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Weather Factor Effect on the Operation of Airlines in Nigeria Between 2022 and 2024: A Case Study of Selected Airlines in Omagwa International Airport, Port Harcourt, Nigeria

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Abstract

Air transportation involves the movement of passengers and cargo using aircraft and helicopters, and providing essential connectivity between regions and people. This study examined the effect of weather on flight operations at Port Harcourt International Airport from 2022 to 2024. The research was conducted to determine other factors influencing flight operations aside weather, examine the variability of weather parameters, analyze their effects on flight performance, assess airline operational patterns, and evaluate the relationship between weather conditions and flight incidents. The study utilized survey design and employed only secondary data. Five out of the eight operating airlines were sampled. Data on weather parameters—visibility, thunderstorms, fog, haze, and gusty winds—were obtained from the Nigeria Meteorological Agency (NIMET), and flight operation records, were sourced from the selected airlines. Findings showed that variability in weather significantly affected flight operations, leading to delays, cancellations, and diversions. A total of 13,429 flights were recorded between 2022 and 2024, with 512 (3.81%) affected by disruptions: 361 (2.69%) due to weather and 151 (1.12%) due to technical issues. Air Peace operated the highest number of flights (26.7%), while Aero had the least (12.1%). Value Jet Airlines experienced the lowest rate of disruptions (0.25%), whereas Air Peace recorded the highest (1.1%). Weather accounted for approximately 22% of operational hitches, with visibility showing the strongest relationship ($r = –0.81$) with flight operations. The study concludes that both weather and technical issues contribute significantly to flight delays, cancellations, and diversions. Improved weather forecasting, technological upgrades, strengthened aviation regulations, and enhanced crew training are recommended for more efficient flight operations.

Keywords: NIMET, Airline, Weather, Visibility, Flight Delays, Cancellations and Diversions.

Introduction

Air transportation is the transportation of passengers and cargo by air craft and helicopter [1]. This mode of transportation has become the primary means of common carrier travelling. It provides a communication link which is sometimes vital, between the different groups of people involved [1]. The aviation industry and associated operations is significantly influenced by weather. Aviation safety, efficiently and capacity are sensitive to weather, and adverse weather can have negative impact to the section [2]. the increase in aviation demand can push an airport's capacity to it's limit, and even a small weather change can lead to a reduction of the airport capacity weather conditions affects all aspect of aerodrome operations such as aircraft, fueling, cleaning, baggage handling, catering, aircraft maintenance, and the actual scheduled flights. The operational capacity of airports, and even a regions entire airspace, can be significantly reduced due to bad weather, resulting in delays, diversions and cancellations of flight [2].

On the average, weather account for nearly 75% of global aviation delays. There are various definitions to describe an aviation delay. The definition adopted for this study is that of the actual off-block/on-block time of an aircraft relative to the operations published schedule. The projected flight time as per the schedule assumes and incompletely efficient operation of the airspace system, we all copying mechanism in the place and accurate weather forecast [3]. Delays not only have local implications, but also affects flight downstream due to the ripple effect and tight airline schedule [4]. Adverse weather condition at on airport can create disturbance in the traffic flow throughout the entire airspace system [4]. Delays trigger additional cause such as extra airport charges, maintenance, crew cost and passenger compensation [5].

Many studies have shown how aviation delays can have a significant financial impact to the sector. According to Evans (1995) 65% of delays experienced by US domestic airlines are

attributed to advanced weather, with estimated cost of US $3 billion per year could be saved from improved winter weather forecasting and icing diagnoses at the US airport [6]. Canada estimated that the use of 100% accurate terminal Aerodrome forecast and Canadian airport would result in a saving of the US $12.5 Million annually, as a conservative number [7]. Another example of financial impact is the approximately US $250,000 for economic loss that Frankfurt airport undergoes per fog Lour experienced [8].

A response to adverse weather for aviation is that of hazard mitigation. Aviation weather mitigation can be realized through two avenues. The first covers measures to improve aircraft or aerodrome to be better suitors for adverse weather. In the last century, the operational capability of aircraft and aerodrome have undergone continuous improvement [9]. Such mitigative examples includes; instrument landing system, auto pilot and auto throttle, deicing fluids, grooved runways, anti-lock braking system, electrical hardening, gyroscopic instrument, cross-wind landing gear and pressurized cabins [9]. The second mitigation avenue is to enhance the operational decision-making process regarding the advance weather. The availability of affordable and high-performance data processing system and high-capacity digital data links has facilitated in the improvement of weather information system, thereby enhancing weather related decisions.

Abubakar and Nurudeen characterizes aviation weather irrigation as a continuum with the need to avoid all adverse weather at one extreme and the ability to safely operate in all weather conditions at the other extreme [9]. Realistic aviation capabilities would fall somewhere between two extremes. Avoidance of adverse weather is dependent on weather observations, accuracy of forecast, timely dissemination and presentation of these weather datasets to all the relevant parties, and the integration of the information into the flight management decision process. In all phases of operations, weather pose a significant impact on the safety and efficiency of air traffic. It is very important to detect, track and predict hazardous weather element and provide information to pilots for easier decision making before taking off and landing. With the formation of regional and global meteorological observation based on weather at high altitudes was made in 1920s with the invention of the radio sound small light weight boxes equipped with instruments and radio transmitter, radio sound is carried high into the atmosphere by a hydrogen or helium filler balloon that ascends into an altitude of about 30km before bursting [10]. During the ascent, these instruments transmit temperature, moisture and pressure data back to the ground station. data are processed and made available for constructing maps or insertion into computer models for every weather prediction. Airport operation has affected very heavily airport operation [4]. It is one of the weather events provoking more flights delays and cancellation [3]. Many airports are located in areas where fog can take place, in the flat bottoms of basins or near the coast. Typically, 1% of the time fog may affect an airport. According to the USA Bureau of Transportation (2013), weather related delays are about one-half of the total delays. Statistics for individual airports reports foggy conditions as one of the major disrupting events for their ordinary operation. Only few airports can operate in dense fog and not many aircraft are equipped to do so. In consequence, fog implies cancellation or severe delay of flights, also because the security delay imposed between takeoff and landing operations. Another issue, important at high latitudes in winter, is freezing fog that deposits ice on the wings and implies de-icing, an operation causing significant delay, especially in busy airports. Generally, the weather impact strongest during takeoff and landing. Typically wind shear, for heavy snowfall and low visibility after these stages of the flight while clear air turbulence is a characteristic enroots hazard. They generally reduce the safety margins and increase the occurrence of incident and eventually accidents. Simultaneously, the capacity of airports is reduced by the need to increase the separation between aircraft, by the need for additional holdings, or by the closure of one or even all runways. As a result, the operational capacity of a regions entire airspace is reduced through delay, diversions and cancellation of flights-all of which have severe knock-on effect for the ordinary traveler [2].

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Methodology

Study Area

Port Harcourt is the largest city and capital of Rivers State, Nigeria. The city is located within latitude 6058' N - 706'N and longitude 4040'E - 4055'E (figure 1)It lies along the bonny of Rivers and is located in the Niger Delta. Rivers State is borded by Warri, Delta state by the Northwest, Owerri, Imo State by the North, Aba , Abia State by the Northeast, Yenagoa, Bayelsa State by the West, Uyo, Akwa Ibom State by the East, gulf of Guinea by the Southwest, Atlantic Ocean by the South, Malabo – Equatoria Guinea by the Southeast, respectively (figure 1).As of 2016, the Port Harcourt Urban area has an estimated population of 1,865,000 inhabitants, up from 1,382,592 as of 2006 (National Population Commission, 2016). It is projected to 3.79 million in 2025 using the annual growth rate of 4.16% (NPC, 2025).

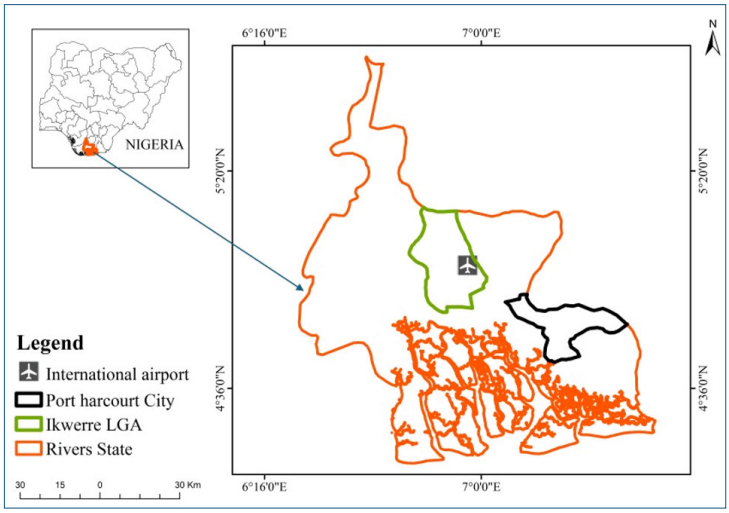

Figure 1: Rivers State Showing Port Harcourt City.

Port Harcourt airport named Port Harcourt International Airport is the third largest airport in Nigeri. It is located at Omagwa in IkwereLocal Government Area of Rivers state. The airport is relatively busy and it handled just over 1 million passengers in 2009. Omagwa airport, located in (or close to) Port Port Harcourt has 1 runway, which is 9846 feet (3001meters) long. This area under study lies between latitude 40 72'N and 40 91N and longitude 60 881E and 70 12'E. (Figure 2). Omagwa airport is 87 feet (27m) above sea level. The airport is referred to by the International Air Transport Association (IATA) using the airport code PHC. The International Civil Aviation Organization (ICAO) use DNPO when referring to Omagwa airport.

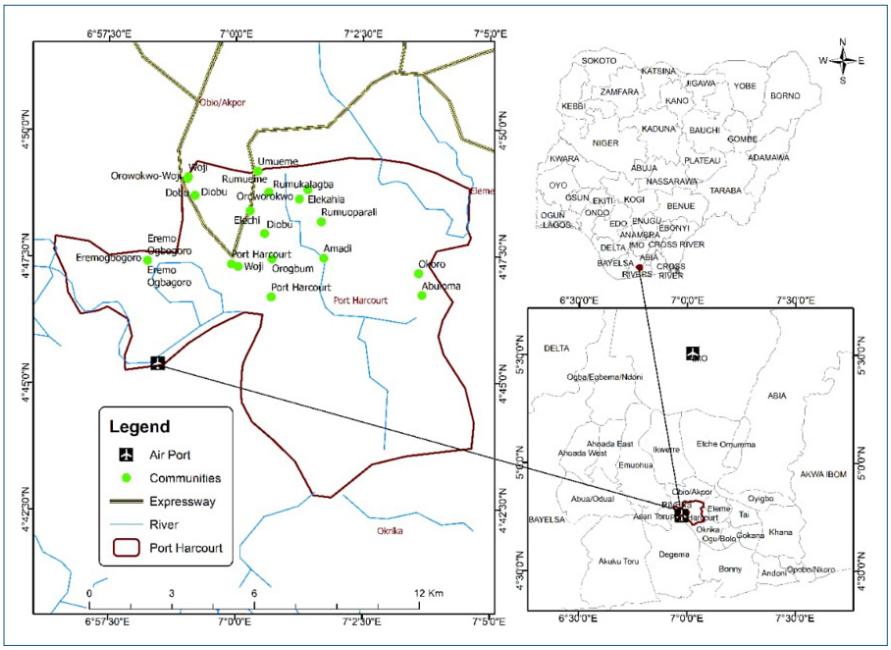

Figure 2: Port Harcourt City Showing Port Harcourt International Airport.

Methodology

This involves the arrangement of conditions for data collection and the analysis of same data in a manner that aims to combine relevance to the research purpose with economy in the procedure. The research design constitute the blue printof data collection, data measurement and data analysis. The research design utilized in this study is the mixed method. Here both the qualitative and quantitative data were utilized for the study, and are purely secondary data. These data were collected on the following area- data on weather (Visibility, thunderstorm, fog, thick dust haze with visibility less than 800m and gusty wind with greater than or equal to16 knots). These weather data were selected because they were observed to have the greatest significant impact on flight operations; data on factors that affects flight operations (weather data and technical hitches); and data on flight operations by airlines (number of flights, flight delays, flight cancellation and flight diversions. The secondary data used for this research are weather data and flight operation data. They include 3 year data for weather and flight operations using monthly weather data collection. The weather data were obtained from theNigeria Meteorological Agency (NIMET), while data on flight operations were obtained from the five sampled Airlines operating in the Airport on a monthly basis. The population for this study is the all the airlines operating in the Port Harcourt International Airport, Omagwa. Reconnaissance survey carried out in the course of the study showed that about eight airlines operates in the airport. Some of these airlines operates both local and international routes. Out of the eight airlines operating in the airport, five of the airlines representing about 62.5 percent of the airlines were systematically sampled for the study. In the course of sampling, three factors were considered. They are - numbers routes of operation, volume of activities/operations and types of Aircrafts used by the airlines. Considering these factors, Air Peace Arik, Value jet, United Nigeria Airlines and Aero contractors. The Information in Table 3.1showed the sampled airlines and their routes.

Table 1: Sampled airlines Operators and their Routes.

Air Peace	Lagos Route	Abuja Route
Arik Air	Lagos Route	Abuja Route
Value Jet	Lagos Route	Abuja Route
Aero Contractors	Lagos Route	Abuja Route
United Nigeria	Lagos Route	Abuja Route

Source: Researchers Fieldwork, 2025.

Discussion of Findings

Weather Parameters that affect Flight Operations and incidencesin the Airport

Weather parameters were observed to affect flight operations. The information on weather parameters that affects flight operation is presented in Table 2.

Table 2: Weather Parameters that affects Flight Operations in the Airport.

Month	Year														
	2022					2023					2024				
	Visibility (<800 m)	TS	Fog	Haze	Wind (<16 knots	Visibility (<800 m)	TS	Fog	Haze	Wind (<16 knots	Visibility (<800 m)	TS	Fog	Haze	Wind (<16 knots
Jan	17	9	10	3	0	13	8	9	3	0	16	4	8	4	0
Feb	4	9	8	2	0	8	3	9	0	2	7	7	12	2	1
March	3	15	0	0	5	1	10	2	0	4	1	17	1	0	3
April	5	25	2	0	3	23	0	1	0	4	10	23	2	0	3
May	6	26	1	0	2	11	23	1	0	3	4	24	3	0	2
June	6	21	7	0	6	5	19	7	0	2	4	26	9	0	5
July	0	16	5	0	1	6	8	4	0	2	11	25	3	0	1
Aug	8	23	4	0	0	0	5	3	0	0	4	10	2	0	0
Sep	13	25	3	0	2	8	19	2	0	3	4	10	3	0	1
Oct	5	23	1	0	0	11	22	5	0	0	5	25	3	0	0
Nov	8	28	6	0	0	9	13	7	0	0	9	17	6	0	1
Dec	8	11	7	7	0	9	2	9	3	0	8	6	7	5	0
Total	83	231	54	12	17	104	132	59	6	20	83	195	58	11	17
Min	3	9	1	2	1	1	3	1	3	2	1	4	1	2	1
Max	17	28	10	7	6	23	23	9	3	4	16	26	12	5	5
Mean	6.92	19.25	4.5	1.00	1.42	8.67	11.0	4.9	0.5	1.67	6.92	16.25	4.8	0.92	1.42
Range	14	19	9	5	5	22	20	8	0	2	15	22	11	3	4
Var.	18.58	41.61	9.33	3	2.92	32.28	59.83	9.24	1.25	2.39	15.67	58.34	21.99	2.91	2.25
Std. Dev.	4.31	6.45	3.03	1.73	1.71	5.68	7.34	3.04	1.12	1.55	3.96	7.64	4.69	1.71	1.50

As evidenced in Table 2, the weather variable and figures indicated the major weather variables and their values for the periods in which one, or other flight incidents have occurred in the airport between the years 2022 and 2024. The values depicts the variables when there is either fight diversions, cancellations or delays in the airport. The major weather variables that lead to incidences of flight cancellation, diversions or delays are visibility, when it is less than 800meters, thunderstorm, fog, thick dusty haze, and gusty wind above or equal to 16 knots. The descriptive statistics from showed that in 2022 and 2025, the mean visibility for a flight to be cancelled, diverted or delayed in the airport was 6.92 meters, while in 2023, the average visibility was 8.67meters. For thunderstorm, a mean value of 19.25, 11.0 and16.25 meters in the years 2022, 2023 and 2024 respectively led to flight cancellation, diversions or delays in the study area. An average fog values of 4.5, 4.9 and 4.8 caused flight incident in 2022, 2023 and 2024 respectively in Port Harcourt International airport. A mean haze value of 1, 0.5 and 0.92 respectively in 2022,2023 and 2024 led to flight incident in the airport. For gusty wind a mean value of 1.42, 1.67 and 1.42 knots caused flight diversions, cancellations and delays in the years 2022, 2023 and 2024 respectively in the airport.

There are some records incidences of flight that resulted from weather in the airport from 2023 and 2025. Value Jet runway excursion in November 2023 on the 14th.A Value Jet CRJ-900 (registration 5N BXR) overran / slipped off runway 03 at Port Harcourt after landing due to low visibility (plate 1). According to NSIB, there were 62 passengers and 5 crew on board. No fatalities or major aircraft damage were reported. The airline reported that algae on the taxiway caused loss of friction, making the aircraft unable to maintain the centerline. The Port Harcourt airspace was temporarily shut after the incident but was later reopened.

Plate 1: Value Jet Runway Excursion in November 2023 on the 14th Due to Low Visibility.

Flight Operations by the Airlines in Port Harcourt International Airport

Flight Operations by the Airlines in Port Harcourt International Airport in 2022
Presented in Tables 2,3, and 4 are the operations of the five selected airlines for periods ranging from 2022 - 2024. The information in Table 3 depicts the operations of the airlines in the year, 2022

Table 3: Flight Operations by the Airlines in Port Harcourt International Airport in 2022.

Airlines	Flight Operation						TFA	%	TCW	%	TCTH	%
	NYM	FCDW	FDDT	FDDW	FDW	FEDW						
Air Peace	1200	6	13	21	8	1	49	1.06	34	0.74	15	0.00
Value jet	1080	0	0	0	0	0	0	0.00	0	0.00	0	0.00
Arik	1050	14	12	19	6	1	52	1.23	41	0.89	11	0.24
Aero	540	5	10	16	8	0	39	0.85	29	0.63	10	0.22
United Nigeria	745	0	11	27	7	0	45	0.98	34	0.74	11	0.24
Total	4615	25	46	83	29	2	185	4.01	138	3.01	47	1.02

Note: NYM = Number of Yearly Flight; FCDW = Flight Cancelled Due to Weather; FDDW = Flight Delay Due to Weather: FDDT = Flight Delay Due to Technical Hitches: FDW = Flight Diversion Due to Weather; FEDW = Flight Executed Due to Weather; TFA = Total Flight Affected; TCW= Total Flight Cancelled due to Weather; TCTH = Total Flight Cancelled Due to Technical Hitches.

The information in Table shows the volume of operation of the five selected airlines, and weather and other activities affected their operations. Air peace airline operated 1200 aircrafts from Port Harcourt International airport in the year 2022. 50 (4.1%) of the aircraft operation was affected by weather and other phenomena. From the 50 aircrafts affected, 36 (2.95%) were affected by the identified weather parameters, while 14 (1.15%) the aircrafts were affected by technical hitches. Out 36 aircrafts affected by weather phenomenon, 21 were delayed, 8were diverted to the nearest airport, 6 were cancelled, and only 1, was successfully executed, and none was affected by weather or technical hitches. This by implication means that the airline had all its aircrafts successfully executed in 2022 from the airport. Arik airline operated a total of 1050 aircraft during the year. Operations of 50 (4.76%) of the aircrafts 4.76% ofwere affected.40 aircraftswere affected due to weather while 10 (0.95%) were affected by technical hitches. From the 40 affecteddue to weather, 19 were delayed, 14 were cancelled, 6 were diverted to another airport while 1 was successfully executed despite the weather.

In 2022,out of thetotal of 4615 aircrafts that operated from the airport, the operations of 185 (4.01%) was affected by weather and technical hitches. Out of the affected 185 aircrafts, 138 (75%) were affected by weather, while 47 (25%) aircrafts were affected by technical hitches. This showed that weather is a very important factor affecting flight operations in the airport.4 out of the 5 selected airlines were affected by weather, and technical hitches, with the exception of Value Jet airline, that operated seamlessly without any hitches in its operation.Air Peace has the highest number of aircrafts operated from the airport, followed by Value, jet and Arik,

and Aero has the least from Airport. Air Peace has its operations least affected (4.1%), followed by Arik (4.76%), while the highest effect wasobserved from Aero Airline (7.22%).

Flight Operations by the Airlines in Port Harcourt International Airport in 2023
Flight Operations in by the various airlines in the airport is presented in Table 4

Table 4: Flight Operations by the Airlines in Port Harcourt International Airport in 2023.

Airlines	Flight Operation						TFA	%	TCW	%	TCTH	%
	NYM	FCDW	FDDT	FDDW	FDW	FEDW						
Air Peace	1150	6	13	22	12	0	53	1.17	40	0.88	13	0.28
Value jet	1060	2	4	12	0	1	19	0.42	16	0.35	3	0.07
Arik	1050	11	9	14	5	0	39	0.86	30	0.66	9	0.20
Aero	540	10	10	12	6	0	39	0.86	28	0.62	11	0.24
United Nigeria	720	5	4	18	0	0	27	0.60	23	0.51	4	0.08
Total	4520	34	40	78	23	1	177	3.91	137	3.03	40	0.88

Note: NYM = Number of Yearly Flight; FCDW = Flight Cancelled Due to Weather; FDDW = Flight Delay Due to Weather: FDDT = Flight Delay Due to Technical Hitches: FDW = Flight Diversion Due to Weather; FEDW = Flight Executed Due to Weather; TFA = Total Flight Affected; TCW= Total Flight Cancelled due to Weather; TCTH = Total Flight Cancelled Due to Technical Hitches.

The information in Table 3 shows the volume of operation of the five selected airlines together with how weather and other activities affected their operations in 2023. Air peace airline operated 1150 aircrafts from Port Harcourt international airport in the year 2023. 53 of the aircraft operation was affected by weather and other phenomena. This implies that about 4.61% of the aircraft operations were affected in 2023. From the 53 aircrafts affected, operations of 40 aircrafts (3.48%) were affected weather parameters, while 13 (1.13%) were affected by technical hitches in the aircraft. From the out 40 aircrafts affected by weather, 22 were delayed, 12 were diverted to the nearest airport, and 6, were cancelled. Value Jet airline operated a total of 1060 aircrafts from Port Harcourt International airport in 2023. 19 (1.79%) of the airline aircraft were affected by weather and technical hitches. From the 19, 16 (1.51%) were affected by weather, while 3 (0.28%) were affected by technical hitches. Among the ones affected by weather, 12 were delayed, 2 were cancelled, 1 was successfully executed and one was diverted.

Aero airline operated a total 540 aircrafts from Port Harcourt International Airport. 39 (7.22%) were affected by weather and technical hitches. From the 39 aircrafts affected, 28 (5.16%) were affected by weather, while 11 of them or 2.06% were affected due to technical hitches. Of the 28 affected by weather, 12 were delayed, 6 were diverted, while 10 were cancelled. United Nigeria Airline operated a total of 720 aircrafts in 2023. The information from the Table showed that operations of 27 of the aircrafts were hampered. Out of the 27 affected aircrafts, 23 were due to weather, where 18 was delayed, and 5 cancelled, and 4 were due to technical hitches.

The 2023 summary showed that the operations all the 5 selected airlines were affected by weather and technical hitches. Air Peace has the highest number of aircrafts operated from the airport, followed by Value, jet and Arik, while Aero contractors have the least from Airport. Value jet has its operations least affected (1.79%), followed by Arik (3.71%), while the highest effect was observed from Aero Airline (7.22%).

Flight Operations by the Airlines in Port Harcourt International Airport in 2024
Table 5 showed the operations of the five sampled airlines in Port Harcourt International Airport in 2024

Table 5: Flight Operations by the Airlines in Port Harcourt International Airport in 2024.

Airlines	Flight Operation						TFA	%	TCW	%	TCTH	%
	NYM	FCDW	FDDT	FDDW	FDW	FEDW						
Air Peace	1230	3	15	15	5	0	39	0.91	23	1.87	15	0.35
Value jet	1080	0	3	11	0	0	14	0.33	13	1.21	3	0.07
Arik	1055	5	16	19	6	0	46	1.07	29	2.75	16	0.37
Aero	540	10	9	11	5	0	35	0.82	26	4.63	9	0.21

United Nigeria	380	3	0	14	0	0	17	0.40	17	3.13	0	0.00
Total	4285	21	43	60	16	0	151	3.52	108	2.52	43	1.00

Note: NYM = Number of Yearly Flight; FCDW = Flight Cancelled Due to Weather; FDDW = Flight Delay Due to Weather: FDDT = Flight Delay Due to Technical Hitches: FDW = Flight Diversion Due to Weather; FEDW = Flight Executed Due to Weather; TFA = Total Flight Affected; TCW= Total Flight Cancelled due to Weather; TCTH = Total Flight Cancelled Due to Technical Hitches.

As evidenced from the information in Table 4, Air peace airline operated 1230 aircrafts from the airport in the year 2024. Out of 1230 aircrafts, 39 of the aircraft operation was affected by weather and technical hitches. This implies that about 3.17% of the aircraft operations were affected in 2024 in the study area. From the 39, 23 (1.30%) were due to weather parameters, and 15 were due to technical hitches in the aircraft. Among the 23 aircrafts whose operations were due to weather, 15 of them were delayed, while 5 were diverted to the nearest airport, and 3 were cancelled. the information from the Table also showed that Value Jet airline operated a total of1080 aircrafts from the airport in 2024, out of which 14(1.2%) were affected by weather and technical hitches. From the 14 affected aircraft operations, 13 of them representing 1.2% were affected by weather, while 1 (0.09%) was affected by technical hitches.From the 13 affected by weather, all of them were delayed.. Arik Air airline in 2024 operated a total of 1055 aircraft.

Operations of 46 of the aircrafts were affected. Out of the 36 aircrafts affected, 30 were due to weather, while 16 were the result of technical hitches. From the 30 affected aircraft operations due to weather, 19 were delayed, 5 were cancelled, and 6 were diverted to another airport. The Operation of the Aero contractor's airline in 2024 indicated that the airline operated a total 540 aircrafts from Port Harcourt International Airport. 35 (4.46%) of the aircraft's operations were affected by weather and technical hitches. From the 35 aircrafts affected, 26 (2.79%) were affected by weather, while 19 (1.67%) were due to technical hitches. Of the 26, affected by weather, 11 were delayed, 5 were diverted, while 10 were cancelled.

In 2024, the operations of the all selected five airlines were affected by weather and technical hitches. Air Peace has the highest number of aircrafts operated from the airport, followed by Value, jet and Arik, while United Nigerian Airline has the least from the Airport. Value Jet has its operations least affected (1.30%), while the highest effect was observed from Aero Airline (4.63%)

Table 6: Summary of Airline Operations from 2022 - 2024.

Air-lines	Operations between 2022 - 2024													
	Total	%	TFA	%	FCDW	%	FDDT	%	FDDW	%	FDW	%	FEDW	%
Air peace	3580	26.7	142	1.1	15	0.1	41	0.31	59	0.66	25	0.19	1	0.01
Value Jet	3220	24	33	0.25	2	0.01	15	0.11	23	0.17	0	0.00	1	0.01
Arik	3155	23.5	135	1.01	30	0.22	37	0.28	52	0.39	17	0.13	1	0.01
Aero	1620	12.1	113	0.84	35	0.26	29	0.22	39	0.29	19	0.14	0	0.00
United Nigeria	1854	13.8	89	0.66	8	0.06	29	0.22	59	0.66	7	0.05	0	0,00
Total	13429	100	512	3.81	93	0.69	151	1.12	232	1.73	68	0.51	3	0.02
Mean	2685 .8		102 .4		18.6		30.2		46.8		13.6		0.6	
Variance	568, 143 .36		902 .1		184.12		83.8		197.6		74.59		0.06	
Standard Deviation	753 .97		30 .03		13.57		9.18		14.1		8.64		0.24	
C.V	28.07		29 .32		72.9		30.39		30.1		65.53		40	

Note: NFM = Number of Monthly Flight; FCDW = Flight cancelled due to weather; FDDW = Flight delay due to weather: FDDT = Flight delay due to technical hitches: FDW = Flight diversion due to weather; FEDW = Flight executed due to weather; TFA = Total Flight Affected.

Summary of Airline Flight Operations 2022 - 2024

The information presented in Table 5 shows the summary and descriptive statistics of the operations of the Airlines from 2022 to 2024.

As evident in Table 5, a total of 13,429 aircrafts were operated between 2022 - 2024 in Port Harcourt International Airport. Air Peace Airline operated the highest number of the aircrafts in the airport, with 3580 aircrafts in the airport between 2002 and 2024. This means that Air Peace operated 26.7% of the aircraft operations in the airport. Value Jet airline and Arik Airlines that operated 3220 and 3155 aircrafts respectively or about 24% and 23.5% of the aircrafts in the airport. The least aircraft operation was Aero contractor's airline with 1620 (12.15) aircrafts in the airport. The operations of 512 aircrafts were affected by weather and technical hitches. This means that the operations of 3.81% of the airlines were affected by weather and technical hitches in the airport within the period under study in this distribution order - Air Peace 142 (1.1%), Value Jet 33 (0.25%), Arik 132 (1.01%), Aero 113(0.89%) and United Nigeria airline 89 (0.66%).Out of the 512 aircraft operations affected by both weather and technical hitches, 361 (2.69%) were affected by weather, while 151(1.12%) were affected technical hitches. Among the flights affected by weather, 93(0.69%) were cancelled, 232(1.73%) were delayed, 68 (0.51%) were diverted to nearest airports, and 3 (0.03%) was successfully executed. The descriptive statistics indicated a mean value of 2685.5 flights for each the airline in three years representing an annual mean flight of 895 for each of the airlines in Port Harcourt international airport.

An average of 102.4 flights were affected in the airport due to weather and technical hitches for the three years from each of the airline. This indicated that annually, an average of about 34 flights are affected in each of the airlines operating in the airport. The coefficient of variation which is used to show the degree of variability or dispersion showed that greatest disparity or variability were observed in flights cancelled, followed by flights diverted due to weather among the airlines in the study area. The least disparity or dispersion was seen in the number flights operated by various airlines in the airport.

Relationship Between Weather and Flight Operations in Port Harcourt International Airport

The information in Tables 7 - 9 illustrates the different kinds of relationships that exists between weather and flight operations in Port Harcourt International Airport. The data in Table 6 showed the result of Analysis of Variance (ANOVA) on whether there a significant variation or difference on the effect of weather on the flight operations by the sampled airlines

Table 7: ANOVA Result Showing Variations in Flight Affected Due to Weather among the Airlines.

Flights Affected in Airlines		Sum of Squares	D. F	Mean Square	F	Sig.
United Nigeria	Between Groups	201.306	20	10.065	2.231	.049
	Within Group	67.667	15	4.511		
	Total	268.972	35			
Arik	Between Groups	264.806	20	13.240	3.789	.006
	Within Group	52.417	15	3.494		
	Total	317.222	35			
Air Peace	Between Groups	226.889	20	11.344	1.685	.153
	Within Group	101.000	15	6.733		
	Total	327.889	35			
Value Jet	Between Groups	31.556	20	1.578	.835	.652
	Within Group	28.333	15	1.889		
	Total	59.889	35			
Aero Contractors	Between Groups	120.972	20	6.049	1.450	.234
	Within Group	62.583	15	4.172		
	Total	183.556	35			

Source: Authors, 2025

The F values (F-Ratio) of 2.231, 3.789, 1.685, 0.835 and 1.450 were calculated for United Nigeria Airline, Arik, Air Peace, Value Jet and Aero airlines respectively. Their respective critical values of F, i.e. (F0.05) were 0.049, 0.006, 0.153, 0.652 and 0.234. The result showed that there is a significant difference in flight operations due to weather in the Operations of United Nigeria airlines and Arik airlines, since they have a critical vale of 0.049 and 0.006 respectively. But no significant variation existed in the operations of Air Peace, Value Jet and Aero Contractors airlines due to weather.

The information in Table 8 showed the result of regression analysis on the effect of weather on flight operations.

Table 8: Model Summary of Effects of Weather on Airline Operations.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.468a	.219	.089	16.82130

a. Predictors: (Constant), Gusty Wind, Visibility data (<800m), Thunderstorm, Fog, Thick Dust Haze
Source: Authors, 2025

The Regression coefficient (R) value of 0.468 showed a positive relationship between weather and flight operations in the study area. Though the relationship is positive, but it is relatively weak. The R square (R2) value of 0.219 which is the coefficient of determination showed that weather contributed to 21.9% of flight operations in the study area. The Residual value of 78.2% can be attributed to other factors like technical hitches and other factors.

The information in Table 9 showed the result of various regression coefficients with the regression slope (a) value of 354.83; b1 (1.00) for visibility; b2 (0.310) for Thunderstorm, b3 (-0.214) for Fog; b4 (4.06) for thick dusty haze and b5 (1.27) for gusty wind.

Table 9: Regression Coefficients of Weather Parameters on Flight Operations.

Model	Unstandardized Coefficients		Standardized Coefficient	T	Sig
	b	Std. Error	B		
1 (Constant)	354.832	11.234		31.586	.000
Visibility data(<800m)	1.001	.612	.276	1.635	.113
Thunderstorm	.310	.423	.146	.732	.470
Fog	-.214	1.123	-.039	-.190	.850
Thick Dust Haze	4.056	2.194	.438	1.849	.074
Gusty Wind	1.274	1.803	.125	.707	.485

a. Dependent Variable: Total number of flight
Source: Authors, 2025

The multiple partial regression model on the relationship between weather effect on flight operation in the study area is presented in equation 1

$Y = 354.8+1.00X1+0.31X2-0.21X3+4.06X4+ 1.27X4 + €$ ..... (Eq. 1)
Where
Y = Total number of flights affected
X1 = Visibility
X2 = Thunderstorm
X3 = Fog
X4 = Thick Dusty Haze
X5 = Gusty Wind

The regression showed that given a unit increase in visibility, flight affected will increase by 1.001 holding thunderstorm, fog, thick dusty wave and gusty wind constant. When thunderstorm increases by 1, total number of flight affected will also increase by 0.31, holding the other variables constant. Furthermore, when fog increases by 1, the total number of flights that will be affected will decrease by 0.21, holding other variables constant, and when thick dusty haze increases by a unit, the total number of flights affected increases by 4.06. Finally, when gusty wind increases by one, the total number of flights affected increases by 1.27, holding the other variables constant.

The result of the regression analysis also showed that thick dusty haze is the weather parameter that has the greatest effect on flight operation in the study area. The result of regression analysis also showed that none of the weather parameters showed significant effect on flight operation in the study area, although thick dusty haze with s significant value of 0.074 almost showed significant effect.

The Information in Table 10 showed the correlation matrix of the weather parameters and the Total number of flights affects by weather

Table 10: Correlation Matrix on the Relationship between Weather and Flight Affected in the Study Area.

	Y	X1	X2	X3	X4	X5
Y	1.00	0.83	0.133	0.21	0.81	-0.56
X1	0.83	1.00	0.299	-0.468	0.211	-0.081
X2	0.133	-0.23	1.00	0.357	-0.468	0.186
X3	0.21	-0.47	0.488	1.00	0.357	-0.252
X4	0.81	0.19	-0.252	-0.252	1.00	-0.374
X5	-0.56	0.36	0.357	0.145	-0.374	1.000

Source: Authors, 2025

Note: Y= Total Number of flight affected, X1 = Visibility, X2= Thunderstorm; X3 = Fog; X4 = Thick Dusty Haze; X5 = Gusty Wind

The correlation matrix in Table 9 showed the nature of relationship that exist between flight operations and the weather parameter. Four of the weather parameters (visibility, thunderstorm, fog, and thick dusty haze) showed a positive relationship, while gusty wind showed a negative relationship. The correlation matrix values of 0.83. 0.133, 0.21 and 0.81 showed that visibility, thunderstorm, fog and thick dusty haze correlated positively with flight operation, while gusty wind with a value 0f -0.56 correlated inversely. The information from the Table also revealed that while visibility and thick dusty haze showed a very strong positive relationship, fog and thunderstorm showed weak positive relationship.

Conclusion

Weather profoundly impacts flight operations, causing flight delays, diversions, and cancellations due to adverse conditions like low visibility from fog, rain, or dust haze, thunderstorms with lightning and turbulence, aircraft icing, and even hotter temperatures affecting takeoff. These disruptions stem from challenges to aircraft takeoff, landing, and in-flight control, necessitating detailed forecasting, advanced technology, strategic planning by airlines and air traffic control, and adherence to safety procedures by flight crews to ensure safe and efficient travel. Fog, rain, and thick dust haze can reduce visibility, making it difficult and dangerous for pilots to take off, land, or see the runway, leading to delays and cancellations. These phenomena introduce hazards such as lightning, hailstones, and severe turbulence with strong, unpredictable updrafts and downdrafts, which can make air travel uncomfortable and unsafe. There five airlines studied showed different levels of operations in the airport, with Air Peace having the highest operation in the airport and United Nigeria airline being the airline with least operation in the airport. Value jet airline was observed to be the most reliable airline in the airport because its operations were least affected by weather and technical hitches within the period under study, while Arik Airline is the airline that has its operations mostly affected by weather and technical hitches between 2022 and 2024 In summary, variations in the weather must be understood alongside the various solutions vital for combating these changes. They can greatly impact aviation, affecting cost, efficiency, and safety [14]. Weather modifications impact air traffic control operations and result in aircraft delays or cancellations. Along with fuel usage and the safety of passengers and crew, routing is another aspect of flights that weather variations impact flights. Pilots, airlines, and air traffic controllers must closely monitor the weather and modify flight operations as necessary [15-19].

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Conflict of Interest

The Authors declare no conflict of Interest

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