

Published 1 February 2026 by the University of KwaZulu-Natal  
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*Journal of Inclusive cities and Built environment*. Vol. 4 Issue 5

**How to cite:** O.A. Kanyio., 2026. Impact of Climate Change on the Aviation Industry in Nigeria. *Journal of Inclusive cities and Built environment*. Vol. 4 Issue 5, Pg 20-30.

## **IMPACT OF CLIMATE CHANGE ON THE AVIATION INDUSTRY IN NIGERIA**

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*Published 1 February 2026*

### **ABSTRACT**

Throughout the 21st century, severe and extreme weather events have led to climate change, bringing forth a high rate of occurrence in various countries of the world. The aviation sector significantly contributes to climate change, resulting in a profound impact on the industry itself.

This study examined the effects of climate change on the aviation industry in the three busiest airports in Nigeria by adopting qualitative research on four distinct themes. After analysing the collected material and presenting the results, thematic analysis was deployed using ATLAS.ti ti-9. Separate text files were created from the interviews that were recorded by transcription. The result demonstrated that as climate change increases, the impacts increase. It also shows that the effects of climate change on the aviation industry are exacerbated when aviation capacity is constrained. The study recommends that the aviation industry in Nigeria must be willing and ready to take prompt action to adapt and build resilience in the industry.

**KEY WORDS** Impact, climate change, aviation, airlines and airports.

## 1. INTRODUCTION

The average weather condition or pattern is known as climate change (James et al., 2025). Currently, the rate of global warming is higher than it has ever been (Royal Society and the US National Academy of Sciences, 2020). Over time, increasing temperatures are changing weather patterns and disrupting the natural balance.

One of the main issues of the twenty-first century is climate change (CC) and its effects, which are becoming a warning. The alterations brought about by a new climate change adversely affect nearly all natural and man-made resources and systems (Gelete & Gokcekus, 2018). The aviation sector is a foremost contributor to climate change, and one of the hardest sectors to achieve greenhouse gas emission reductions (Ryley, Baumeister & Coutler, 2020). This resulted in the aviation industry being among the first to use weather as a basis for operational decision-making (Olabode, 2021).

Nigeria's tropical environment results in unique seasonal weather patterns that have a big influence on aviation (Mande, 2019) and was included among the nations pushing for carbon footprints for their airports to advance the International Civil Aviation Organisation's (ICAO) goal of zero emissions by the year 2050 (The Nation Newspaper, 2024). In Nigeria, the aviation industry is a multifaceted system comprising of network of government agencies such as Federal Airport Authority of Nigeria [FAAN], Nigerian Civil Aviation of Nigeria [NCAA], Nigerian Airspace Management Agency (NAMA), the Nigerian Safety Investigation Bureau [NISB], and the Nigerian Meteorological Agency [NiMet], airlines, infrastructure, and international affiliations.

Despite these, Nigeria's aviation industry remains increasingly vulnerable to the negative effects of weather-related climate change. This presents a significant threat to air travel and the aviation industry. The industry and its infrastructure systems are at risk from climate change because of

their complexity and susceptibility to disruptive weather events. Furthermore, climate change impacts affect various sectors differently (Amit, Dilip, & Bishm, 2023). The aviation industry in Nigeria faces unique challenges, which are a threat to coastal airports like Murtala Muhammed International Airport in Lagos. In addition, despite the growing body of studies on climate change and its effects on flight operations, passenger security and safety in Nigeria, there is still a paucity in this field. Finally, extreme weather and climate change impacts create operational and business risks, affecting productivity and efficiency. Therefore, the purpose of this study is to evaluate how extreme weather affects Nigeria's aviation sector. The objectives of this research are to examine how severe weather affects airline operations and the economy, as well as how it affects airport operational performance, capacity and infrastructure (navigation equipment).

This study is significant to all the stakeholders in the industry, the private sector, government agencies, regulatory bodies, academics, and communities. It will provide a clear understanding of the extreme weather conditions unique to the aviation sector, their effects, proactive planning support, guidance for forming well-informed policies in infrastructure design, and an increase in operational effectiveness and security. It would facilitate the adoption of improved safety procedures and risk management for a more resilient and sustainable Nigerian aviation industry.

The study's geographic focus is Ikeja, Murtala Muhammed International Airport [MMIA], Ikeja, Lagos State, Nnamdi Azikiwe International Airport [NAIA], Abuja and Port-Harcourt International Airport [PHIA], Rivers State. This study is limited to weather-related climate change impacts peculiar to the industry in Nigeria.

## 2. LITERATURE REVIEW

### 2.1. Impact of Climate Change on the Aviation Industry

From the worldwide issue, numerous industries, including aviation, are significantly impacted by extreme weather and climate change in a number of ways (Adger, Arnell & Thompkins, 2005). The impact of climate change on the aviation business and economics was examined in the ICAO CAEP aviation and climate change factsheet (2020). Disruptive occurrences have a major short-term impact on business and the economy since they can cause delays, cancellations, and damage to infrastructure. Longer-term, slow but steady effects can have an impact on industry and the economy by altering traveller demand and causing infrastructure damage or loss, and on all aspects of operational performance such as scheduling, flight planning, connectivity of flights, safety planning and trajectory optimisation. Pümpel (2016) stressed that rainfall, wind and storm surges also affect drainage systems, flood runways, terminal buildings, ATC towers, electricity generators, communications infrastructure, navigational aids and fuel stockpiles at coastal airports. Kim, Pant, and Yamashita (2018) reiterated that extreme weather affects ground access to airports, impacts the operating activities of air transportation by disrupting ground operations, causing capacity reductions, delays, diversions, and cancellations, and poses safety risks to ground crew, airside vehicles, and aircraft operations with related financial consequences.

Németh, Švec, and Kandrác (2018) stressed that global climate changes have an impact on European aviation. Extreme weather conditions hurt aircraft performance, operating characteristics, air traffic flow, airport infrastructure such as terminals, runways, taxiways, car parks, fuel storage and navigation equipment, offsite ATC equipment, ground transport access, airport capacity and operations, causing delays, diversions and cancellations. Vogiatzis et al. (2021) argued that winds impact

airport infrastructure, leading to damage to infrastructure and aircraft at terminals, and risks for personnel. Moomen (2012) stated that extreme weather conditions lead to increased expenses.

In research conducted at Murtala Mohammed International Airport in Lagos, Nigeria, Weli and Ifediba (2014) opined that extreme weather conditions impact aircraft operations, resulting in flight delays, cancellations, and diversions. The impact of weather and climate on aviation operations at Aminu Kano International Airport, Nigeria, was investigated by Caroline (2015). The study found that 45% of the fluctuation in aircraft diversions was caused by meteorological hazards such as thunderstorms, severe rain, and dense dust haze.

### 3. METHODOLOGY

#### 3.1. Study Areas

This study focused on three geographical areas situated in three states in Nigeria, namely Lagos state, the Federal Capital Territory, Abuja and Rivers state. Murtala Muhammed International Airport (MMIA) is in the suburb of Ikeja, 22km North-West of Lagos. It lies between latitude 6034'38" N and longitude 003019'16" E, about 20 kilometres from the centre of the city of Lagos. According to Ogundolapo (2014). The airport is situated on hundreds of hectares of landmass sandwiched between Ikeja, Agege, Shasha, Ejigbo, Mafoluku, and Oshodi communities in Lagos State. MMIA is the major airport serving the city of Lagos, South-Western Nigeria and the entire nation. It was constructed during World War II. Nnamdi Azikiwe International Airport (NAIA) is in the Bassa Community in the Abuja Municipal Area Council, Nigeria. It is about 49 km from the main town (Federal Airport Authority of Nigeria [FAAN], 2016). The airport is located at the reference coordinates. It lies between latitude 090 00'15"N and longitude 070 19'07"E and at an altitude of 314.98m. Port-Harcourt International Airport (PHIA) is located off Airport Road, Ogrila-Agwa road,

Omagwa, a suburb of Port-Harcourt, the capital city of Rivers state in Nigeria (Elem, 2020). It is located on the outskirts of the metropolis and about 32 km away from the capital of Port-Harcourt and lies between latitude 5.0169° or 5°1'0.8" North and longitude 6.9502° or 6° 57' 0.6" East.

#### 3.2. Research Design

A qualitative research design was used in this study to examine the trends, motivations, perspectives, and experiences that respondents have gained from their exposure to the subject under investigation.

#### 3.3. Type and Sources of Data

Primary data was deployed. It was gathered and carried out via telephone interviews and structured in-person interviews.

#### 3.4. Population

In this research, nine (9) interviewees were chosen, based on more than 10 years of experience in the field. This was based on the study by Mwangi (1998), who opined that employees with more than five (5) years of experience are highly experienced.

**Table 1. Population of the Study**

Professional Status	Numbers	Organization	Experience
Flight Operations Managers	3 (one from each airline)	Airlines	Many years of experience in the aviation industry in the fields of flight operations
Airport Operations Managers/ representative	3 (one each from the airport of study)	Airport	Overseeing all airport terminals in the study areas
NiMet officials	3 (one from each airport of study)	Airport	Provide timely and accurate weather information
<b>Total</b>	<b>9</b>		

Source: Author's Computation, 2025

#### 3.5. Sampling Technique

The sampling technique was the judgment sampling method. This is also known as purposive sampling (Ebenezer & Piate, 2023). This approach was used because it gives the researcher immediate access to the target market. Although non-probability sampling, it helps to pick sample members knowledgeable about the topic (Palinkas, Horwitz, Green, Wisdom, Duan & Hoagwood, 2015). Additionally, it helps the researcher justify drawing generalisations from the study group, regardless of whether these generalisations are theoretical, analytical, or logical. It is helpful to locate information-rich sources while providing real-time results (Nikolopoulou, 2022). As a result, the researcher spoke with their intended audience directly and realised their goals. The researcher's preferences are the only factor used in sample selection. The researcher selected a representative sample from the airport managers, Nigerian Metrology Agency [NiMET], and heads of operations of three notable indigenous

commercial airlines in the study area, namely Air Peace, Arik Air, and Max Air (Alubankudi, Akpudo, Stephens, and Nwachukwu, 2023).

### 3.6. Method of Data Collection

An interview procedure with open-ended questions was used as the data collection strategy. This allowed for exploration and made it easier to gather the information needed to comprehend the subject. Additionally, each question's structure and language were carefully considered to enhance participant involvement and clarity. The data collection procedure was consistent for all interviewees labelled as participants. Participants interviewed acknowledged full understanding of the objective of the discussion and agreed that the oral interview could be recorded. Since protecting participants' privacy and anonymity was just as important as ethics, their identity was not crucial. The MMIA interviewee is labelled participant 1. For Abuja, it was labelled participant 2, and participant 3 for Por-Harcourt.

### 3.7. Procedure for Data Collection

In this study, the procedure for the collection of data was through personal observation, scheduled interviews with representatives of several agencies and other information extraction methods. The researcher conducted the interviews. Data was collected at specific times and places (offices) to ensure that the targeted respondents were contacted. To arrive at accurate and beneficial conclusions, every viewpoint on the many concerns was examined. First, the common responses to the different themes were coded, and then, the differences and similarities of the expressed opinions were listed.

## 4. RESULTS AND DISCUSSION

From the interviews, it was clear that most of the topics were agreed upon by the participants. Although they only disagree on a small number of issues. The study has five distinct themes, which

are the extreme weather conditions caused by climate change; the business and economy of commercial passenger air transport on scheduled flights (operational cost and travel demand); operational performance of the airports (facilities management); airport capacity (apron capacity, airspace capacity/Terminal Maneuvering Areas [TMA], and Instrument Landing System); and aviation infrastructure (control tower and air navigation systems). These themes highlight the multifaceted nature of the aviation industry and its susceptibility to external factors. By examining these areas, stakeholders can better understand the challenges and opportunities ahead in the face of climate change and evolving market dynamics. At the airports of research, interviews were conducted with one NiMet official, airport management or representatives, and airline operations managers.

### Theme 1: Interview on the Extreme Weather Conditions Prevalent in the Study Areas

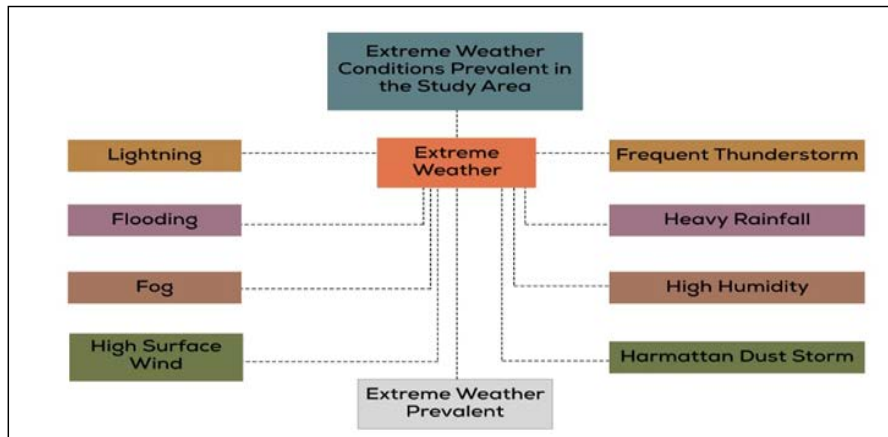
This was directed to the NiMet officials in each study area.

*"...To be candid with you, the foremost weather conditions here in Lagos are Frequent thunderstorms & lightning, Heavy rainfall & flooding (experienced most especially April–October), High humidity affecting aircraft performance, Low visibility due to fog or rain and Tropical storms from the Atlantic due to the absolute location of Lagos State. I can say categorically that it has a grave impact on the aviation industry and the operations in nearly all airports in Nigeria, especially Nigeria's major international airports, with extreme effects in some cities. The predominant extreme weather conditions in Lagos zone affecting the aviation industry include harmattan, a dry and dusty wind, and thunderstorm..." (Participant 1).*

*"...Madam, I know you understand the research so well, but for the interview purpose, let me make it clear to you that at least in Abuja, we experience three major weather conditions which I can authoritatively say affect the aviation industry due to my years of experience at work and living here. Insha Allah, they are harmattan dust storms between December and February yearly, and sudden thunderstorms around May to September yearly. This is due to the season. It's rainy times and high surface winds are often experienced. This makes it extremely difficult for us to see clearly. Madam, here in the North, the fog and haze are typically really bad..." (Participant 2).*

*"...You know we in the southern Nigeria have our peculiarities. We are within the Delta region and close to the Atlantic Ocean, near the equator, as we are taught and have known and understood due to our service at the airport. Our major challenge with extreme weather is flooding... this is a result of our location in geography. Strong tropical rainstorms repeated, and, on many occasions, we have heavy thunderstorms that can be deafening, extended and can be seriously prolonged and most times lightning. If anybody tells you that it does not impact aviation, that person knows nothing. Na true true I dey talk (I speak the truth). E dey cause (it causes) poor visibility..." (Participant 3).*

**Figure 4.1: The Schematic Network showing the Prevalent Extreme Weather Conditions in the Study Areas.**



In order of frequency, the foremost climate change weather conditions experienced are thunderstorms, which can either be sudden or heavy. Lightning and flooding. This supports the research of Abbas, Ojo, and Igbru (2012), who claimed that lightning and thunderstorms are the extreme weather occurrences linked to climate change in Nigeria. It also supported the findings of Aderinto and Dahunsi's (2008) study, which suggested that flooding due to rainfall was another important factor affecting the aviation sector, particularly air transport services, which can result in flight cancellations and delays.

**Theme 2: Interview on the Impact of CC on Airline Business and Economics**

"...As an air transport operator for mainly passengers, we perform operations to move people or goods from one location to another, and their logistics. It impacts our operations. We have heavy rainfall and flooding in Lagos. Common here. And most times, ma, it leads to hmm, flight delays, cancellations. We have thunderstorms and strong winds, which may lead to turbulence and reduce the number of takeoffs and landings per hour, leading to long flight paths, reducing access to ground operations and scheduling. Thunderstorms are also a major cause of air crashes experienced in this nation and globally, automatically leading to the closure of the operator's business. The impact has reduced air density. Really, though, the airline's finances, which comprise our income, are greatly impacted when

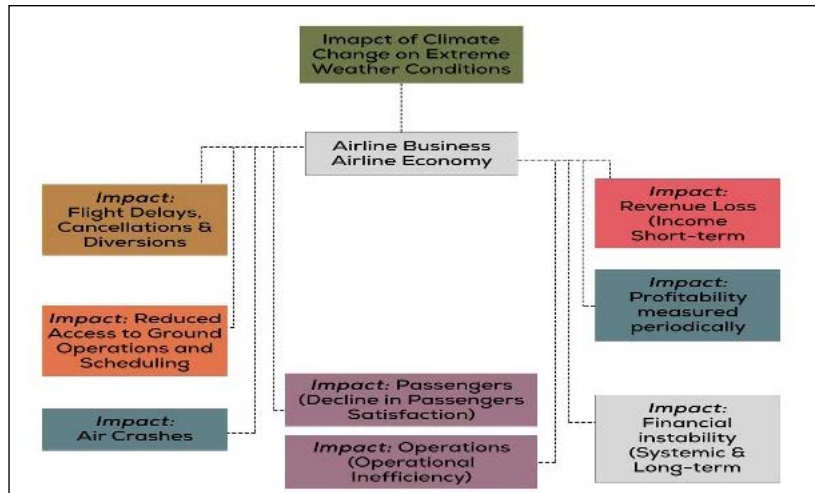
this occurs. You know what revenue means to us. This can impact aircraft performance, especially during takeoff operations. That is, aircraft scheduling, crew management, and flight planning. These climate changes due to extreme weather conditions experienced have rendered some airlines in the country failed and failing establishments, while some were offering partial services..." (Participant 1)

"...Due to these extreme weather events, numerous airlines have gone extinct. The outcome of all the extreme weather conditions is on the airline's final goal and objective of making a profit. It causes flight delays, re-routing, and reduces access to ground operations. We cannot make a profit without our revenue. Our business required a huge amount of capital investment to be competitive, stay on the ground and remain in business by operating our aircraft in profitable routes. Our load factor, financial success as measured by our RASK, CASK, flight rate, on-time performance, and our customers' opinion of our services and scheduling are all impacted by these harsh weather circumstances. Finally, when it leads to the loss of the aircraft and or passengers, it can lead to the end of the airline business and economics..." (Participant 2)

"...Yes. I earnestly believe that these issues discussed today have ruined many airlines in Nigeria, while the owners have gone bankruptcy. In all honesty and sincerity, Madam, climate change, because of extreme weather, has serious implications on our business and economy, which is our revenue.

It causes flight delays, and when this happens, its effects are on the business (disruptions of flights), and eventually our economy/we must refund to obey laid-down international rules and regulations. It often leads to flight cancellations with a business effect-distrust in our passengers, and economic effect-we are paying compensations. It also led to aircraft crashes. The 1987 air crash at Port-Harcourt Airport 1987 stated that the prevalent weather at the time of the crash was a thunderstorm. The Sosoliso air crash at the airport was attributable to the turbulent weather conditions. Today, nobody speaks of Sosoliso Airlines. It has gone down in history. Extreme weather leads to a low load factor and a smaller number of passenger tickets sold. You can guess the implication, madam. This is significant for our revenue. You know our profit margin is so slim and extremely low. Breaking even with all these climate change challenges affects our revenue and profit-making. Business and economy may go into a comatose and eventual death..." (Participant 3)

**Figure 4.2: Impact of Climate Change on Airline Business and Economics**



**\*\*RASK:** Revenue per Available Seat Kilometre. **\*\* CASK:** Cost per Available Seat Kilometre

From the interview, extreme weather and climate change have impacted the airline business and economy, as they affect the parameters for efficiency and profitability. Every element of operational performance, including scheduling, flight planning, flight connectivity, safety, and trajectory optimisation, was influenced by the increasing weather volatility brought on by climate change. This corroborates the report of ICAO CAEP aviation and climate change factsheet (2020), which states that extreme weather conditions have a cost implication on the airline business, such as delayed or cancelled flights. This also validates the study of Flanagan et al. (2018), who stressed that climate change is reshaping design and operations globally.

**Theme 3: Interview on the Impact of CC on the Operational Performance of the Airport**

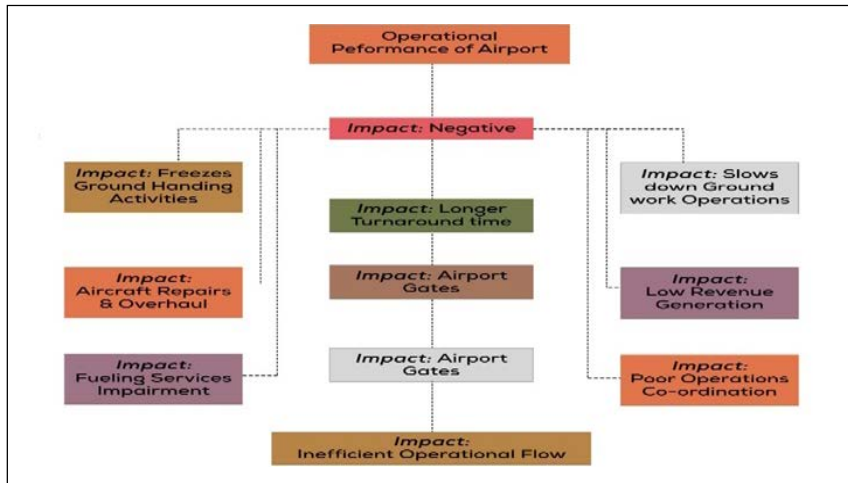
“...Operational performance is crucial to a business’s ability to survive. It is how competently and excellently a company carries out its core activities. In an airport business, it is how efficiently the airport facilitates air travel and related activities. Extreme weather and climate change events have hurt airport operational performance. It slows down the groundwork, as the workers on the ground can’t work during lightning conditions. Aircraft service, baggage handling, fuelling, catering, cleaning, and maintenance are among the ground handling functions that are frozen, which

ultimately has a significant effect on airport turnaround times and operations management. No synchronised operations of all the different performing areas at the airport. Finally, the impact is felt on revenue generation as operations are slowing down...” (Participant 1)

“...Operations is a catch-all term for the core business process of any organisation or business. In an airport setting, operations reveals the comprehensive events within an airport. Operational performance is therefore the smooth and efficient functioning of the airlines, the passengers, business on-airport enterprises, visitors, and airport staff. The impact of climate change on the operational performance of airports will affect safety protocols, as it may slow turnaround times. It will reduce aircraft movement, ground handling activities, baggage handling, passenger processing, aircraft repairing and overhauling. Return on the huge investment might not be too good...” (Participant 2)

“...Operations deal with the organisation of the activities carried out in business. Operational performance of the airport speaks volumes. It is multidimensional. It entails the efficiency and effectiveness of an airport in carrying out its specific and mandatory functions. It reveals how the huge investment expended brings out the expected outcomes. The airside, landside, terminals, gates, and other operational aspects of an airport are all impacted by climate change. Ma’am, the effect is on aircraft

ground handling, which makes sure that the aircraft is operated safely and effectively when on the ground. There will be inefficient operational flow, slow activities, hazardous and risky loading and unloading services, aircraft turnaround time is increased, and flight delays will be on the rampage, no strict safety procedures carried out, catering services, which ensure passengers’ comfort are compromised, poor operations coordination, and fueling services will be impaired. As you rightly asked, all these hurt revenue generation...” (Participant 3).



**Figure 4.3: Impact of Climate Change on the Operational Performance of the Airport**

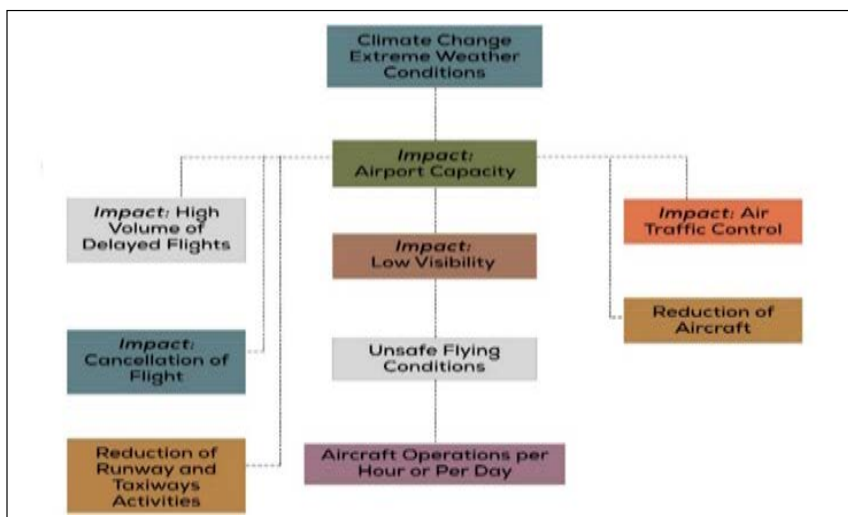
Weather has an impact on all facets of airport operations as well as the economics and commerce of air travel. For instance, flight scheduling, baggage handling, catering, cleaning, and aircraft maintenance. In addition to the physical slowdown that occurs when people perform their duties in more difficult-than-normal conditions, extreme weather also causes traffic congestions at airports by obstructing air traffic control systems and causing aircraft saturation at departure, destination, or somewhere in between. Even in the best of weather, aircraft traffic delays are frequent, and they are certain to worsen when ice, snow, poor runway visibility, and severe crosswinds are present. Even the slightest interruption can have significant repercussions.

**Theme 4: Interview on the Impact of CC on Airport Capacity**

“...Thunderstorms and strong winds have an impact on airport capacity. It leads to the compacting of airspace capacity. This later affects air traffic control. Ma’am, it frequently forces air traffic control to redirect aircraft. It also has the resultant power to thin down air corridors. This limits the number of aircraft that can safely arrive or depart per hour. The impacts are low visibility, leading to unsafe flying conditions. When the airport is in its peak travel hours, the climate change events lead to a high volume of delayed or cancelled flights, and air traffic flow is slowed down or constrained. Ground operation is also impacted as it almost stops work or activities...” (Participant 1)

“...Reduced airspace capabilities resulted from the water problem at Abuja Airport a while back. This pointedly made the runways and taxiways not fit for use. With reduced activities and not fit runways and taxiways slows down arrival and departure charges. This also makes the time for departure superfluous...” (Participant 2).

“...The maximum number of aircraft operations, including takeoffs and landings, that an airport can handle within a given period, such as an hour or a day. The feasibility of integrating renewable energy sources into airports. The weather, aircraft mix, air traffic control regulations, and the actual design of the airport are some of the variables that might affect an airport’s capacity, but extreme weather makes it worse. It impacts the number of aircraft operations per hour or day...” (Participant 3).



**Figure 4.4: Impact of Climate Change on Airport Capacity**

From the interview, extreme weather conditions can significantly reduce airport capacity, which refers to the number of aircraft operations (takeoffs and landings) an airport can handle within a given timeframe. It significantly reduces airport capacity leading to flight cancellations, delays, and diversions. These weather events disrupt various airport operations, including aircraft fueling, baggage handling, and maintenance, ultimately impacting the overall functioning of the airport and airspace. This corroborates with the study of Sasse and Hauf (2003), who insisted that these impacts are both direct (physical limitations) and indirect (safety protocols, regulatory constraints, and operational delays).

**Theme 5: Interview on the Impact of CC on Aviation Infrastructure**

*“...A key major aviation infrastructure globally is the airport, its control tower, terminals, and hangars. Without these, the aviation industry is incomplete, while without our major customers, the airline operating at the airport, the aviation industry is not whole. The impact of climate change due to extreme weather conditions leads to flooded runways due to rainstorms and damaged terminals because of extreme winds, electrical disruptions due to thunderstorms leading to blackouts, and interruptions of activities of ground operations. Thunderstorms pose a serious risk to the aviation sector. It results in wind shear and turbulence. The airlines will have to temporarily move their operations to other airports as a result of this. It causes infrastructure to deteriorate quickly, age, and lose value. Due to flight cancellations and losses, it also has a significant effect on airport and airline income....” (Participant 1).*

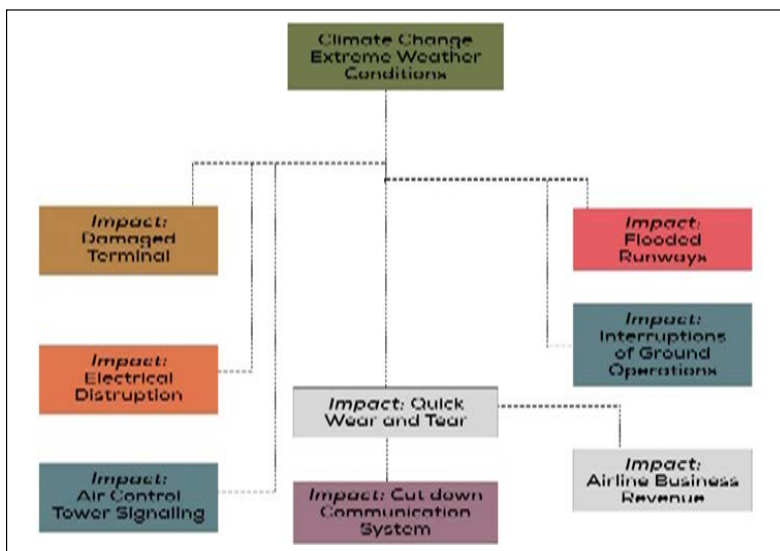
*“...Weather events in Abuja may alter in frequency, intensity, or both. I recall when the airport in Abuja was flooded due to a heavy downpour. All aviation infrastructure is impacted by the severe thunderstorm with its concomitant lightning and thunder, hailstones, icing, low-level wind shear, fog, and harmattan dust haze. The air traffic control system was affected by climate change as a result of this weather...” (Participant 2)*

*These extreme weather and climate change events are severe for the aviation industry. It has a weighty impact on the sector. Severe weather conditions associated with thunderstorms and lightning, assuredly disrupt aviation infrastructure. Lightning strikes at the airport can damage terminal buildings, cut down communication systems, and electrical circuits, potentially disrupting airport operations. The severity of thunder creates harmful and unsafe situations for aircraft, an essential aviation infrastructure, impact on tarmac and natural infrastructure, which are the ground crew personnel...” (Participant 3)*

From the report, extreme weather conditions significantly affect aviation infrastructure. It spans through immediate operational disruptions of the air control tower, damaged terminal, cutting down of the communication system, long-term infrastructure stress, safety concerns, and economic losses. The heavy rainfall/ Flooding causes waterlogging, erosion, and debris on runways. The domestic aviation industry is also impacted by airport infrastructure issues brought on by climate change and extreme weather. This is supported by the work of Sylva and Amah (2021) who stated in their study that the consequence of extreme weather on aviation infrastructure led to poor airport infrastructure, inadequate provision of power, breakdown in communication, inadequate number and small fleet sizes of aircrafts, lack of perimeter fencing of airports and poor technology, which eventually trickles down to domestic airlines.

**5. DISCUSSION OF FINDINGS**

Findings from the research revealed that no discrepancy exists between the prevailing extreme weather conditions and the impact identified in the three study areas. This shows that the aviation industry in the study areas has a serious role in ensuring environmental stability, socio-economic planning and disaster risk reduction. This corroborates with the report of the World Meteorological Organisation [WMO] (2020), which elucidated that a region with no difference in stands to benefit from better-quality and enhanced environmental resilience has coordinated economic planning that supports integrated responses to extreme weather conditions or threats. In addition, homogeneous weather conditions enhance early warning systems and response mechanisms to be put in place. This also agrees with the report of the Intergovernmental Panel on Climate Change [IPCC] (2021) which states that uniform weather makes it easier for the aviation industry and airport system to implement early warning systems and response plans. The study also found that the effects of



**Figure 4.5: The Semantic Network showing the different Impact of Climate Change on Aviation Infrastructure**

climate change and extreme weather on the airline industry and economy are multifaceted, affecting the fragile systems that support airline operations and financial sustainability.

At the business level, it manifests in flight delays, cancellations, diversions, reduced access to ground operations and scheduling, low number of take-offs and landings per hour. All of these jeopardise service dependability, which has detrimental effects on passenger satisfaction. At the economy level, it leads to operational inefficiency due to financial losses, as airlines bear the burden of ticket refunds, stranded passengers' accommodation, and extra charges to the airport. All these result in tightening the profit margins, leading to financial instability, which might reduce investor confidence. This corroborates with the report of the International Civil Aviation Organisation [ICAO] (2016), which stated that the airline industry is extremely vulnerable to the intensifying effects of extreme weather conditions, leading to low productivity or efficiency, increased operational risks and financial losses from grounded flights, and increased insurance premiums.

Findings revealed that extreme weather conditions driven by climate change pose significant threats to airport operations, capacity and infrastructure. This corroborates with the study of the United Nations Office for Disaster Risk Reduction [UNDRR] (2015). The study maintained that airports and their infrastructure are particularly vulnerable to extreme weather. The study emphasised that this happens especially in many international airports near coastlines and are increasingly exposed to flooding, citing Lagos, Bangkok and New York airports as examples. In addition, extreme weather disrupts the smooth operations and performance of the airport by having negative impacts manifesting as longer turn-around time, inefficient operational flow, poor operations coordination, slowing down groundwork operations and low revenue generation. This validates the study of Balakrishnan & Donohue (2008), who

declared that extreme weather reduces on-time performance and schedule reliability.

Extreme weather impacts airport capacity by restraining the actual capacity of the airports from numerous magnitudes by contributing to a high level of delays, cancellation of flights, reduction of runways and taxiways activities leading to increased runway occupancy times, and shrinking available slots for airlines, low visibility, unsafe flying conditions, and limiting air traffic activities. These put the aviation infrastructure's capacity efficiency, dependability, and safety at risk, necessitating delays, detours, or cancellations. This confirms the study of Balakrishnan and Donohue (2008); Kulesa (2003), who emphasised how climate change-driven extreme weather events reveal airports' procedural and physical weaknesses, lowering the system's overall capacity and efficiency. In addition, extreme weather driven by climate change poses significant impacts to the physical infrastructure of airports as it accelerates the runways, taxiways, terminals and navigation systems depreciation. These infrastructure damages increase maintenance costs. This revalidates the study of Balakrishnan & Donohue (2008), which elucidates that airport infrastructural damages because of extreme weather led to high maintenance costs and necessitate expensive climate adaptation strategies by airport management. This climate change-induced extreme weather condition compromises the functionality, safety, durability, and financial sustainability of airports (Mills and Andrey, 2002).

## 6. CONCLUSION

The study concludes that, like in other countries throughout the world, Nigeria's aviation business is affected in multiple ways by climate change-related extreme weather conditions. This includes effects on flight operations, airport infrastructure, and overall air traffic management. As a result, stakeholders must develop adaptive strategies to mitigate these challenges and ensure the sustainability

of the aviation sector. By investing in resilient infrastructure and adopting innovative technologies, the industry can better navigate the uncertainties posed by a changing climate while continuing to support economic growth and connectivity.

## 7. RECOMMENDATIONS

Based on the findings, the aviation industry urgently needs aggressive policy and infrastructure adaptation, given the rising occurrence and intensity of extreme weather events due to climate change. The Nigerian Civil Aviation Authority [NCAA], in partnership with the Federal Airport Authority of Nigeria [FAAN] should develop and implement resilience framework that will mandate climate risk assessments for all major airports, conduct risk assessments of their new and existing infrastructure to lower risks and expenses, adapt capacity management models, and guarantee future punctuality and regularity in the aviation industry and establish infrastructure adoption plans like the climate-smart air traffic control systems, and storm resilient terminals. Moreover, investing in weather monitoring equipment, technologies, and other logical systems should be a top priority for the Ministry of Aviation, meteorology agencies, and other planning units due to operational sensitivity. Furthermore, the Ministry of Aviation should adopt policies that integrate climate adaptation into aviation planning. This will aid in protecting the infrastructure, maintaining airport capacity, and ensuring long-term airline operational sustainability.

Airline operators should strengthen their operative agility by purchasing aircraft with cutting-edge avionics and weather resilience or prediction technologies, invest in smarter weather forecasting by incorporating real-time meteorological data into their flight planning system, and take proactive measures to alleviate weather risks, invest in decision-support systems, have robust financial planning, which can protect both their business reputation and revenue generation, while aligning their operations with

international best practices outlined by the International Civil Aviation Organisation.

Conclusively, the Nigerian government should start seeing extreme weather conditions as not inconveniences that happen occasionally to aviation industry operations, but understand that it is a strategic threat to the entire industry and ensure the training and re-training of meteorological personnel in the aviation sector, often to considerably lessen the effects of overstrain in weather observation and reporting. The implication is that this will help the industry navigate these conditions ahead, emerge stronger, safer and more adaptive to the changing climate, while improving the airport by making its operation efficient.

## 8. REFERENCES

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