# EVALUATION OF THE EFFECTS OF LOW HORIZONTAL VISIBILITY ON FLIGHT OPERATIONS IN NNAMDI AZIKIWE INTERNATIONAL AIRPORT, ABUJA.

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***Abstract***

*The aim of the study is to evaluate the effects of low horizontal visibility on flight operations in Nnamdi Azikiwe International Airport Abuja, Nigeria. The data for low horizontal visibility frequency (2009-2018) were collected from the Nigerian Meteorological Agency (NIMET), while the data for flight operations and Air accident were obtained from the Nigerian Airspace Management Agency (NAMA) and AIB (Accident Investigation Bureau) respectively. The linear regression analysis was used to examine the relationship between the selected weather parameter and flight operations in the study area, it was achieved with the use of the data analysis pack of the Microsoft excel program. To compare the relationship between the weather element (visibility) and air accidents at the Nnamdi Azikiwe International Airport Abuja, the linear regression analysis was also used to determine the degree of relationship that exists between these two variables of interest. The time series plot of monthly total of visibility and monthly average of visibility shows that the poor visibility at Nnamdi Azikiwe International Airport occurred during dry seasons i.e mostly January and December period under the years of study. The lowest occurred in the month of January. The trend in visibility in the study area in an annual and monthly basis both have a negative trend which means that visibility on annual and monthly basis are decreasing. The coefficient of the visibility (-5.531E-5) is negative meaning the lower the poor visibility occurred, the lower the number of flight diversion. The F-statistic value of 15.804 at 5% ($p<0.05$) implies that there is a significant relationship between flight diversion and visibility under the year of study. The coefficient of the visibility (-1.078E-6) is negative meaning the lower the poor visibility occurred, the lower the air accident. The F-statistic value of 2.727 at 5% ($p>0.05$) implies that there is no*

*significant relationship between air accident and visibility under the year of study. I hereby recommend that The Nigerian Meteorological Agency (NIMET) and Nigeria Airspace Management Agency (NAMA) should be provided with advanced equipment to facilitate their duty, Aircraft with modern technology that can operate in terms of fog and mist should be introduced to the Nigerian Airports.*

***Keyword**: Visibility, Regression, Flight, Coefficient, Relationship and horizontal*

## INTRODUCTION

The effect of weather variation brought about by global warming is a lot of concern to the aviation industry. Abass *el. al.* (2012) stated that several airlines have been moribund, while some offer partial services as a result of extreme weather events. Aviation, probably more than any other mode of transportation, is greatly affected by weather. From thunderstorms and snow storms, to wind and fog, thick-dust haze as well as temperature and pressure extremes, every phase of flight has the potential to be influenced by weather (Kulesa *et al*. 2013). Aircraft travels through the atmosphere. The atmosphere varies vertically and horizontally in pressure, temperature, density and atmospheric humidity. It contains variable quantity of water vapour, which when condensed produce a gaseous fog and continues like that to cloud, sleet hail and precipitation all which affect visibility (Oliver, 1997). Safety and efficiency of air traffic may be affected by weather phenomenon such as reduced visibility, turbulence, wind shear, thunderstorm particularly at the terminals of an airport, results in delays, diversion, cancellation of flight and reduced Airport capacity as well as accident (Oliver, 1997). Weather extremes have tremendous influence on flight operations. From time immemorial, flight operations like any other human endeavours have been significantly affected, in terms of takeoff, landing and even in-flight by extreme weather. Extreme weather values have long been known to be threatening to all aspects of air transportation, each year more than one quarter to one-half of all accidents is weather related. While the economic losses due to flight delays, diversions, cancellations, and accidents caused by weather are estimated at more than one billion per year [National Weather Service (NWS), 2008]. Visibility is one of the major weather elements, which affects all forms of traffic from road to aviation. It is the most obvious weather parameter that affects aircraft operations (Hughes, 1982). Weather continues to play a significant role in number of aviation accidents and incidents. While National Transportation Safety Board (NTSB) reports most

commonly find human error to be the direct accidents caused, weather is a primary contributing factor in 23 percent of all aviation accidents (Kenneth and Libbrecht, 2001). Though many studies might have been conducted on the effect of visibility on aircraft operations in different parts of the country and world in general, more research needs to be carried out in the area under study.. The word horizontal is very important in that there may be mist or fog in a small nearby valley which may block the observers view. Visibility is measured by references to objects or lights whose distance from the observation is known (Seinfeld *et al,* 2006). According to Seinfeld *et al.* (2006), Fog and mist are generally assumed to be composed principally of water droplets. Haze and smoke can be of smaller particle size. This has implications for sensors such as Thermal Imagers (TI/FLIR) operating in the far-IR at wavelengths of about 10μm which are better able to penetrate. Haze and some smokes because their particle size is smaller than the wavelength; the IR radiation is therefore not significantly deflected or absorbed by the particles.

Low visibility can be caused by different weather parameters; these are rainfall, thunderstorms, fog, and thick-dust haze. Liquid visibility and fog account for most low visibility in Nnamdi Azikiwe International Airport, Abuja while thick dust haze can restrict visibility and making it difficult for landing and take – off of extreme danger.

**The Study Area**

The Nnamdi Azikiwe International airport was built in 2000 and opened in 2002. The airport is located on latitude 09°00`N and longitude 07°15`E. It is about 49km away from the main town. The airport type is public, elevation is AMLS 1,123ft/342m, runways direction is 04/22 and length is 3,609m/11,842ft (Abdulazeez, 2009). Although the Airport is the most modern in Nigeria with many world class facilities such as state of the art radar systems, watch towers, hangars, well laid runways and two terminals one for domestic flights and the other for international flight services it is yet to be completed as work is on going with its second phase. The length of its asphalt surface runway is 3,609m and has an elevation of 342m (Nigerian Aeronautical Information Publication [NAIP], 2013). It has a presidential wing made up of a taxiway linking the runway, Presidential Hanger, guest chalet and the Presidential Lounge, which is fully developed. However, with its first phase, the Airport has excellent facilities. The second Phase of the airport is ongoing construction and renovations, when completed will have a parallel taxiway, the first module of the international terminal building, fire fighting station, protocol lounge, access roads and the linking of the international

and presidential wings with water lines from water scheme services (Wikipedia online version, 2009).

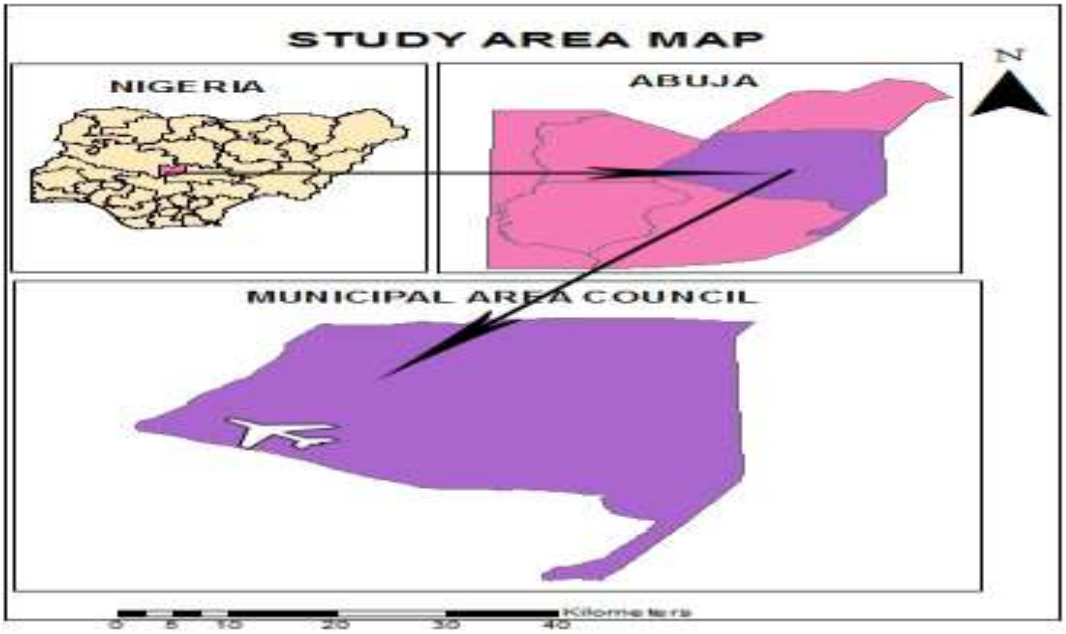


**Figure 1.1** Location of Nnamdi Azikiwe International Airport, Abuja Nigeria. Source: (Department of Geography, Federal University of Technology, Minna, Nigeria 2019)

## LITERATURE REVIEW

### Visibility and Flight Operations

The accurate forecasting of visibility, fog clearance and fog formation at most airports according to Maunder (1970) is in many cases difficult. Nevertheless, accurate visibility and fog forecasts are important especially if flight delay or diversion must be controlled at low latitudes (at approach/landing). Smith (1975) has shown that even with the increasing sophistication of automatic landing equipment poor visibility from fog and low cloud ceilings is still the major impediment to flight operations throughout the world. Ehigiator (2007) reported that poor visibility due to harmattan haze disrupted flight operations from Lagos to Owerri. While some airlines delayed flights to the northern part of the country for some hours, others cancelled their flights outrightly because the visibility was worse. Ehigiator and Orakpo (2010) reported that poor visibility resulted in the cancellation of flights from Lagos to Benin, Owerri and the northern part of the country. This was because NIMET forecasted that there was a significant build up

of surface pressure systems over the Sahara Desert and the Sahel regions in the past few days, which resulted in the lifting of considerable quantity of dust particles into the atmosphere in those regions. The raised dust particles were transported southwards and caused significant reduction in the horizontal visibility over the extreme north-eastern part of the country. Places around Maiduguri, Potiskum, Nguru and Kano experienced severe harmattan dust haze with the associated reduction in horizontal visibility to less than 800m, and in some days, horizontal visibility was reduced in Maiduguri and Yola to less than 300m. Base on this weather condition, Nigeria Civil Aviation Authority (NCAA) set weather minima for most airports in the North to less than 1000m and at 800m and set a fine of N50, 000.00 for erring pilots and N500, 000.00 for the airlines. Abubakar and Nurudeen (2011) also reported the cases of flight delay and cancellation because of poor visibility. They reported that flights from Kano, Abuja, Yola and other parts of the North especially, were delayed for 2 hours and above due to poor visibility.

NIMET (2011) reported that the year 2010 witnessed a few instances of disruptions due to severe weather conditions. However, the month of March recorded a severe dust hazy spell, which reduced horizontal visibility to between 200m-800m for several days and this caused many disruptions in flight operations across the country. These disruption affected flight operations in Lagos, Abuja, Kano, Kaduna, Minna, Maiduguri, Sokoto, and Enugu. Others were Owerri, Port Harcourt and Calabar airports. There were also cases of outright cancellations. In January and December, early morning fog was reported in Lagos, Port Harcourt and Jos, which reduced horizontal visibility to between 200m-800m. This resulted in flight delays at these airports. In addition, thousands of Europe-bound Nigerians were stranded at the Murtala Mohammed International Airport Lagos, as heavy snow pounded European airports in December. These harsh weather conditions affected the number of inbound and outbound flights at the Murtala Mohammed International Airport during the period. NIMET (2011) also reported flight delays, cancellations and diversions due to adverse weather conditions during the year 2010. Preliminary analysis of air traffic at the Nnamdi Azikiwe International Airport Abuja shows March with the highest number of flight disruptions largely due to the harmattan dust haze. The prevailing dust haze during the period (March) resulted in very low horizontal visibility at most of the nation's airports. In addition, flight disruptions were reported during the wet season mainly due to heavy downpours, severe thunderstorms and squally weather. On an everyday basis, people use weather forecasts to determine what to wear on a given day. Since outdoor activities are severely curtailed by heavy rain, snow and the wind chill,

forecasts can be used to plan activities around these events, and to plan and survive them (Wikipedia online version, 2009).

Frequently, there is a time lag between awareness of an impending event or need and occurrence of that event. This lead-time is the reason for planning and forecasting. In this situation, forecasting is needed to determine when an event will occur or a need arise, so that appropriate actions can be taken (McGee, 1982) and Abdulazeez (2009). Meteorology and Climatology, according to Smith (1975) have been applied to the problems of aviation ever since man first started to fly. The meteorological agencies in the nation's airports have done a lot in discharging their principal functions of providing service to the state's military and civil aircrafts in forecasting the weather. Different techniques are used for the various types of forecasts to know the state of the atmosphere at any given moment, and to know the physical laws that govern the changes of that state (Ayoade, 2004). Some studies have been successful in developing methods for predicting weather at airports. One of such is the low stratus and fog situations connected with cyclones and their fronts by (Riehl, 1965).

Aviation industry in Nigeria depends on Nigerian Meteorological Agency (NIMET) for its weather reports. NIMET supply the weather reports and the flight operations department plan flights base on the reports. However, the recent spate of untoward accidents and incidents in some airports across the country was attributed to high unreliable weather reports from NIMET (Ayigbe, 2007), which put a big question mark on the ability for the aviation authority in Nigeria to make the environment safe and conducive for flying (Oketunbi & Shadere, 2005). The incidents were so bad that some Airlines, according to Shadere (2005) struggled to recover from the misfortunes that befell them because of wrong information given from the control towers.

Visibility for aeronautical purposes is the greatest distance at which a black object of suitable dimensions situated when observed against a bright background. It is also defined as the greatest distance at which lights of 1,000 candles can be seen and identified against an unlit background; the two distances have different values in air of a given extinction (Seinfeld *et al,* 2006). Troposphere air contains microscopic particles at varying concentrations, clouds, dry aerosols such as air pollutants, smoke dust as well as hydrometeors such as snow and other forms of precipitation reaches visibility and influence air traffic operation negatively (Doganis, 2002).

## Flight Operations

‵Flight operations″ deals with flight and aircraft dispatch, flight Crew and flight watch. In other words, ‵Flight operations″ is such a generalized term which encompasses many things in the aviation operations, and that definitions given to this term are based on Airlines at a local station of operation. For many Airlines, at a local station, flight operations refer to the agents who perform weight and balance functions for flight transiting their city. However, it is more acceptably defined, as the central decision-making center for the Airline that handles flights (Civil Aviation Forum, 2001 and 2005). Webster Online Dictionary (2009) described flight operations as a department constituting sections such as flight training, flight control, flight dispatching and a meteorological section, strictly supervised by a Manager to ensure maximum operating efficiency and air traffic safety. Other sections identified by Civil Aviation Forum (2001 and 2005) are flight engineers, flight crew, flight watch and aircraft flight: departure and arrival. The aircraft flight section constitutes three important phases of flying viz takeoff, in-flight and landing. Of these, landing has been observed to be the most troublesome phase of flight operations, followed by takeoffs. Studies on aviation accidents have shown that approximately 80 percent of all aviation accidents occur shortly before, after, or during takeoff or landing, and often described as resulting from ``human error''. While, mid-flight disasters are rare but not entirely unheard of (Wikipedia online version, 2008). For example, the investigations into the crashes of Bellview and Sosoliso airlines in 2005 and ADC airline in 2006 in Nigeria were reported to occur between takeoff and landing and caused by wind shear (variation in the local wind speed and direction) however, induced by human error (All Africa Global Media, 2005 and Ayigbe, 2006).

## Weather Parameters of Visibility

The word weather (‘along with climate’) has been mis-defined by various authors. Of recent, these definitions have no place in climatology as a science course. For example, the essential difference between the two forms is that weather only relates to the state of the atmosphere during one specific period. For climate, it relates to the statistical likelihood of occurrence of various states of the atmosphere over a longer period. In the past, climate was defined as “average weather” and also as a synthesis of a given location over a period of about 30 – 35 years. This is wrong and misleading (Aremu, 2008). However, weather should be defined according to Gibbs (1987) as the state of the atmosphere over a given region during one given period (minute, hour, day, month, season, year, decade etc.) and climate as the

"statistical probability of the occurrence of various states of the atmosphere over a given region during a given period" (Aremu, 2008). He added that the definition of climate as an average weather must be avoided. In aviation, there are so many weather parameters that do affect visibility of aircraft operations; these include dust particles, fog, haze, rain, cloud ceiling, mist, snow, thunderstorm, turbulence etc. (Hughes, 1982)

## METHODOLOGY

Identifying the seasons with poor visibility vis-à-vis air transport. Data on the selected weather element (visibility) were collected from the Nigerian Meteorological Agency, Abuja Airport. The data was processed to determine the mean monthly and annual values. The months were clustered into seasons. Descriptive statistics such as bar charts and line graphs were used to analyse the seasonality of the selected weather parameter over the study area.

Analyzing visibility trend from 2009-2019. The selected weather data of low horizontal visibility was plotted to determine the trend of low horizontal visibility. Descriptive statistics was also used to achieve the objectives and was carried out with the use of the Microsoft Excel program.

Linear trend estimation which were treated as time series analysis was used to determine the trend for visibility for the specified years under investigation.

To determine the relationship between the weather element (visibility) and flight operations of Abuja international airport, the linear regression analysis was used to determine the degree of relationship that exists between two variables of interest. Hence the linear regression analysis was used to examine the relationship between the selected weather parameters and flight operations in the study area, it was achieved with the use of the data analysis pack of the Microsoft excel program.

Basic straight relapse is a measurable strategy that enables us to outline and study connections between two nonstop (quantitative) factors:

One variable, indicated X, is viewed as the indicator, or autonomous variable.

The other variable, indicate by Y, is viewed as the reaction or ward variable.

The degree of correlation between X and Y (in this case visibility < 2000m and diverted flight) were measured by product moment correlation coefficient, r, which is described as

$$r = \frac{\mathrm{N}\Sigma xy - (\Sigma x)(\Sigma y)}{\sqrt{(N\Sigma x^2 - (\Sigma x)^2)(\mathrm{N}\Sigma y^2 - (\Sigma y)^2)}}$$

Where s.d. of x= standard deviation of x

s.d of y= standard deviation of y 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 (diverted flight).
Comparing the relationship between the occurrence of low horizontal visibility and air accidents at the Nnamdi Azikiwe International Airport Abuja, the linear regression analysis was used to determine the degree of relationship that exists between these two variables of interest.
Correlation reflects the extent to which a change in one set of variable is explained by a change in the other set. In this research it is used to show the relationship between the occurrence of low horizontal visibility and air accidents. However, through this statistical technique one can be able to show the magnitude of the association and its direction. The correlation coefficient ranges from +1.00 to -1.00. Zero correlation indicates no association. Of the various types of correlation analysis, Pearson's Production Moment Correlation (PPMC) was used.

## RESULTS AND DISCUSSION

The time series plot of monthly total of visibility (in figure 1a) and monthly average of visibility (in figure 1b) shows that the poor visibility at Nnamdi Azikiwe International Airport occurred during dry seasons i.e mostly January and December period under the years of study. The lowest occurred in the month of January.

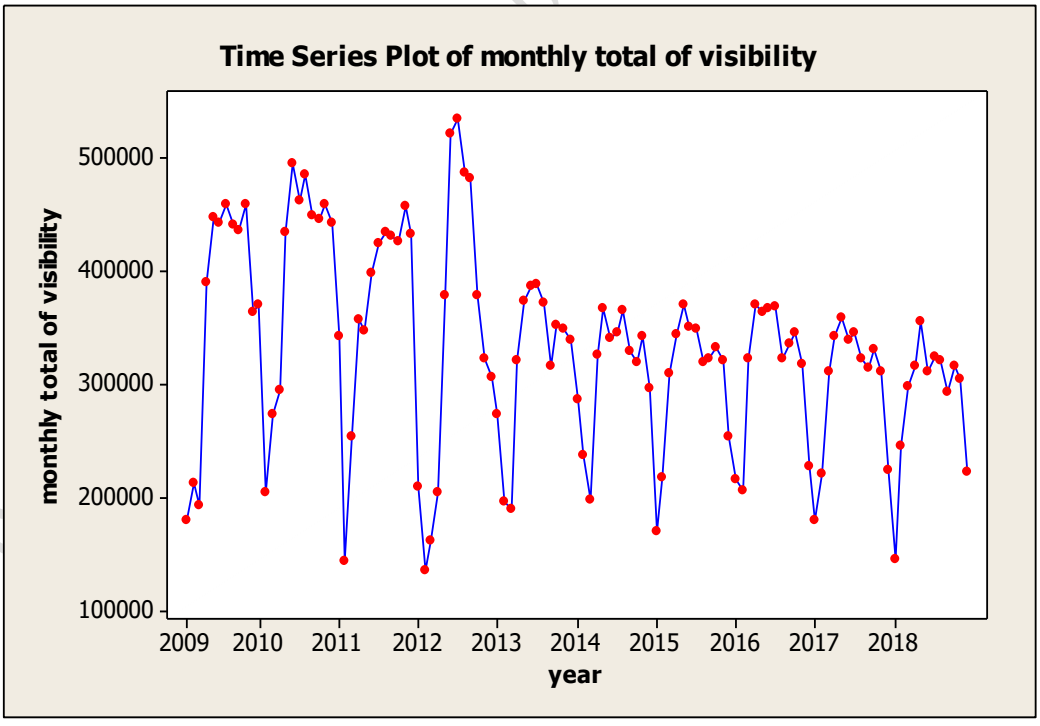

Figure 1a: Time series plot of monthly total of visibility in Nnamdi Azikiwe International Airport.

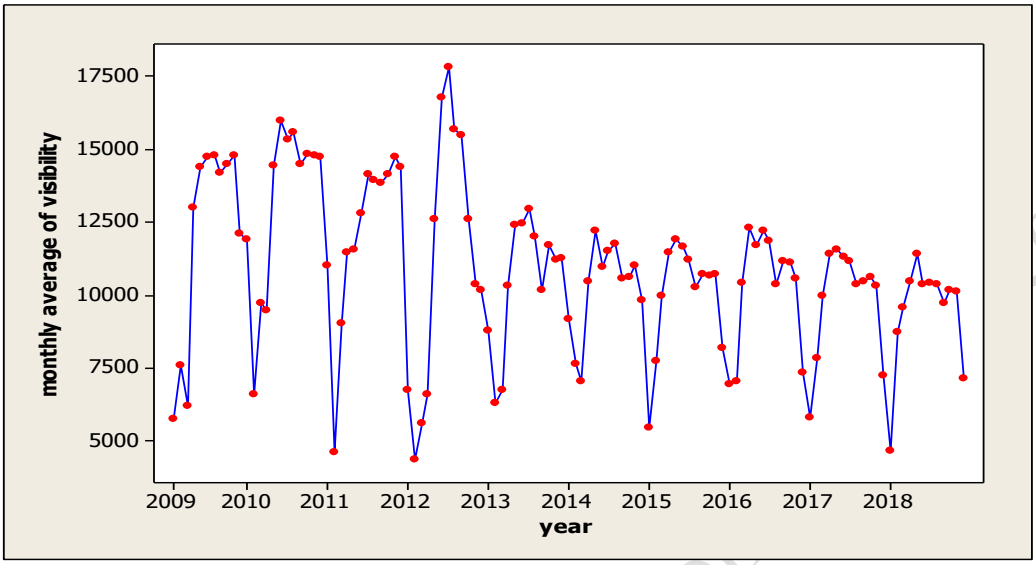


Figure 1b: Monthly average of visibility in Nnamdi Azikiwe International Airport.

Annual trend Analysis of Poor visibility

The annual and monthly trend of visibility shows the variability and fluctuation among the data sets with no definite pattern as shown in figure 2a and 2b respectively.

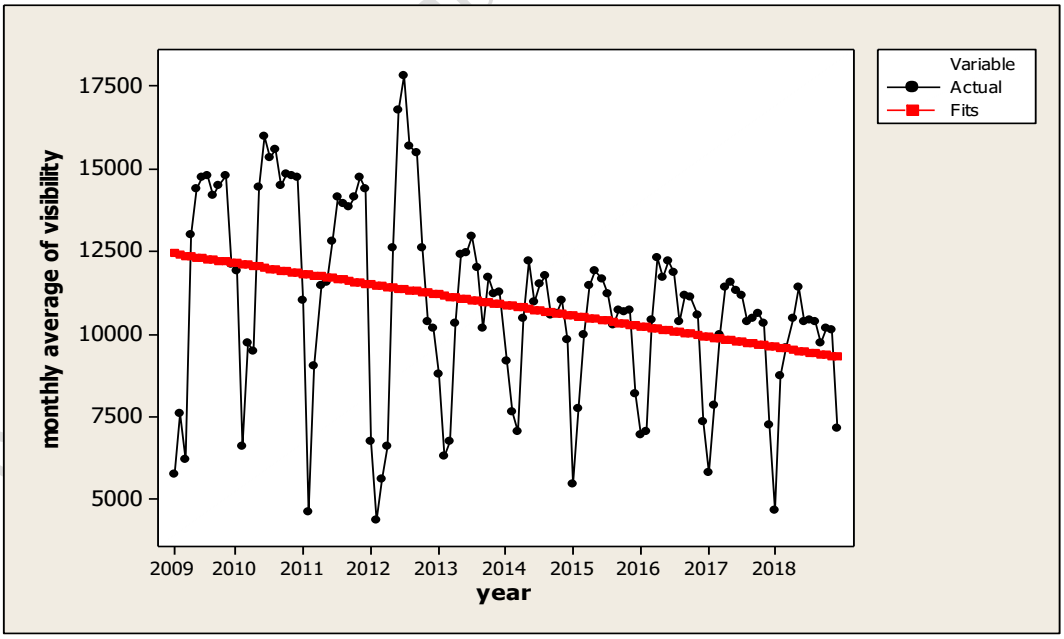

Figure 2a: Annual trend of visibility in Nnamdi Azikiwe International Airport Abuja.

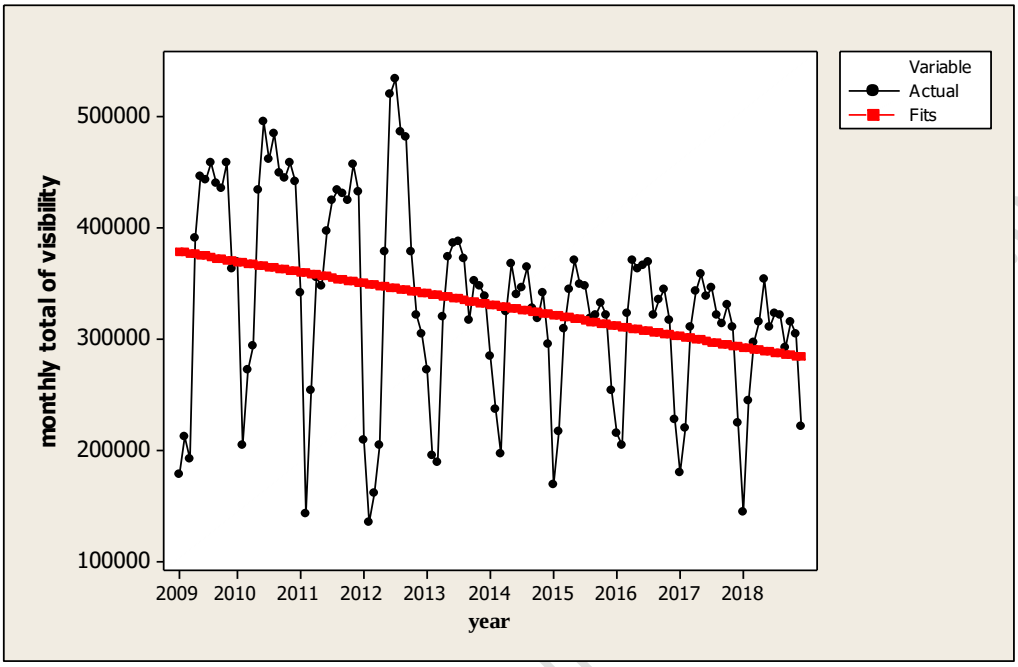


Figure 2b: monthly trend of visibility in Nnamdi Azikiwe International Airport Abuja.

Figure 2a and 2b represent the trend in visibility in the study area in an annual and monthly basis respectively. They both have a negative trend which means that visibility on annual and monthly basis are decreasing.

Table 4.1: Regression result of flight diversion and visibility under the year of study (2009-2018)

| **Explanatory** | **α coefficient** | **Standard error** | **t-statistic** | **Prob** |
|---|---|---|---|---|
| **Constant** | 385.891 | 55.161 | 6.996 | .000 |
| **Visibility** | -5.531E-5 | .000 | -3.975 | .004 |

$R^2$ = 66.4%, Adj $R^2$ = 62.2%, F = 15.804

The value of $R^2$ which shows a value of 66.4% which implies that the variation in the dependent variable (flight diversion) can be predicted by 66.4 percent from the independent variable (visibility). The coefficient of the visibility (-5.531E-5) is negative meaning the lower the visibility occurred, the lower the number of flight

diversion. The F-statistic value of 15.804 at 5% ($p<0.05$) implies that there is a significant relationship between flight diversion and visibility under the year of study.

**Correlation between poor horizontal visibility and air accidents**

Table 4.2: Regression result of air accident and visibility under the year of study (2009-2018)

| Explanatory | α coefficient | Standard error | t-statistic | Prob |
|---|---|---|---|---|
| **Constant** | 4.748 | 2.588 | 1.835 | .104 |
| **Visibility** | -1.078E-6 | .000 | -1.651 | .137 |

$R^2$ = 25.4%, Adj $R^2$ = 16.1%, F = 2.727

The value of $R^2$which shows a value of 25.4% implies that the variation in the dependent variable (air accident) can be predicted by 25.4 percent from the independent variable (visibility). The coefficient of the visibility (-1.078E-6) is negative meaning the lower the visibility occurred, the lower the air accident. The F-statistic value of 2.727 at 5% ($p>0.05$) implies that there is no significant relationship between air accident and visibility under the years of study.

**CONCLUSION**

Base on the result of this study, it is therefore evident that flight operations is greatly affected by visibility at Nnamdi Azikiwe International Airport Abuja, as revealed by weather parameters data records of Visibility by NIMET. Also data records of flight diversion by NAMA and air accident data by AIB. During dry season/Harmattan period in the months of December, January, the visibility was reduced by dust haze and during raining season most especially in the months of, June, July, August, and September the visibility was affected by rainfall. Bad visibility/weather experienced in these two seasons had given rise to flight delayed, cancellation, diversion and flight returned, but this trend tends to reduce in the months of April, May, October and November, because these months the weather seems to be relatively good due to the absent of fog and dust haze.

To sum it up therefore, poor visibility adequately account for number of flight diverted. It can be concluded that the main influence in aviation industry is visibility and so, flight operations revolved mainly around the fluctuations of visibility which results to poor visibility. The understanding of the effect of

visibility in aviation industry is necessity for sustainable socio- economic development of any nation.

## RECOMMENDATION

In aviation industries, the effect of visibility on flight operations is the major cause of flight delay, cancellation, diversion and reroute as well as plane crashes. The following recommendations aroused from the findings of the study, thus becomes pertinent in order to ensure that air accident is reduced to the barest minimum, so as to give flight operators and passenger a service of safety. Also to reduce the cost involved by poor visibility to aviation industries. These recommendations include:

1. The Federal Airport Authority (FAA) should ensure the efficient use of navigational aids such as Instrumental Landing System (ILS) and radio detecting ranging equipment (radar) to all airports in the country.
2. Aviation industries should engage in the used of cloud seeding to dispersed fog in the Airports.
3. The Nigeria Meteorological Agency (NIMET) and Nigeria Airspace Management Agency (NAMA) should be provided with advanced equipment to facilitate their duty
4. Aircraft with modern technology that can operate in terms of fog and mist should be introduced to the Nigerian Airports.
5. Heavy luggage carrying by passengers should be discouraged to avoid flight delays as a result of operational reasons.
6. Old Aircraft should be replaced with new once to avoid technical problems caused by bad engine.
7. More accurate ways of weather information should be emphasised through the training and retraining of aviation personnel.
8. Reliable and well equipped weather stations with prediction of weather elements should be established not only in airports, but also in strategic locations across the country to enable the spatial analysis of weather across air routes.

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