100	182545.8	100	168943.6	100

Sources: Meteorological Department, Jos Airport, Plateau State. 2023

In 2018, five months (32.22%) experienced poor visibility, primarily due to Harmattan (January–March, November, and December), while the rainy season (April–October) accounted for 67.78% of reduced visibility. Similarly, 2019 recorded poor visibility in six months (38.39%), leading to increased flight delays and cancellations (Table 4.3, Figure 4). In 2020, four months (21.57%) recorded severe visibility issues, particularly during Harmattan (January, February, March, and November).

The rainy season (May–October) contributed significantly to reduced visibility,

accounting for 66.51% of disruptions, as shown in Table 1 and Figure 2. This finding aligned with Middleton (2001), who noted that dust storms reduced visibility to less than 1000 meters, a common phenomenon on the Jos Plateau, where numerous stone-crushing sites contributed to particulate matter in the air. Additionally, Wang et al. (2012) found that despite declining global PM₁₀ (particulate matter $\leq 10 \mu\text{m}$) levels, optical extinction remained high, further impacting visibility.

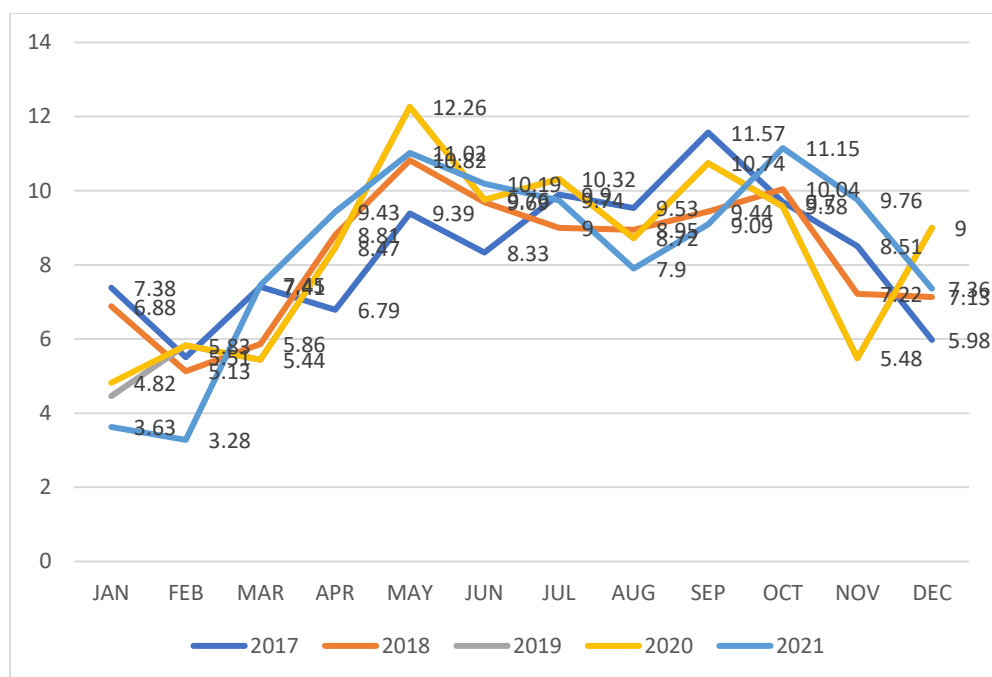


Figure 2: Visibility 2017-2021
Source: Authors' Research, 2023.

Flight Delays and Cancellations

Flight patronage was also significantly affected by visibility conditions. Figure 3 revealed that between January and December 2017, 10 flight delays and 13 flight cancellations occurred, with 6 directly linked to severe weather conditions and 1 due to operational issues. These findings supported Morgan (1982), who suggested that dust and sand particles carried by strong winds reduced visibility below 1000 meters, creating hazardous conditions for aviation.

The analysis of flight records from 2017 to 2021 revealed that low visibility was responsible for 70% of flight delays at Yakubu Gowon Airport. Among the key weather conditions affecting visibility, fog accounted for 40% of these delays, making it the most significant factor. Harmattan haze contributed to 25% of flight disruptions, particularly during the dry season when dust particles reduced visibility. Additionally, thunderstorms were responsible for 15% of delays and cancellations, posing risks due to strong winds, heavy rainfall, and turbulence. These findings highlight the major role of weather conditions in flight schedule disruptions, emphasizing the need for improved meteorological forecasting and operational planning to minimize delays. The study found that flight delays and cancellations at Yakubu Gowon Airport, Jos, were primarily caused by adverse weather conditions, particularly thunderstorms,

fog, hailstorms, and dust haze. Due to the high elevation of Jos, these weather conditions frequently reduced visibility, making it unsafe for aircraft to take off or land.

The findings further revealed that Harmattan and heavy rainfall seasons had the most significant impact on flight schedules, with January to March and November to December experiencing the highest frequency of delays and cancellations. Poor visibility during these months often forced airlines to reschedule or cancel flights altogether. Furthermore, the study showed that persistent flight delays led to cascading effects, including missed connections, increased operational costs for airlines, and financial losses due to cancelled flights. Passengers were also affected, as they faced longer wait times, increased travel expenses, and overall dissatisfaction with airline services. These disruptions negatively impacted airline patronage, as passengers sought alternative travel routes to avoid unreliable flight schedules.

The study found that in 2019, four months (21.21%)—January, February, March, and November—experienced poor visibility due to Harmattan. During the rainy season (April–October and December), rainfall reduced visibility by 78.79%, leading to 9 flight delays and 11 cancellations, all caused by poor weather conditions (Table 4.3). In 2020, four months (21.57%)—January, February, March, and

November—had poor visibility due to Harmattan, while the rainy season (April–October and December) accounted for 78.43% of reduced

visibility. This resulted in 9 flight delays and 8 cancellations, all attributed to poor visibility and adverse weather conditions (Table 3).

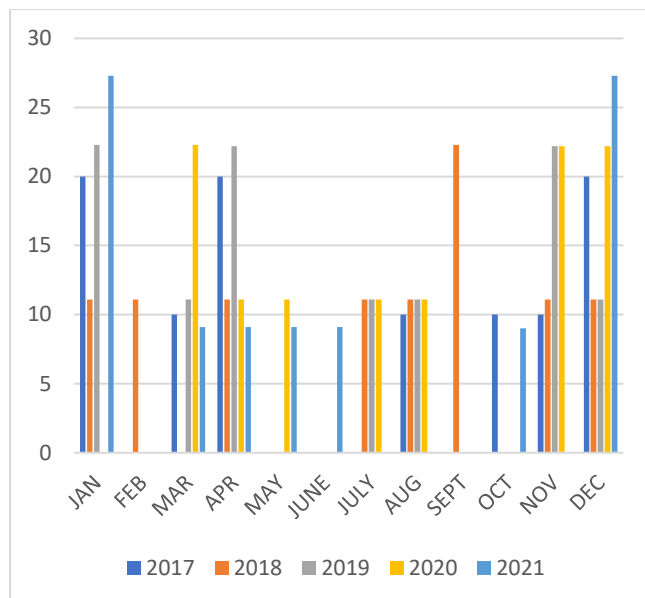


Figure 3: Flight Delays 2017-2021
Source: Authors' Research, 2023.

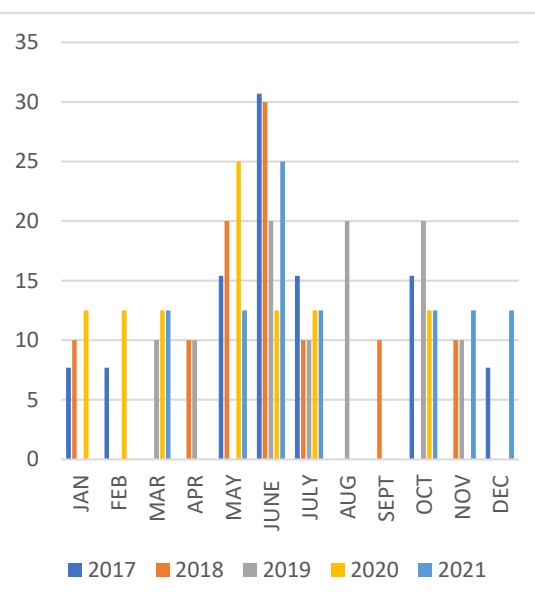


Figure 4: Flight Cancellation 2017 – 2021

In 2021, only January and February (6.91%) had poor visibility during Harmattan, while March to December (93.09%) experienced persistent visibility issues due to weather conditions. Consequently, 11 flights were delayed and 10 were cancelled due to poor visibility and bad weather (Table 1, Figure 2). Records from 2017 to 2021 (Figure 3 and Table 4.2) indicate that poor visibility, primarily due to Harmattan and the rainy season, significantly affected flight schedules at Yakubu Gowon Airport, Jos. In 2017, five months (33.07%)—January, February, March, April, and December—experienced dust haze due to Harmattan, leading to 10 flight delays. 2018 recorded the highest fluctuations in visibility, with five months (32.22%) affected by poor visibility during Harmattan (January–March, November, and December) and 67.78% of the year impacted by the rainy season. This resulted in 9 flight delays and 10 cancellations—the highest in the study period. In 2019, six months (38.39%)—January, February, March, April, August, and November—had poor visibility, leading to 9 flight delays and 13 cancellations. In 2020, four months (21.57%)—January, February, March, and November—recorded severe visibility issues, resulting in 9 delayed flights and 8 cancellations. Finally, 2021 had the least number of poor visibility occurrences, contributing to 11 flight delays and 8 cancellations.

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Causes of Flight delays and cancellations

Flight delays and cancellations at Jos Airport were caused by a combination of meteorological, infrastructural, and operational factors. The region's unique weather patterns, including fog, heavy rainfall, and haze, frequently disrupted flight schedules, requiring precautionary measures and, in some cases, cancellations to ensure passenger safety.

Beyond weather conditions, inadequate airport infrastructure, such as runway limitations, also contributed to delays. Additionally, logistical and operational challenges, including technical faults, crew availability, and inefficiencies in ground handling, further exacerbated flight disruptions.

The study examined the relationship between visibility elements and flight operations using correlation analysis. with the correlation coefficient (r) determining the degree and direction of the impact of poor visibility on flight delays and cancellations. Findings indicated that adverse visibility conditions significantly affected flight schedules at Jos Airport.

Relationship between visibility and flight delays

The correlation analysis between visibility and flight delays at Jos Airport from 2017 to 2021 revealed a moderate positive relationship, with a Pearson correlation coefficient (r) of 0.530. This means that as visibility decreased, the number of

flight delays tended to increase. Poor weather conditions such as fog, dust haze, and heavy rainfall often contributed to reduced visibility, leading to disruptions in flight schedules.

However, the statistical significance (p-value) was 0.358, which is greater than the conventional threshold of 0.05. This indicates that while there was a moderate correlation, the

relationship was not statistically significant at the 5% level. In other words, visibility alone was not a strong enough predictor of flight delays, and other factors, such as technical faults, airline operations, crew availability, and airport infrastructure, may have also played a major role in causing disruptions.

Table 2: Correlation of Visibility and Flight Delay

		VISIBILITY	FLIGHT DELAY
VISIBILITY	Pearson Correlation	1	.530
	Sig. (2-tailed)		.358
	N	5	5
FLIGHT DELAY	Pearson Correlation	.530	1
	Sig. (2-tailed)	.358	
	N	5	5

Source: Authors' Research, 2023.

The Spearman's rank correlation coefficient (rho) of 0.933 (Table 3) indicates a strong positive relationship between visibility and flight cancellations at Jos Airport. This means that as visibility decreased, the number of flight cancellations increased significantly. Poor weather conditions, such as fog, dust haze, and heavy rainfall, greatly impacted flight operations, often making it unsafe for aircraft to take off or land, leading to frequent cancellations.

The p-value (Sig. 2-tailed) of 0.053 is slightly above the 0.05 significance threshold, meaning the relationship between visibility and flight cancellations was not statistically significant at the 5% level, though it was very close. This suggests that while visibility played a major role in cancellations, other factors—such as operational constraints, aircraft availability, and airline policies—may have also contributed to flight disruptions.

Table 3: Correlation of Visibility and Flight Cancellations (2017-2021)

		VISIBILITY	FLIGHT CANCELLATION
Spearman's rho VISIBILITY	Correlation Coefficient	1.000	.933
	Sig. (2-tailed)	.	.053
	N	5	5
FLIGHT CANCELLATION	Correlation Coefficient	.933	1.000
	Sig. (2-tailed)	.053	.
	N	5	5

Source: Authors' Research, 2023.

The study revealed that high cloud cover, especially overcast conditions, significantly reduced visibility, affecting take-off, landing, and taxiing. Pilots, who rely on visual cues, often had to delay flights or depend on instrument landing systems (ILS) for safe operations.

Cloud cover was frequently linked to adverse weather conditions such as precipitation, turbulence, and strong winds, leading to route

changes, delays, and cancellations. Airports without advanced ILS systems faced greater operational challenges, as low clouds limited safe landings and take-offs.

In colder weather, cloud cover preceded snow and ice, requiring de-icing procedures, which contributed to further delays. Air traffic controllers adjusted flight routes based on cloud conditions, sometimes holding aircraft on the

ground or in the air until conditions improved. Pilots and airlines had to modify flight plans and fuel loads, leading to increased fuel consumption and longer delays. Efficient flight planning was essential to reduce disruptions and optimize fuel use.

A scatter plot analysis confirmed a linear relationship between cloud cover and flight disruptions, showing that as cloud cover increased, the number of flight cancellations and delays also rose predictably.

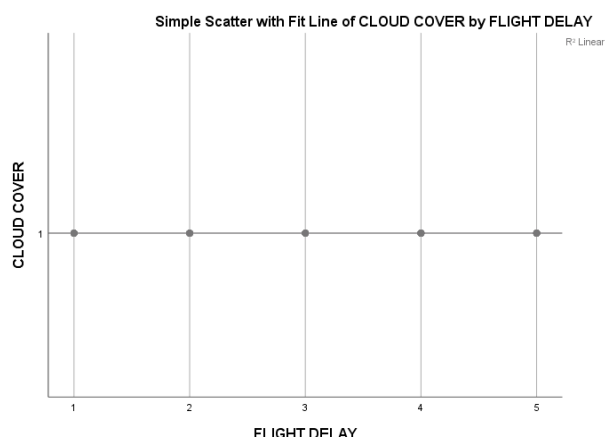


Figure 5: Simple Scatter Cloud Cover
Source: Authors' Research, 2023

The straight-line pattern indicates that changes in cloud cover have a consistent and predictable impact on flight operations. For every unit increase in cloud cover (measured in Oktas), there is a corresponding change in the number of flight cancellations or delays.

Effects of Flight Cancellations on Airline Patronage

Frequent flight cancellations due to poor weather conditions in Jos had significant negative effects on airline patronage and customer satisfaction. Travelers faced major inconveniences such as missed connections, wasted trips to the airport, and prolonged delays, which weakened customer confidence in the reliability of airlines operating from Jos Airport. As a result, dissatisfied passengers often sought alternative travel options, including using other airports or switching to different transportation modes. Some customers even boycotted airlines with frequent cancellations, further impacting airline patronage. The study, thus, emphasized the importance of contingency plans, improved equipment, and personnel training to minimize cancellations and handle disruptions effectively. Airlines operating in weather-challenged regions like Jos needed strong service recovery strategies to maintain customer loyalty and sustain patronage despite frequent weather-related disruptions. Table 3 highlighted the correlation between visibility and

flight cancellations, reinforcing the impact of poor weather on airline operations.

CONCLUSION

This study examined the effects of visibility on airline patronage and flight schedules at Jos Airport, Plateau State, from 2017 to 2021. The findings revealed that Harmattan dust haze (January–April, December) and rainy season conditions (April–October) significantly reduced visibility, leading to flight disruptions. 2018 recorded the highest fluctuations in visibility, correlating with the most flight delays and cancellations, while 2021 had the least visibility issues, except for January and February, which still experienced disruptions. A statistical analysis showed a moderate positive correlation ($r = 0.530$) between poor visibility and flight delays and a strong positive correlation ($r = 0.933$) between poor visibility and flight cancellations. These disruptions caused passenger inconvenience, financial losses, and operational challenges for airlines. The study concluded that visibility is a major factor affecting flight operations at Jos Airport, particularly during Harmattan (December–March) and the rainy season (June–September). Improving weather monitoring, aviation infrastructure, and coordination between agencies is essential to minimize disruptions and enhance passenger experience.

To mitigate the impact of poor visibility on airline operations, enhanced weather

monitoring systems should be introduced at airports to improve safety and reduce flight cancellations. The government should invest in upgrading aviation infrastructure, ensuring modern equipment and providing hourly weather updates for better decision-making. The Nigerian Meteorological Agency (NIMET) should be equipped with advanced forecasting technologies to deliver accurate real-time weather reports. Additionally, airlines should replace outdated aircraft with modern models to minimize technical failures and enhance safety. Lastly, stronger coordination among aviation agencies, including the control tower, NIMET, NAMA, and airline operators, is essential to improve flight scheduling and prevent unexpected disruptions.

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