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Research article

ANALYSIS OF RAINFALL ON INTRA-URBAN TRAVEL PATTERNS AMONG PEOPLE LIVING WITH DISABILITIES IN THE FEDERAL CAPITAL TERRITORY, ABUJA

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ABSTRACT

Climate change increasingly disrupts urban mobility, yet its intersection with disability remains critically under-researched in African cities. This study examines the impact of rainfall on intra-urban travel patterns among people living with disabilities (PLWDs) in the Federal Capital Territory, Abuja, using a mixed-methods approach with 366 survey respondents across the six Area Councils and qualitative focus group discussions. Findings reveals that rainfall significantly dictates modal choice ($X2 = 95.69$, $p< 0.001$), forcing a shift from walking and assistive devices toward costly private transport options (taxi use rising from 28.7% to 46.5% on rainy days). Trip volume dropped by 55.2% during rainfall (from 585 to 323 trips), with regression analysis showing that journey purpose and weather jointly explain 48% of trip variation ($F = 5.133$, $p = 0.027$). While journey purpose and trip duration remained statistically unchanged ($p = 0.776$ and p 0.095 respectively), spatial inequalities emerged, as AMAC accounted for 51.3% of trips, while Abaji accounts below 4%, reflecting infrastructural centralization. Crucially, no significant association was found between disability type and modal choice ($p = 0.31$), indicating systemic barriers affecting all the people living with disabilities (PLWDs). The study exposes a profound implementation gap in the Discrimination Against Persons with Disabilities (Prohibition) Act, 2018, as climate-resilient transport infrastructure remains absent. We recommend disability-centered climate adaptation strategies, equitable infrastructure investment across all Area Councils, and enforceable universal design standards to advance inclusive mobility and climate justice in Nigeria.

KEYWORDS

People Living with Disabilities, Rainfall, Intra-Urban, Travel Patterns, Area Councils in Abuja

Introduction

Urban rainfall significantly influences travel behavior in developing countries, impacting mobility accessibility for all residents. Heavy precipitation disrupts intra-urban travel by causing delays, forcing route adjustments where roads become impassable and altering travel patterns across socioeconomic groups (Enesi et al., 2023). In Nigeria, where transport systems struggle with infrastructure challenges, the burden on people living with disabilities (PLWDs) is amplified (Onyemenam et al.,2025). Extreme weather limits travel access for vulnerable groups due to lack of inclusive transport measures (Chukwudum et al., 2025). The Federal Capital Territory, Abuja established in 1976 as Nigeria's administrative headquarters, experiences rainfall patterns that significantly shape intra-urban travel. Heavy downpours slow vehicle movement due to poor visibility and bad road conditions, which is traceable to high influence of climate change particularly, northern part of Nigeria. Aminu et al., (2026) assesses community perceptions of flood incidences and their climate change linkages in Gombe State , Nigeria using a four multistage sampling design, the study concludes that there is a significant relationship between resident's awareness of climate change and their perceived flood-frequency changes, and recommends strengthening climate change awareness programs particularly among the vulnerable groups. The Abuja Municipal Area Council, the most populous and metropolitan centre, enjoys relatively better infrastructure than other councils, though traffic congestion and limited public transport persists.

Rainfall disrupts intra-urban movement through pot holes, surface flooding, congestion, and vehicle breakdowns. For people living with disabilities (PLWDs), these disruptions are compounded by lack of accessible infrastructure, disability aids, poverty, and weak policy enforcement. The nexus between rainfall and intra-urban travel requires urgent attention, as people living with disabilities (PLWDs) disproportionately feel these impacts. Despite Nigeria's endorsement of United Nations Conventions on the Rights of Persons with Disabilities (CRPD), climate policy and urban resilience planning rarely include people living with disabilities (PLWDs) needs. Bwari, Gwagwalada, Kuje, and parts of Abuja Municipal Council are prone to flash floods. Recent flooding events in Angwan Hakimi and Orozo (2024) caused destruction of homes and roads, creating accessibility problems. Wheelchair users and individuals with visual, cognitive, and physical impairments are most affected, as evacuation during hazards is difficult. Perennial flas flooding across Nigeria (Mokwa, 2025;

Lagos, Adamawa, Akwa Ibom, Taraba) has affected approximately 400,000 people, demonstrating the overwhelming nature of this hazard.

Infrastructural exclusion and climate change have double implications for people living with disabilities (PLWDs), making mobility more difficult. As climate change intensifies, challenges faced by people living with disabilities (PLWDs) exacerbate, leading to reduced transport accessibility, increased travel costs, and limited options. Rising temperatures, increased urban floods, and infrastructural fragility affect mobility chains, and widening social vulnerability gaps. International institutions including the United Nations, African Development Bank, and World Health Organisation emphasise disability-inclusivity in climate resilience strategies. In Nigeria, the nexus between research and policy development on climate change, disability, and intra-urban mobility remains unconnected. This study fills this gap by analyzing the impact of rainfall on intra-urban travel of people living with disabilities (PLWDs) in the Federal Capital Territory, Abuja.

The objectives of this study are:

1. Examine rainfall impact on intra-urban travel patterns of people living with disabilities (PLWDs)
2. Assess demographic and socioeconomic characteristics influencing mobility choices
3. Determine the relationship between weather conditions and transport modal choice among people living with disabilities within Federal Capital Territory, Abuja
4. Analyse spatial variations in rainfall impacts on intra-urban travels of people living with disabilities (PLWDs) within Federal Capital Territory, Abuja

LITERATURE REVIEW

Rainfall patterns in the federal Capital Territory demonstrate clear temporal and spatial differences with significant socioeconomic impacts. Floyd and Hassan (2022) investigated climate variability between 1983 and 2010, revealing significant increases in total annual rainfall with long-term variability reaching 33.5%. They noted the area's poor adaptive capacity highlights increased flood risks, emphasizing inclusive infrastructure planning. Dada et al. (2021) analysed rainfall and convective systems across Nigerian cities including Abuja from 1985-2015, demonstrating positive agreement between rainfall and maximum temperature during dry and transitional seasons but negative correlation during the core wet season. This reveals that rainfall intensity and temperature dynamics vary seasonally. Olawale et al. (2024) examined seasonal and inter-annual precipitation variability across Nigeria from 1980-2020, confirming that north-central Nigeria shows strong year-to year variability. Federal Capital Territory, Abuja's rainfall patterns is influenced not only by latitude but also by urban-induced miroclimatic changes such as overland heat and land-use conversion.

Ugwu et al. (2024) analysed rainfall dynamics over 34 years (1986-2019) in north-central Nigeria, showing moderate to high variability with trends differing across seasons and locations, aligning with multi-decadal shifts reported by Floyd and Hassan (2022). Itiowe et al. (2020) found increased dryness and rainfall irregularity between 2013-2016, particularly during traditional rainy months, supporting conclusions that the onset, cessation, and peak intensity are unstable. Collectively, these studies indicate Federal Capital Territory, Abuja's rainfall is undergoing significant transformation marked by seasonal irregularity, inter-annual fluctuation, and heightened variability. While some scholars identify increasing totals, others highlight declining consistency and shifting intensity (Ikechukwu, 2024). These dual challenges of flooding and water scarcity have major implications for urban livelihoods, transport systems, and vulnerable groups.

Demographic and Socioeconomic Factors Affecting Intra-urban Travel of People Living With Disabilities' (PLWDs)

Mobility patterns among people living with disabilities are strongly influenced by demographic and socioeconomic factors determining access to opportunities, transport mode, choice, and environmental exposure. Mogaji (2023) highlights economic insecurity and limited transport infrastructure as major determinants of travel decisions in Nigeria. Duri et al. (2022) identify poverty, unemployment, and low literacy across Africa as major contributors to transport disadvantage, emphasizing that socioeconomic exclusion compounds physical inaccessibility. Nwaka et al. (2023) found that transport service shortages, coupled with lack of demographic vulnerability integration (age and gender) into transport planning, restrict travel opportunities in sub-Saharan Africa. Women and older adults with disabilities face more mobility challenges due to income inequality and safety concerns. Abdullah and Amatullah (2022) examined gender disparities in Federal Capital Territory, Abuja's public transport access, observing that women with lower incomes use public transport more frequently but face greater unsafe conditions. Income, gender, and education collectively influence urban mobility choices. Krause et al. (2023) showed heavy rainfall in Accra disproportionately affected mobility in low-income

neighbourhoods with poor drainage. Uzoho et al. (2024) observed that in Nigeria, climate-related hazards increase vulnerability of people living with disabilities (PLWDs), especially those with low financial and social status.

Intra-Urban Travel Patterns of People Living with Disabilities (PLWDs)

Mobility is a significant determinant of social inclusion and economic participation. The World Bank (2020) notes that people living with disabilities (PLWDs) persistently face mobility barriers limiting access to education, employment, and social life. These barriers arise from interactions among infrastructural, institutional, socioeconomic, and environmental inadequacies. Abdullah and Amatullah (2022) revealed most Federal Capital Territory, Abuja public transport facilities lack universal design principles, limiting transport access. Inadequate design of terminals, walkways, and vehicles significantly restricts mobility for users with physical or sensory impairments. Female commuters with disabilities face compounded safety and accessibility challenges. Mogaji (2023) found affordability, convenience, and safety concerns influence mode choice, with people living with disabilities often choosing cheaper, less comfortable options out of necessity rather than preference. Economic insecurity restricts access to employment, education, and healthcare opportunities. Duri et al. (2022) highlight limited income and employment as lenses for transport exclusion, arguing that transport barriers may be stemmed by addressing socioeconomic inequalities and infrastructural challenges. Mwaka et al. (2023) identified similar patterns across sub-Saharan Africa, noting age and gender differences influence travel frequency and mode selection. Also, Ajom et al., (2026), evaluates the institutional readiness and practical value of Geographic Information Systems for sustainable urban planning, management and development control in Calabar Metropolis. Nigeria and found that all respondents regarded Geographical Information System (GIS) deployment as necessary, while approval delays, weak inter-office communication, inadequate staffing, limited political commitment, funding constraints and perceived corruption remained prominent barriers to GIS pathways , as well digitize geographical environment will improve planning and transportation of vulnerable groups across African countries

Spatial Variations and Rainfall Impacts

Spatial variations are important in understanding rainfall impacts on intra-urban travel across different locations. Krause et al. (2023) indicate neighborhoods with different topographical layers, infrastructure quality, and socioeconomic characteristics experience different mobility outcomes during heavy rainfall. Aderibigbe et al. (2022) examined road networks in flood-prone Accra, finding suburban areas has over 80% of road networks exposed to flood challenges while central areas experienced significantly lower exposure. This demonstrates rainfall-induced transport constraints have intense mobility implications for people living with disabilities (PLWDs).Uzoho et al. (2024) found that in Abia State, Nigeria, people living with disabilities (PLWDs) experience various travel challenges during flooding, including limited transport access, exclusion from emergency response, and assistive device damage. Environmental destructive factors interact with socioeconomic and infrastructural inequalities, exacerbating mobility challenges. Micheal ,(2026) argues that ethically informed fear, should not be understood as panic or irrational anxiety but as reflective awareness of the consequences of environmental degradation, can cultivate precaution accountability, ecological stewardship, and intergenerational responsibility . The Fearological ethic can apply to every segment of environmental management including sustainable transportation of vulnerable groups like people living with disabilities (PLWDs). Xu et al. (2023) explained that infrastructural and population mobility resilience during urban floods varies significantly by location, with well-urbanised areas recovering more quickly. People living with disabilities (PLWDs) in flood-prone areas may experience slower recovery and more severe travel challenges. Omolehin (2025) demonstrate spatial inequalities of infrastructural facilities, observing that people living with disabilities (PLWDs) in northern Nigeria flood-prone areas experience delayed travel, rely on expensive and unsafe options, or relocate temporarily compared to people without disabilities. Despite these findings, empirical research gaps exist on spatial variations of rainfall-induced mobility challenges, environmental and climatic resilience for people living with disabilities (PLWDs) in Nigerian urban centres.

MATERIALS AND METHODS

Research Design

This study adopts a mixed-methods approach combining quantitative survey methods with qualitative focus group discussions. This design enables simultaneous collection and independent analysis of both quantitative and qualitative data types, followed by integration during interpretation to provide comprehensive understanding of

rainfall impacts on intra-urban travel of people living with disabilities in Federal Capital Territory, Abuja. This approach captures statistical trends and lived experiences, enhancing validity and depth of findings.

Study Area

Location and Extent

The study area is the Federal Capital Territory (FCT), Abuja, which serves as the administrative and political capital of Nigeria**.** The Federal Capital Territory is located in the north-central part of Nigeria. lies between latitudes 8° 25'N to 9 ° 25' north of the equator and longitude 6 ° 45'E to 7° 39'°east of the Greenwich Meridian. The territory is bordered by Kaduna State in the north, Nasarawa State to the east and south, Kogi State to the southwest, and Niger State to the west. The territory covers a land area of 7315 square kilometers, (Ogbuenyi, et al. 2022). The Federal Capital Territory comprises six Area Councils, Abuja Municipal (AMAC), Bwari, Gwagwalada, Kuje, Kwali, and Abaji which collectively represent both urban and rural environments (Igbokwe et al., 2024) 2020). The Federal Capital Territory was officially relocated from Lagos to Abuja in 1976 to create a more centrally located and well-planned administrative capital. The urban development potential varies significantly across the six Area Councils, with the Abuja Municipal Area Council (AMAC) exhibiting the highest growth indices while other Councils Area show limited infrastructure development (Igbokwe et. al., 2024). This spatial inequalities across the Area Councils have been documented as major constraints to inclusive urban development. Federal Capital Territory, Abuja hosts a diverse population, including a significant population of people living with disabilities (PLWDs). According to National Population Commission (2022), the total population of the Federal Capital Territory, Abuja is approximately 3,067,500, distributed across the six Area Councils.

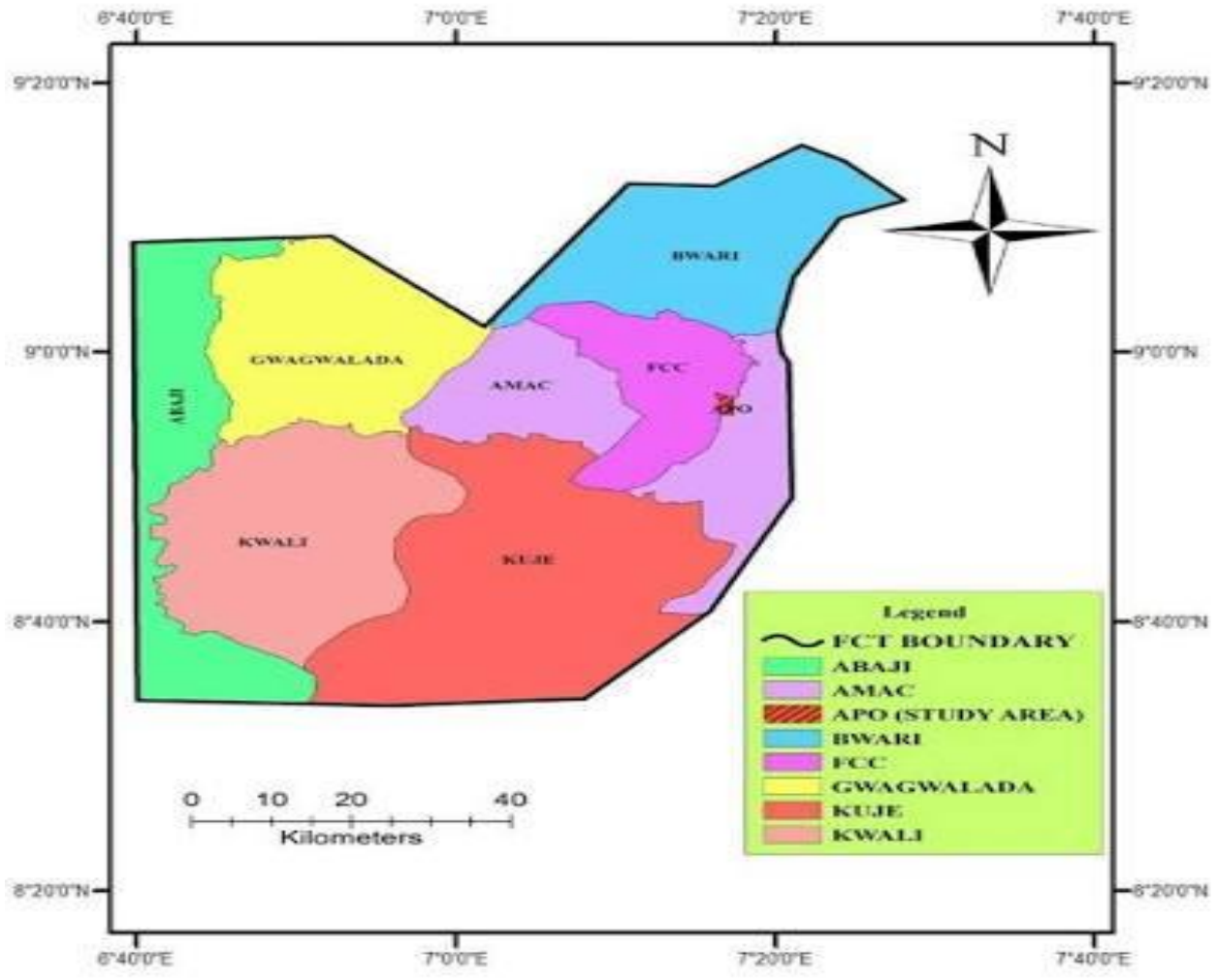

Figure 3.1: The Study Area

Adapted from Ministry of Land, Planning and Survey, F.C.D.A. Abuja (2025)

Climate Pattern of Federal Capital Territory, Abuja

The Federal Capital Territory, Abuja, experiences moderate temperature changes through the seasons. March is the warmest month with daytime highs of 37^0 C, while August is the coolest at 28^0 C, evenly distributed, with about 1513mm of annual rainfall, the Federal Capital Territory; Abuja has a notably heavy rainfall, even though the rainfall is not evenly distributed across the year (Nimet, 2025). It has distinct dry (November to March) and wet (April to October) of tropical savanna climate characterized by flooding and storm-water issues. (Ogbuenyi, 2022).

Study Population and Sampling

Target Population

The target population comprises of adults (18 years and above) living with physical, visual, hearing, cognitive, or mobility impairments who reside within the six area Councils of the Federal Capital Territory, Abuja, and engage in daily intra-urban travel for work, education, healthcare, religion and other socioeconomic activities.

Sample Size Determination

The sample size was derived from the National Population Commission (2023) estimate of the study area population (3,067,500). Using the World Health Organisation (WHO, 2025) disability prevalence of 15%, the study arrived at a sample frame of 460, 125 (Table 1). To determine a statistically representative sample size for a heterogeneous population, the Chris Morgan method was used. According to Morgan (2007), for a population exceeding 100,000, the sample size can be determined using formula:

$s= X^2 NP (1-P) + d^2 (N-1) + X^2 P (1-P)$

n = sample size

X^2= Chi-square for the specified confidence level at 1 degree freedom

N= Population Size

P= population proportion (.50)

ME = desired Margin of Error (expressed as a proportion)

The formula yields a sample size of 384. To enhance reliability and account for potential non- response, this study will use a sample of 400 people living with disabilities (PLWDs). This is to achieve a 95% confidence level and a 5% margin of error, and to ensure spatial representation across the Federal Capital Territory, Abuja. The sample size will be proportionally distributed across the six Area Councils (Table 1) using the formula.

The National Population Commission conducted its last population census in 2006, and continued to project the population of Nigerians states based on various variables. The population projection by National Population Commission, 2025 states that Nigerian total population was projected to be 232, 676,020, and Federal Capital Territory, Abuja to be 3,067,500

ni= Ni/N*n ---------- Equation 1

Where:

ni= sample size for Area Council

Ni= estimated population of people living with disabilities in the Area Council

N= total population of people living with disabilities (460,125) in the study area

n = total sample size (400)

Due to the absence of a comprehensive disability-specific national census since 2006, direct prevalence data for persons with disabilities (PLWDs) in Nigeria remain unavailable. To bridge this critical data gap and inform policy and advocacy, this research utilizes the widely recognized global benchmarks established by the World Health Organisation, which estimates that 15% of any given population lives with a disability in any nation of the world.

Table 1: Sample Frame and Sample Size

Area Council	2025 Total Population	Estimated PLWDs (15%)	Proportional Sample Size
Abaji	127,900	19,185	17
AMAC	1,693,400	254,010	221
Bwari	500,100	75,015	65
Gwagwalada	346,000	51,900	45
Kuje	212,100	31,815	28
Kwali	188,000	28,200	24
Total	**3,067,500**	**460,125**	**400**

Source: Estimated population according to the National Population Commission (2023)

Sampling Technique

Quantitative Sampling:

Stratified random sampling was employed, stratifying by six disability type (mobility, visual, hearing, speech, cognitive/psychological, and multiple disabilities), within each stratum, respondents were randomly selected from designated points including; disability schools , motor parks, offices, markets, residential areas, religious centres, disability advocacy organization meetings points, and locations across six Area Councils in Federal Capital Territory, Abuja.

Qualitative Sampling:

Purposive sampling was used to select key informants for focus group discussions based on the following criteria; Leaders of disability associations (JONAPWD), Representative from the National Disability Commission, Teachers teaching in disabilities schools in the study area

Data Sources and Analysis

Primary quantitative data consisted of Demographic and socioeconomic characteristics of people living with disabilities (PLWDs) and are sourced from structured questionnaire; intra-urban travel characteristics including modal choice, trip frequency, journey purposes, are sourced from travel diary, The primary qualitative data are sourced from the interview conducted with key informant which includes the leaders of disabilities advocacy groups. Secondary Data includes; rainfall data which is sourced from World Weather Online, and Nigerian Metrological Station (Nimet, 2025) rainfall trend reports. While other secondary data are sourced from published literatures on climate variability, disability, and intra-urban mobility of people living with disabilities (PLWDs).Data analysis used for this study are descriptive and inferential statistics.

Research Instruments

Structured questionnaire was designed in four sections:

Section A: Consists of demographic Information data which include gender, age, marital status, education level, occupation, income, disability type and vehicle ownership
Section B: Consists of travel characteristics data and uses travel diary to generate daily trip frequency (brighter days and rainy days), modal choice, trip duration, journey purpose, and trip distance
Section C: Consists of rainfall impact assessment; which include perception of rainfall impact on mobility (Likert scale: 1= No Impact, 5= Very High Impact), frequency of trip cancellation during rainfall, alternative arrangements during rainfall and challenges faced during rainy season travel.
Section D: Consists Infrastructure and Policy Awareness data and uses questionnaire to generate level of awareness of disability in transport policies, perception of people on infrastructure accessibility and recommendations for improvement.

Qualitative Instrument: Focus Group Discussion Guide consists of semi-structured Focus Group Discussion guide which aimed to captures daily travel experiences and challenges, impact of rainfall on mobility decisions, coping strategies during rainfall, perceptions of transport infrastructure accessibility, awareness and effectiveness of disability policies and recommendations for inclusive transport planning

Instrument Validity and Reliability

Quantitative Instrument Validity and Reliability

Content Validity: Questionnaire content was validated by two experts; one experts from transport geography and environmental management and one expert in disability studies. The experts review assessed relevance, clarity, comprehensiveness, and appropriateness thereby incorporating face validity which was done by pre-testing of about thirty people living with disabilities members of Nigerian Disabilities Commission, Abuja. The instrument. Content validity index (CVI) was calculated at 0.89 (acceptable >0.80). While face validity was conducted with pre-testing of thirty people living with disabilities and field back was obtained on clarity, comprehension, and cultural appropriateness.

Qualitative Instrument Reliability. The credibility was obtained through the triangulation of data sources of people livng with disabilities (PLWDs caregivers, and policymakers as members of the interviews section verify interpretations of data obtained as a result of prolong engagement with people living with disabilities (PLWDs). A detailed audit of the research activities was carried out.

Data Collection Procedures

Fieldwork Period

Instrument development and validation was conducted between February-March, 2025, which cover a duration of six weeks followed by Pre-testing of questionnaire which took place in March 2025. Questionnaire distribution and focus group discussion was conducted between May to October 2025. The total fieldwork lasted for 6 months. During the fieldwork, questionnaires were administered face-face by the researchers and trained assistants. For participants with visual impairments, questions were read aloud, while for hearing impairments, sign language interpreters were provided for some of the people living with disabilities (PLWDs) of hearing concerns, caregivers, also helped for participants with cognitive impairment. Travel diaries were completed over 7 consecutive days. The Focus Group Discussions (FGDs) were classified according to disabilities type. i.e, mobility, visual, hearing, multiple, caregivers and disability leaders, which was held at different intervals and dates across the Six Area Councils. The participants for the focus groups discussion consists of National Disability Commission staff , JONAPWD representatives, Disability Rights advocates and transport officials. All focus group discussions were recorded with participant consent while notes were taken by research assistants.

Analytical Techniques

Frequency distribution tables, simple percentages, the mean and charts were used to summarize data obtained. In addition, this study also employed Chi-square test of independence to examine relationships between weather, and modal choice, journey purpose, and modal choice within the Federal Capital Territory, Abuja. This test was considered appropriate because both variables were categorical, and the analysis sought to determine the choice of transport mode varied significantly between different weather conditions and journey purpose. Regression analysis was use to predict relationship between rainfall and trip volume. It was considered appropriate because trip volume represents a quantitative outcome, while rainfall was treated as the explanatory variable. The analysis enabled the study to determine the direction and magnitude of the relationship and assess the extent to which variation in rainfall explained in trip volume.

Ethical Considerations

Ethical approval was obtained from the National Disability Commission, Federal Capital Territory, Abuja.

RESULTS

Response Rate and Sample Characteristics

Table 2: Sample Distribution by Area Council

Local Governments Area	Population	Sample Size	Number of Completed Questionnaire	Percentage Completed Questionnaire
Abaji	127,900	17	15	3.75
Abuja Municipal	1,693,400	221	206	51.5
Bwari	500,100	65	61	15.25
Gwagwalada	346,000	45	40	10
Kuje	212,100	28	23	5.23
Kwali	188,000	24	21	5.25
Total	3,067,500	400	366	91.5

Source: Author, Field Survey, 2025

Rainfall Characteristics

Table 3: Rainfall Characteristics

Estimated population according to the National Population Commission (2023). Table 3 presents the rainfall characteristics of the Federal Capital Territory, Abuja, for the Years 2024 and 2025 as predicted by the Nigerian Meteorological Agency (NiMet, 2025). The results show a relatively stable rainfall regime over the two years, with both years recording approximately 200 days of rainfall and normal deviations from the long-term climatic average.

Table 3: Rainfall Characteristics in the Study Area for 2024- 2025

Rainfall Parameter	2024 Prediction	2025 Prediction	Departure from Normal (2024)	Departure from Normal (2025)
Onset Date of Rainfall	14th May, 2024	29th April 2025	Normal	Normal
Length of Rainy Season (days)	200	200	Normal	Normal
Annual Rainfall Amount (mm)	1,620mm	1,525mm	Normal	Normal
Dry Spell Prediction	Normal	Normal	Normal	Normal
Length of Growing Season	Normal	Normal	Normal	Normal
Cessation Date of Rainfall	12th November 2024	15th November, 2025	Normal	Normal

Note: Data adapted from Seasonal Climate Prediction for Nigeria: 2025 Edition (Nigerian Meteorological Agency {NiMet}, 2025)

This stability suggests that rainfall in the Federal Capital Territory, Abuja, remains predictable and consistent, which has implications for urban planning and mobility management. However, even within a normal rainfall regime, daily rainfall intensity and drainage capacity can significantly affect the mobility of people living with disabilities (PLWDs). For example, wheelchair users or individuals with visual impairments may experience restricted access to Bus stops (Transport terminals), pedestrian walkways, or public facilities during heavy rainfall. Similar findings by Mogaji (2023) and Duri et al. (2022), they both affirm that even moderate but frequent rainfall can amplify transport exclusion, especially in most Nigerian urban centers with similar rainfall characteristics. Furthermore, the stable rainfall pattern provides a useful framework for predictive planning. Transport and urban development authorities in the Federal Capital Territory, Abuja, can integrate Nimet forecasts into inclusive mobility strategies, such as providing covered pedestrian crossings, accessible drainage systems, and rain-protected bus shelters to reduce travel disruption during wet seasons. Thus, while the rainfall is normal, the impact on mobility among people living with disabilities (PLWDs) depends largely on infrastructure readiness, transport design, and policy responsiveness.

Table 4: Average Monthly Rainfall in Abuja

Months	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
(mm)	0.8	5.9	32.4	88.0	185.3	194.2	249.3	338.3	235.4	175.2	9.2	1.3

Source: World Weather Online (WWO), 2025.

Demographic and Socioeconomic Characteristics

Table 5: Demographic and Socioeconomic Characteristics

Variable	Category	Frequency	Percentage
Gender	Male	200	54.64
	Female	166	45.36
Age Group	18-29	70	19.13
	30-60	276	75.41
	61 +	20	5.46
Disability Type	Mobility	142	38.79
	Visual	85	23.22
	Hearing	60	16.39
	Speech	32	8.74
	Cognitive	25	6.83
	Multiple	22	6.01
Education	Informal	133	36.34
	Primary	98	26.78
	Secondary	89	24.32
	Tertiary	46	12.57
Occupation	Civil Servant	28	7.65

	Self Employed	53	14.48
	Artisan	85	23.22
	Trader	82	22.40
	Unemployed	107	29.23
	Retired	11	3.00
Income	No Regular Income	123	33.61
	N50,000- 100,000	199	54.37
	101,000+	42	11.48
Vehicle Ownership	Yes	36	9.84
	No	330	90.16

Source: Authors, Field Study, 2025

Modal Choice During Rainfall and Bright Weather

Table 6: Preferred Modal Choice by Weather Conditions

Mode	Brighter Weather Days (n)	Brighter Weather Days (%)	Rainy Weather Days (n)	Rainy Weather Days (%)
Private Car	45	12.30	62	16.94
Taxi	105	28.69	170	46.45
Bus	45	12.30	40	10.93
Tricycle	84	22.95	90	24.59
Motorcycle	15	4.10	0	0.00
Walking	26	7.10	4	1.09
Assistive Aid	46	12.57	0	0.00
Total	366	100.00	366	100.00

Source: Authors, Field Study 2025.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	95.699[a]	6	.000
Likelihood Ratio	121.316	6	.000
Linear-by-Linear Association	71.514	1	.000
N of Valid Cases	732		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.50.

A Pearson Chi-square test of independence was conducted to examine the relationship between weather conditions and commuters living with disabilities modal choices. The relationship was statistically significant, $X^2(6) = 95.69$, $P < 0.001$. Rainy weather led to a substantial shift towards motorized transport like taxis and private cars during rainfall.

Journey Purposes Characteristics

Table 7: Journey Purposes of People Living with Disabilities (PLWDs)

Purpose	Trip 1Frequency/Week	%	Common Modes
Work	248	67.76	Taxi
School	42	11.48	Bus/Car
Shooping	28	7.65	Taxi
Religion	13	3.55	Taxi/Bus
healthcare	31	8.47	Taxi/Aided
Taking People	0	0.00	
Entertainment	4	1.01	Taxi
Total	366	100	

Source: Authors, Field Study, 2025

Disability type * Modal Choice Cross-tabulation

Count

		Modal Choice				Total
		Taxi	Bus/Car	Taxi/Bus	Taxi/Aided	
Disability type	Mobility	1	0	0	0	1
	Visual	0	1	0	0	1
	Hearing	1	0	0	0	1
	Speech	0	0	1	0	1
	Cognitive	1	0	0	1	2
Total		3	1	1	1	6

A Pearson Chi-square test was conducted to examine the association between disability type and modal choice. The analysis revealed no statistically significant association between disability type and modal choice, $X^2(12, N= 6) = 14.00$, $p=0.301$. Although taxi was the most frequently reported mode, the observed difference in modal choice across disability types was not statistically significant.

Spatial Distribution

Table 8: Shows average trips Distribution across the Area Councils

Area Councils	Frequency	Total number of trips	Percentage of trip per Area Council
Abaji	15	15	2.56
AMAC	206	300	51.28
Bwari	61	87	14.87
Gwagwalada	40	101	17.26
Kuje	23	61	10.43
Kwali	21	21	3.59
Total	366	585	100

Source: Authors; Field Study, 2025

Trip Volume: Bright weather days and Rainy Days

Table 9: Trip count according to journey purpose across FCT during rainfall and brighter days

Purpose	Trip Counts During Bright weather Days	%	Trip Counts During Rainy Days	%	Total Trips During Brighter Days and Rainy
Work	248	67.77	105	56.76	353
School	42	11.48	31	16.76	73
Shopping	28	7.65	16	8.65	44
Religion	13	3.55	8	4.32	21
Healthcare	31	8.46	25	13.51	56
Entertainment	4	1.09	0	0	4
Total	366	100	185	100	554

Source: Authors; Field Study, 2025

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	27246.518	2	13623.259	5.133	.027[b]
	Residual	29196.696	11	2654.245		
	Total	56443.214	13			

a. Dependent Variable: Number of trip

b. Predictors: (Constant), Journey Purpose, Number of trips

A multiple linear regression analysis was conducted to predict the influence of journey purpose and weather conditions on the number of trips . The model was statistically, $F(2,11) = 5.133$, $p= 0.027$, with R^2 of 0.483, Adjusted $R^2 = 0.389$ This indicates that journey purpose and weather conditions jointly explained 48.3% of the variation in the number of trips

DISCUSSION

This study examined the impact of rainfall on intra-urban travel patterns among people living with disabilities (PLWDs) in the Federal Capital, Abuja. The findings reveal a complex interplay between climatic factors, socioeconomic vulnerabilities, and infrastructural inadequacies that collectively shape mobility experiences. This section interprets the key findings, situates them within existing literature, and draws out theoretical and practical implications.

Rainfall as Determinant of Modal Choice

The study found a statistical significant relationship between weather conditions and modal choice among people living with disabilities ($X^2= 95.69$, $p < 0.0001$). During rainy weather, there was a substantial shift to taxis increasing from 28.7% to 46.5%) and private cars (from 12.3% to 16.9%). Conversely, walking decreases from 7.1% to 1.1%, while motorcycle dropped during rainfall. This findings aligns with Mogaji (2023), who observed that affordability, convenience, and safety concerns influence mode choice, with people living with disabilities (PLWDs) often choosing more expensive options out of necessity rather than preference. The shift toward taxis and private cars during rainfall reflects a survival strategy as people living with disabilities (PLWDs) priortise safety and accessibility over cost, even when this imposes significant financial burdens. Abdullah and Amatullah (2022) similarly found that women with disabilities in Federal Capital Territory, Abuja faced compounded safety concerns during adverse weather, forcing them into more expensive transport arrangements. The complete abandonment of assistive aids (wheelchairs, crutches, mobility scooters) during rainfall is an issue of concerns. This finding corroborates Uzoho et al. (2024), who documented that assistive devices are often damaged by water exposure or rendered unusable on flooded, slippery surfaces. For people living with disabilities (PLWDs) who rely on these aids for independent mobility, rainfall effectively strips them of their primary mobility means, forcing dependence on others or cost alternatives. The study further confirms that rainfall is not merely a nuisance but a critical determinant of how people living with disabilities (PLWDs) navigate the study area. This has significant implications for transport planning.

Trip Suppression and Socioeconomic Exclusion

One of the most striking findings of this study is the 55.2% reduction in trip volume during rainy days (from 585 to 323 trips). The regression analysis confirmed that journey purpose and weather conditions jointly explained 48.3% of the variation in trip counts (F= 5.133, p = 0.27, R^2 = 0.483). This ''trip suppression'' has profound socioeconomic consequences. Work trips dominated both rainy days and bright weather days (67% and 56.8% respectively), underscoring the necessity of employment-related travel. However, the drop from 248 work trips during bright weather to 105 during rainfall suggests that many people living with disabilities (PLWDs) are unable to commute during adverse weather like heavy torrential rainfall. This aligns with Duri et al. (2022), who identified transport exclusion as a major barrier to employment and economic participation for people living with disabilities in Africa. When rainfall prevents people with disabilities (PLWDs) from reaching their workplaces, it perpetuates cycles of poverty and economic insecurity, which this study found to be prevalent as 33.6% of respondents had no regular income, and 54.4% earned below one hundred Naira monthly, despite harsh economic conditions in Nigeria.

Healthcare trips also showed notable suppression, dropping from 31 to 25 trips during rainfall (19% reduction). For people living with disabilities with chronic health conditions requiring regular medical attention, this represents a critical access failure. The World Health Organisation (2023) emphasizes that healthcare access is a fundamental right, yet rainfall-induced transport barriers systematically deny this right to vulnerable populations. Trip suppression is not merely an inconvenience but a mechanism of social exclusion. As Nwaka et al. (2023) argued, when people living with disabilities cannot travel, they are excluded from employment, education, healthcare, and social participation. This study provides empirical evidence that rainfall exacerbates this exclusion, contributing to ''transport disadvantage'' documented across sub-Saharan Africa (Nwaka et al., 2023).

Spatial Inequalities: The Urban-Rural Divide

The spatial distribution of trips reveals stark inequalities across the six Area Councils. Abuja Municipal Area Council (AMAC) accounted for 51.28% of all trips, while rural councils like Abaji (2.56%), Kwali (3.59%), and Kuje (10.43%) recorded disproportionately low trips volumes. This reflects the centralized infrastructure investment documented by Igbokwe et al. (2024), who found that AMAC exhibits the highest growth indices while other Area Councils show limited development. For people living with disabilities (PLWDs) in the sub-urban area Councils, rainfall impacts are compounded by lack of paved surfaces, absence of accessible infrastructure, and limited transport options. Aderibigbe et al. (2022) demonstrated that sub-urban areas in Accra had over 80% of road networks exposed to flood challenges, while central areas experienced significantly lower exposure. This study extends that finding to Abuja, showing that people living with disabilities (PLWDs) in satellite areas face not just rain-induced disruptions but permanent infrastructural deficits that make independent travel nearly impossible. The spatial concentration of trips in AMAC also highlights a policy implementation failure's, given the Discrimination Against Persons with Disabilities (Prohibition) Act, 2018, which mandates equal access, yet the distribution of mobility-enabling infrastructure remains grossly uneven. This aligns with the findings of Floyd and Hassan (2022), who noted that Federal Capital Territory, Abuja's poor adaptive capacity highlights increased flood risks, emphasizing the need for inclusive infrastructure planning across all Councils areas.

Disability Type and Modal Choice: Universal Barriers

The Chi-square test revealed no statistical significant association between disability type and modal choice (x^2 = 14.00, p = 0.301). Although taxi was the most frequently reported mode across all disability types, the observed differences were not significant. This finding shows that infrastructural and systemic barriers affect all people living with disabilities uniformly. Regardless of whether a person has a mobility, visual, hearing, speech, or cognitive impairment, the transport system fails them in similar ways; lack of ramps, poor signage, unhelpful drivers, and unsafe walking environments. This aligns with Mwaka et al. (2023), who found that barriers to public transport use among people living with disabilities (PLWDs) are more infrastructural and institutional than impairment-specific. Similarly, Ojekere and Mkpandiok (2024) found that people living with disabilities in Benin City faced universal access challenges regardless of disability type. The implication is that interventions need not be impairment-specific but should adopt universal design principles that benefit all.

The Policy-Implementation Gap

The study exposes a critical disconnect between Nigeria's legal framework and on the gound reality. The Discrimination Against Persons with Disabilities (Prohibition) Act, 2018, mandates accessibility, yet transport infrastructure fails to meet even basic standards. Chukwudum et al. (2025) noted, extreme weather limits travel access for vulnerable groups due to lack of inclusive transport measures. This policy-implementation gap is not

unique to Federal Capital territory, Abuja as Ajom et al. (2026) found that in Calabar, institutional readiness for GIS-based sustainable planning was undermined by approval delays, weak inter-office communication, inadequate staffing, limited political commitment, funding constraints, and perceived corruption. Similar barriers likely impede disability-inclusive transport planning in Federal Capital Territory, Abuja. The study's findings that rainfall climatic event causes severe mobility disruptions suggests that current infrastructure is not even weather-resilient for the general population, let alone people living with disabilities (PLWDs), as Micheal (2026) argued ethically informed environmental awareness can cultivate precautionary accountability and ecological stewardship. Translating this into policy would mean designing transport systems that anticipate rather than react to climate variability.

CONCLUSION

Rainfall is one of the determinants of travel experiences for people living with disabilities (PLWDs) in Federal Capital Territory, Abuja. It has significantly shape modal choice and trip volume, affecting how and how often people travel. However, rainfall does not significantly affect journey purposes or trip duration, while trip frequency and means may change, underlying travel needs remain constant. Area Councils influence journey purposes, but rainfall impacts are consistent across all local governments, reflecting shared vulnerability. Climate factors interact with socioeconomic and infrastructural realities to shape inclusive mobility, contributing to knowledge on climate-disability intersections in African urban contexts.

Recommendations

Based on the study findings, the following recommendations are proposed:
There is a need to integrate rainfall considerations into mobility planning, equitable distribution of infrastructural investments across all the six Area Councils, apply universally design standards, enforce Discrimination Against Persons with Disabilities (Prohibition)Act, 2018. Others includes, provision of wheelchair accessible buses, transport subsidies for low-income people living with disabilities (PLWDs)

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References

Abdullah, A., & Amatullah, A. (2022). Gender disparities in the access and use of urban public transport in Abuja, Nigeria. *Sustainability*, *14*(9), 5219. https://doi.org/10.3390/su14095219

Aderibigbe, Oluwayemi-Oniya, and Trynos Gumbo. "Influence of Socio-Economic Attributes on Travel Behaviour in the Rural Areas of Nigeria: Towards a Sustainable Rural Planning and Development." *Urban, Planning and Transport Research*, vol. 10, no. 1, 2 June 2022, pp. 181–199, https://doi.org/10.1080/21650020.2022.2072946.

Ajom, S., Nwokaeze, E., Olutunde Babawale, Koko, S., & Etim, A. (2026). Geographic Information Systems for sustainable Urban Planning and Development Control in Calabar Metropolis, Nigeria. *Journal of Enviromental Sciences and Built Environental Research*, *1*(2), 70–80. https://doi.org/10.83374/jesber.vol1no2.37

Atomode, T. I., & Edeje, J. P. (2022). Analysis of intra-urban trips in Lokoja, Nigeria. *Nigerian Journal of Logistics and Transport*.

Chukwudum, Q. C., Anyaele, D. O., Unumeri, G., Stein, P. J. S., & Stein, M. A. (2025). Disability, perceptions of climate change impacts, and inclusive climate action priorities in Abia State, Nigeria. *Sustainability*, *17*(20), 9229. https://doi.org/10.3390/su17209229

Dada, E.O., et al. (2021). Rainfall and convective systems across selected cities in Nigeria, 1985 -2015. International Journal of Climatology, 41(3), 2154-2171

Discrimination against Persons with Disabilities (Prohibition) Act, 2019. (2019). *Judy Legal*. https://lite.judy.legal/amp/legislation/akn/ng/act/2019/dapas

Dukku, A., & Olatunde, A. (2026). *View of community perceptions of flood incidence and perceived climate-change linkages in selected flood-prone local government areas (LGAs) of Gombe State, Nigeria*. Jesber-Unical.Org.Ng. https://jesber-unical.org.ng/index.php/home/article/view/60/49

Duri, J., et al. (2022). Transport exclusion and disability in Africa: A systematic review. Journal of Transport Geography, 105, 103478.

Enesi, C. M., et al. (2023). Assessment of urban green open spaces and environmental impacts on recreation and environmental sustainability: Evidence from Abuja, Nigeria's Federal Capital Territory. *Journal of Environmental Research and Management, 3*(1), 207–222. https://www.researchgate.net/publication/376985704

Eneyo, M. (2026). Fearological ethics: A new approach to sustainable environmental protection in Nigeria. *Journal of Environmental Sciences and Built Environmental Research, 1*(2), 158–179. https://doi.org/10.83374/jesber.vol1no2.45

Floyd, A. C., & Hassan, S. M. (2022). Risk assessment of climate variability in the Federal Capital Territory, Abuja, Nigeria. *NIPES Journal of Science and Technology Research, 4*(1), 90–105. https://doi.org/10.37933/nipes/4.1.2022.8

Igbokwe, J. I. Okafor, P. C., &Nwachukwu, C.A. (2024). Urban development potential analysis of the six Area Councils of the Federal Capital Territory, Abuja using GIS and Analytical Hierarchy Process (AHP). Journal of Geographic Information System, 16(2), 89 - 112.

Ikechukwu, O. (2024). Rainfall variability and consistency in north-central Nigeria. Journal of Climate Studies, 18 (2), 112-128

Itiowe, K., et al. (2020). Climatic change and drought patterns in the Federal Capital Territory, Abuja. Environmental Monitoring and Assessment, 192 (7), 425.

International Journal of Research and Innovation in Social Science. (2023). *Inclusion and climate resilience for people with disabilities in Africa: A systematic review of challenges*. https://rsisinternational.org/journals/ijriss/articles/inclusion-and-climate-resilience-for-people-with-disabilities-in-africa-a-systematic-review-of-challenges

Kailes, J. (2020). *Guidance for integrating people with disabilities in emergency drills and exercises* (2nd ed.).

Krause, M., et al. (2023). Rainfall, Flooding, and mobility in Accra. Urban Geography, 44(3), 512 - 534

Mogaji, Emmanuel, et al. "Transport and Mobility Decisions of Consumers with Disabilities." *Journal of Consumer Behaviour*, 11 July 2022, https://doi.org/10.1002/cb.2089.

Mwaka, C R, et al. "Barriers and Facilitators of Public Transport Use among People with Disabilities: A Scoping Review." *Frontiers in Rehabilitation Sciences*, vol. 4, no. 4, 8 Jan. 2024, www.ncbi.nlm.nih.gov/pmc/articles/PMC10812606/, https://doi.org/10.3389/fresc.2023.1336514.

National Bureau of Statistics. (2023). *National Bureau of Statistics*. https://www.nigerianstat.gov.ng/

NiMet. (2020). *Publications*. https://nimet.gov.ng/publication_detail?id=42

Ogbuenyi, C. O. (2022). A geographical analysis of the Federal Capital Territory, Abuja: Physical characteristics, administrative structure and spatial development. Nigerian Journal of Geography and the Environment, 12(1), 45-67.

Ogunleye, O., & Eruobodo, A. (2025). [Insert title of article]. *American Journal of Environmental and Energy Law*. https://www.ajouronline.com/index.php/AJEEL/article/view/5822

Ojekere, S., & Mkpandiok, D. (2024). Analysis of public transport inclusiveness among persons with disabilities before and during COVID-19 in Benin City, Nigeria. *Journal of Disability Studies, 10*(1), 10–18. https://www.pubs.iscience.in/journal/index.php/jds/article/view/1500

Olawale, S., et al. (2024). Seasonal and inter-annual precipitation variability across Nigeria, 1980-2020. Climate Dynamics, 62 (8), 7891-7908

Omolehin, T. (2025). Spatial inequalities in infrastructure and mobility for persons with disabilities in northern Nigeria. Disability Studies Quarterly, 45 (1).

Onyemenam, O. (2025). Effects of planning laws and policies on the development of Asaba metropolitan region in Delta State, Nigeria. *Journal of Planning and Development, 30*(1), 75–90. https://www.researchgate.net/publication/390602483

United Nations. (2024). *Disability: Division for Inclusive Social Development (DISD)*. https://social.desa.un.org/issues/disability

Ugwu, C. O., et al. (2024). Rainfall dynamics in north-central Nigeria, 1986-2019. Journal of Hydrology: Regional Studies, 52, 101678.

Uzoho, O., et al. (2024). Environmental disruptions and travel challenges for persons with disabilities in Abia State, Nigeria. Environmental Hazards, 23 (4), 345-362

World Bank Group. (2017). *Climate change knowledge portal*. https://climateknowledgeportal.worldbank.org

World Health Organization. (2023). *Disabilities*. WHO Regional Office for Africa. https://www.afro.who.int/health-topics/disabilities

Xu, H., et al. (2023). Spatial variability in flood resilience: Infrastructure and population mobility. Natural Hazards, 115 (20, 1567-1588.

Ogunyale, K. (2023, July 22). *[Flood series] Mapping out areas in Abuja prone to flooding*. The ICIR. https://www.icirnigeria.org/flood-series-mapping-out-areas-in-abuja-prone-to-flooding

Atlas, W. (2024, January 25). *Yearly & monthly weather - Abuja, Nigeria*. https://www.weather-atlas.com/en/nigeria/abuja-climate

Sanusi, O. (2025, March 20). *Latest news and investigations*. The ICIR. https://www.icirnigeria.org

Abujaba. (2025, July 18). *Understanding flooding in Lokogoma Estates, Abuja: Causes & solutions*. https://abujaba.com/flooding-in-lokogoma-estates-abuja

The Journal Nigeria. (2025, August). *Neglected warnings, rising waters: Abuja, north-central Nigeria face deadly flood risks*. https://thejournalnigeria.com/neglected-warnings-rising-waters-abuja-north-central-nigeria-face-deadly-flood-risks

United Nations. (2025, August 21). *UN flagship report on disability and development 2024*. https://social.desa.un.org/publications/un-flafship-report-on-disability-and-development-2024