https://doi.org/10.31871/WJIR.11.1.51
World Journal of Innovative Research (WJIR)
ISSN: 2454-8236, Volume-11, Issue-1, July 2021 Pages 59-82

Assessment of Farmers Adaptive Capacity to Climate Variability in the Federal Capital Territory (FCT), Abuja, Nigeria

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***Abstract*— The study assessed the adaptive capacity of crop farmers in the six Area Councils of FCT using Geoinformatics. Socio-economic indicators were used to map the adaptive capacity of FCT farmers to climate variability from 1981-2017. The arable crops considered are: yam, beans and maize. The selected climatic variables based on their importance to crop production are: rainfall, temperature, relative humidity and potential evapotranspiration. A total of 240 questionnaires were administered to 24 farming communities (ten farming household in each community) using systematic sampling. The ability of farmers to adapt to climate variability was assessed based on five factors that have a direct influence on crop production which are: financial, human, natural, physical and social capital. The indicator scores were summarized (using Microsoft office excel), normalized and weighed. The weight was assigned through the Analytic Hierarchy Process (AHP). This was used to determine the Adaptive Capacity Index (ACI) which was used to produce the Adaptive Capacity Map. The mean adaptive capacity of farmers in FCT shows that, croplands in Abaji registered the highest adaptive capacity (0.7494) followed by croplands in Kuje (0.6608). Moderate adaptation was recorded in Bwari (0.5507) while low adaptations were documented in AMAC (0.3873) and Kwali (0.2676). Lowest adaptation was revealed in Gwagwalada (0.0691). AMAC, Kwali, Gwagwalada and Bwari will have low yields without the required external assistance. Abaji and Kuje will use their assets to recover from climate variability and restore their crop yields. Provision of irrigation infrastructures**

and diversification into off-farm activities were recommended.

***Index Terms*— Adaptation, Croplands, Geoinformatics, Socio-economic, Questionnaires.**

I. INTRODUCTION

Climate variability is the variation in the mean and standard deviation of climate over a given period of time (such as specific month, season, year or decade) from a longer period mean that brings about changes of climate with time (; National Oceanic and Atmospheric Administration (NOAA, 2018) and Abbadi, 2013). The degree of climate variability is defined by the differences between long-term statistics of meteorological elements calculated for different periods. The Intergovernmental Panel on Climate Change (IPCC, 2019) refers to climate change as any change in climate over time, whether due to natural variability or as a result of human activity. It may also be referred to as any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). (NOAA, 2018) refers to climate change as statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer) which may result from human activities, such as the burning of fossil fuels and deforestation.

Globally, climate variability has become a major environmental problem affecting the future survival and the development of mankind and has attracted widespread attention of governmental organizations and academic communities in the world (National Academy of Science and Royal Society, 2020). It is probably the most complex and challenging environmental concern facing the world today (Vesco et al, 2021). It is perhaps the most serious environmental threat to the fight against hunger, malnutrition, disease and poverty in the world, mainly through its impact on agricultural productivity (Bathiany et al, 2018). The manifestation of climate variability such as rising temperatures, erratic rainfall patterns, frequent and severe floods and droughts have grave consequences on the livelihood security of farming communities, making them more vulnerable (Mahmood et al, 2019).

The Food and Agricultural Organization (FAO, 2015) in its study highlighted the strong relationship between poverty and vulnerability to disasters and noted that climate-related disaster accounted for about 25% of the total documented damage and loss in crop production between 2003 and 2013 in developing countries. FAO, (2019) submitted that over 820 million people were undernourished in 2018, while agriculture provides livelihoods for 2.5 billion people.According to FAO, climate change could push 122 million more people, mainly farmers, into extreme poverty by 2030 and projected to increase cereal prices by 29 percent in 2050. Agriculture absorbs 26 percent of the economic impact of climate disasters, rising to 83 percent for drought in developing countries. Water scarcity affects 40 percent of the population. For every 1 °C rise, 500 million extra people will face a 20 percent dip in renewable water resources (FAO, 2019).

Africa’s food production system is among the worst vulnerable in the world due to their high exposure, over dependence on rain-fed crop production and poverty that

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limits their capacity to adapt (Madu, 2016; WMO, 2020). West Africa is one of the most vulnerable to the unpredictable changes of the climate, as the scope of the impacts of climate variability over the last three or four decades has shown (Ogallah et al, 2017). Tanko and Muhsinat (2014) reported that crop productivity in FCT decreases despite increasing acreage of croplands under cultivation. The paper attributed the crop productivity reduction to climatic variations.

Mitigation and adaptation have been identified as the two primary elements of climate variability response (Nkechi et al., 2016; Elum, 2017). Mitigation refers to actions taken to either reduce the greenhouse emissions or increase terrestrial storage of carbon while adaptation refers to all the responses to climate change targeted at reducing vulnerability (Hansen et al, 2017). Adaptation is the major response option to climate change in Nigeria as the country is not among the countries on emission reduction commitments (Gbode et al, 2018; Abraham and Fonta 2018). The vulnerability of cropland due to climatic factors is not determined by the nature and magnitude of stress exposure alone, but by the combination of the farmers’ capacity to cope with and/or recover from environmental change (Haider, 2019).

Agriculture provides food for the Nigerian teeming population while serving as an employment hub for most Nigerians (Onwutuebe, 2019). Despite these vital contributions of agriculture to the economy of Nigeria, it’s still being threatened by climatic variations (Ebele and Emodi, 2016; Shiruet al., 2018). In order to combat the menace of climate variability, the knowledge of its nature, causation, mitigation and adaptation strategies should be of importance to the farmers (Federal Ministry of Environment (FME, 2020; Anabaraonye et al, 2019). This depends to a certain extent on the perception knowledge of the farmers about climate variability, the information available to the farmers and their ability to use this information correctly because of their level of education (FME, 2020).

Many studies (IPCC, 2014; Ishaya et al, 2014, Jellasonet al, 2019) documented the implications of climate variability for agriculture and pose a reasonable concern that climate variability is a threat to economic prosperity and sustainable development, especially in developing countries (Okongor et al, 2021). The impacts of global climate variability are mainly felt by the inhabitants of developing countries. Subsistence or small holder farmers in these countries are most vulnerable. Their vulnerability to extreme climate variability is linked to their location in the tropics, poor socio-economic status, tilting demographic structures and impotent policy trends limiting their capacity to adapt to climate variability (Elisha et al, 2017).

A. *Statement of Research Problem*

Most climate change studies are concerned with effects, impacts and adaption. Among such studies in Africa and Nigeria are: Analysis and mapping of climate change risk and vulnerability in central rift valley of Ethiopia (Gizachew and Shimelis, 2014), evidence of climate change impacts on agriculture and food security in Nigeria (Bello et al, 2012), awareness and adaptation to climate change among yam-based farmers in rural Oyo state, Nigeria (Oluwatayo and Ojo, 2016) and Evidence of climate change and adaptation strategies among grain farmers in Sokoto State, Nigeria(Elisha et al, 2017), agricultural vulnerability to climate change in Sokoto State (Atedhor, 2015). Relatively few studies if any analyze the adaptive capacity of crop farmers to climate variability in FCT using Geo-informatic techniques. Some of the climate change studies within the FCT are: climate variability and crop zones for the Federal Capital Territory, Nigeria (Hassan, 2012), post-adaptation vulnerability ofcereals torainfall and temperature variability inthe Federal Capital Territory of Nigeria (Ishaya et al, 2014). Despite the wide coverage of climate change studies in FCT of Nigeria over the years, it was observed that no emphasis has been placed on assessing the adaptive capacity of the farmers to climate variability in the Federal Capital Territory (FCT) Using Geo-Informatics Technique. It is in view of this note that this study was necessary to bridge the gap created by most studies in the study area.

B. *Objectives*

The study assessed the adaptive capacity of crop farmers in the six Area Councils of FCT using Geoinformatics. This was achieved through the following objectives:

1. to examine the distribution pattern of climate indices in FCT between 1981-2017
2. to assess the socio-economic characteristics of farmers in FCT
3. to determine the adaptive capacity index (ACI) of FCT Area Councils and
4. to produce the adaptive capacity map of FCT Area Councils.

C. Hypothesis

╫0: Climate variables do not influence crop production in FCT

II. MATERIALS AND METHODS

A. *The Study Area*

The study area lies between latitude 8015’ and 9012’north of the equator and longitude 6027’ and 7023’14” east of Greenwich Meridian (Ishaya et al, 2014). The Federal Capital Territory has a landmass of approximately 8,000 km² of which the actual city occupies about 512 sq.km (Hassan, 2012). It experiences two weather conditions annually. These are warm, humid rainy season and a dry season, which experiences a brief interlude of harmattan occasioned by the North East Trade Wind (Mohammed et al, 2014). The mean sunshine hour between November and April is about 250 hours in the south to over 275 hours in the north-east. This drops to about 125 hours monthly average during the rainy season. The maximum temperature during the dry season occurs in the month of March and ranges between 370C in the south-west to about 300C in the north-east (Ishaya and Hassan, 2013). The onset of the rain is from about the middle of March and April in the southern and northern parts of the territory respectively (Aondoakaa, 2012, Ishaya et al, 2018). The end of the rainy season is around the middle of October in the north and early November in the south (Ayanshola, 2015). The duration of the rainy season (length of rainy season-LRS) ranges between 190 days in the north to 240 days in the south. The annual and monthly rainfall viability coefficient ranges between 85% - 117% and 20% - 280% respectively. The rainfall intensity is high in the months of July, August and September which account for about 60% of the total rainfall in the region (Hassan, 2012). The relative humidity falls considerably in the afternoons in the dry season and rises everywhere during the raining season. In the raining season, the afternoon humidity can be as high as 50%, but it is as low as 20% during the dry season (Ishaya and Hassan, 2013). The warm and moist tropical maritime air mass from the atlantics moves from south-west to north-east direction while the warm and dry tropical continental air mass from the sahara moves from north-east to south-west in opposite direction. The movement of these air masses necessitated the absence of any real cold season in FCT (Ishaya et al, 2014).

The territory is predominantly underlain by high grade metamorphic and igneous rocks of precambrian age. These rocks consist of gneiss, migmatites and granites (Aondoakaa, 2012). The alluvial, luvisols and entisols are the three soil types identified in FCT. The alluvial soils are found on the low-lying areas of main rivers and streams. The luvisols are soils on the foot plains of inselbergs, wooded hills and mountains. The entisols are soils formed on inselbergs and wooded hills. These types of soils are rocky and stony in nature and are therefore referred to as skeletal soils.

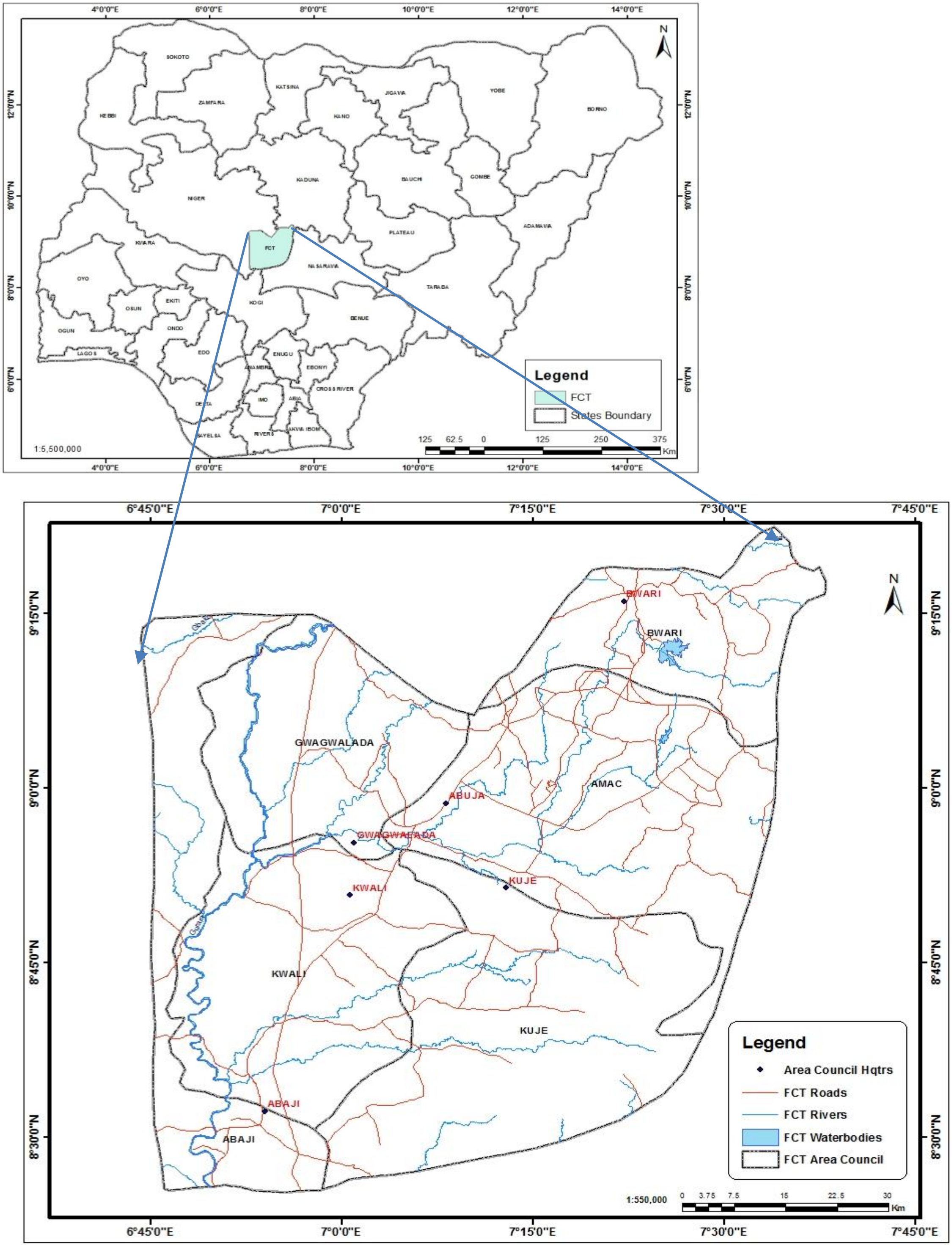

Figure 1: The Study Area Showing the Six Area Councils

B. *Method of Data Collection and Analysis*

Meteorological data covering FCT like maximum and minimum temperature, rainfall, potential evapotranspiration and relative humidity were downloaded from the National Center for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) website (https://globalweather.tamu.edu). The data was obtained for a period of 37 (1981-2017) years. The data was updated till 2017 by Research Data Archive's (RDA) Computational and Information Systems Laboratory (CISL), NCEP Climate Forecast System Version 2 (CFSv2) Web Processing Service (WPS) of Center for Environmental Data Analysis (CEDA) constructed by Climatic Research Unit (CRU TS 4.01) at a spatial resolution of 0.3 × 0.3 degree. Data available at: (http://wps-web1.ceda.ac.uk/submit/form?proc_id=Subsetter). Simple statistical computations of sums, monthly and annual averages were performed on the climate variables of rainfall, temperature, relative humidity and evapotranspiration. The results were summarized into monthly and annual mean for analysis. Time series analysis was carried out on the dataset using Microsoft Office Excel to present them over time. This is done to confirm the certainty of climate variability on the study area in terms of trends and variability analysis.

Questionnaires on adaptive capacity were used to obtain relevant information on socio-economic characteristics of the farmers. A total of 240 copies of questionnaires were administered. The questionnaires were made up of structured (close-ended) and unstructured (open ended) questions to obtain qualitative and quantitative information on the farmers. The questionnaire is of two sections. Section A is on the demographic data of the respondents while section B focused on the indicators of adaptive capacity of the farmers. Multi-stage systematic sampling technique was used for the selection of respondents (farmers). Four (4) farming communities were selected from each of the Area Councils using systematic sampling technique making a total of 24 farm settlements in all. The same sampling technique was also used to select ten (10) farming households from each community making a total of 240 households in all. Two key experts were selected from each community to assist in the interview. Some of these experts are opinion leaders and community Chief. Household heads and experts were the main target because of their experience and knowledge regarding farming operations in their locality and to elicit their (experts) ratings on the relative importance of indicators and sub-indicators of adaptive capacity. The data from the farmers on the questionnaires were centered on their experiences and observations of climate variability and its effect on cropland potentialities in their area.

Table 1: Monthly Mean of Climate Variables in FCT Area Councils

Maximum Temperature (^{0}C)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	38.76	40.69	41.33	39.71	36.36	33.59	30.02	28.30	30.06	33.39	36.75	37.46	35.53
AMAC	37.12	38.93	39.25	37.38	34.23	31.42	28.05	26.46	28.11	30.57	33.97	35.48	33.41
Bwari	36.49	38.16	38.46	36.65	33.35	30.49	26.97	25.40	27.31	29.93	33.64	34.96	32.65
Gwagwalada	39.35	41.47	42.06	40.21	36.82	34.20	30.80	28.92	30.26	33.12	36.59	37.76	35.97
Kuje	38.82	40.97	41.16	39.03	35.57	32.87	29.56	27.89	29.17	31.70	35.25	36.98	34.91
Kwali	40.05	42.25	42.57	40.43	36.91	34.30	30.96	29.09	30.29	32.91	36.58	38.19	36.21
Mean	38.43	40.41	40.80	38.90	35.54	32.81	29.40	27.68	29.20	31.94	35.46	36.81	34.78

Minimum Temperature (^{0}C)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	18.43	19.69	21.93	23.80	23.42	22.47	21.48	21.19	21.66	21.87	20.70	19.44	21.34
AMAC	16.46	17.61	20.48	22.74	22.29	21.37	20.58	20.42	20.72	20.59	18.78	17.57	19.97
Bwari	16.37	17.24	19.61	21.89	21.65	20.85	20.03	19.78	20.14	20.00	18.21	17.38	19.43
Gwagwalada	18.12	19.57	22.37	24.30	23.73	22.70	21.75	21.52	21.94	22.13	20.85	19.08	21.50
Kuje	17.68	19.29	22.33	23.86	23.25	22.20	21.32	21.18	21.54	21.64	20.19	18.34	21.07
Kwali	17.72	19.66	22.87	24.53	23.88	22.75	21.81	21.61	22.01	22.24	20.93	18.46	21.54
Mean	17.46	18.84	21.60	23.52	23.04	22.06	21.16	20.95	21.33	21.41	19.94	18.38	20.81

Mean Temperature (^{0}C)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	28.60	30.19	31.63	31.76	29.89	28.03	25.75	24.74	25.86	27.63	28.73	28.45	28.44
AMAC	26.79	28.27	29.86	30.06	28.26	26.39	24.32	23.44	24.41	25.58	26.38	26.53	26.69
Bwari	26.43	27.70	29.04	29.27	27.50	25.67	23.50	22.59	23.72	24.96	25.93	26.17	26.04
Gwagwalada	28.73	30.52	32.21	32.26	30.28	28.45	26.27	25.22	26.10	27.62	28.72	28.42	28.73
Kuje	28.25	30.13	31.74	31.44	29.41	27.54	25.44	24.53	25.35	26.67	27.72	27.66	27.99
Kwali	28.89	30.96	32.72	32.48	30.39	28.52	26.39	25.35	26.15	27.58	28.76	28.33	28.88
Mean	27.95	29.63	31.20	31.21	29.29	27.44	25.28	24.31	25.27	26.67	27.70	27.59	27.79

Rainfall/Precipitation (mm)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	0.66	2.54	18.63	96.77	144.71	186.18	256.50	301.28	275.81	74.74	3.96	0.12	113.49
AMAC	2.02	5.46	24.65	112.81	187.78	200.64	325.92	365.68	315.83	116.04	8.38	1.12	138.86
Bwari	1.81	5.72	24.09	114.17	205.07	233.02	386.33	445.02	366.05	141.50	8.80	0.89	161.04
Gwagwalada	0.73	2.40	15.72	116.37	144.80	174.72	228.53	263.52	237.55	67.18	3.56	0.25	104.61
Kuje	2.04	5.26	26.23	123.46	175.65	190.97	263.89	304.71	288.93	107.80	7.17	1.10	124.77
Kwali	1.28	2.69	17.63	123.80	151.57	175.35	230.34	267.00	248.67	81.65	4.89	0.61	108.79
Mean	1.42	4.01	21.16	114.56	168.26	193.48	281.92	324.53	288.81	98.15	6.13	0.68	125.26

Relative Humidity (%)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	23.51	29.59	40.52	52.02	62.94	70.38	79.57	83.02	80.65	72.15	47.22	26.71	55.69
AMAC	28.29	36.09	46.51	57.19	68.34	75.76	84.17	86.71	84.99	79.47	56.61	32.31	61.37
Bwari	26.49	33.12	44.13	57.13	69.33	77.32	85.58	88.12	86.07	79.41	53.06	29.74	60.79
Gwagwalada	26.30	33.55	43.61	53.12	63.36	70.36	79.26	82.63	81.34	74.44	53.35	31.20	57.71
Kuje	30.45	38.03	47.47	56.24	66.33	73.77	82.02	84.78	83.82	77.91	59.31	35.74	61.32
Kwali	29.78	37.18	45.93	54.06	63.82	70.91	79.64	82.84	82.04	75.40	57.21	35.49	59.53
Mean	27.47	34.59	44.70	54.96	65.69	73.08	81.71	84.68	83.15	76.46	54.46	31.87	59.4

Potential Evapotranspiration (mm)

Area Councils	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Mean
Abaji	4.74	5.14	5.06	4.56	3.70	3.19	2.77	2.69	2.93	3.37	3.98	4.30	3.87
AMAC	5.51	5.96	5.63	5.02	4.00	3.39	2.89	2.71	3.07	3.68	4.66	5.03	4.30
Bwari	5.66	6.12	5.79	5.09	3.98	3.34	2.86	2.69	3.09	3.72	4.78	5.21	4.36
Gwagwalada	5.32	5.78	5.49	4.94	4.03	3.36	2.92	2.77	3.09	3.66	4.54	4.81	4.23
Kuje	5.18	5.62	5.39	4.83	3.82	3.27	2.85	2.72	3.02	3.56	4.37	4.73	4.11
Kwali	5.04	5.47	5.25	4.80	3.91	3.30	2.88	2.74	3.05	3.52	4.24	4.58	4.06
Mean	5.24	5.68	5.44	4.87	3.91	3.31	2.86	2.72	3.04	3.58	4.43	4.78	4.16

Source: Summarized from Climate Forecast System Re-analysis [CFSR] (1981-2017)

Table 2: Long-term Mean of Exposure Indicators in FCT Area Councils (1981 - 2017)

Area Councils	Temperature (^{0}C)	Rainfall (mm)	Evapotranspiration (mm)	Rel. Humidity (%)
Abaji	28.438	1361.908	3.870	55.7
AMAC	26.691	1666.315	4.296	61.4
Bwari	26.040	1932.458	4.361	60.8
Gwagwalada	28.734	1255.329	4.227	57.7
Kuje	27.991	1497.199	4.113	61.3
Kwali	28.876	1305.470	4.063	59.5

Source: Derived from CFSR Data (1981-2017)

The ability of crop farmers to adapt to climate variability in this study was assessed based on five factors that have direct influence on crop production. The adaptive capacity of the farmers was based on the Sustainable Livelihoods Framework (SLF) developed by the United Nations Development Programme, (UNDP, 2019). It analyses the livelihoods of the poor using financial, human, natural, physical and social capital.

Table 3: Description of Assets and Indicators of Adaptive Capacity of Farmers

S/No	Assets	Indicators
1	Human	Education, farm labour, knowledge of climate risk and agriculture and vocational training.
2	Social	Information, community support, extended families and formal or informal social-welfare support
3	Physical	Access to services and facilities (road, market, school and medical centre), equipment, irrigated land and house quality
4	Natural	Land ownership, soil and Reliable water resources.
5	Financial	Savings from crop sales and off-farm income, salaries, remittances or pensions and loans groups

Source: UNDP (2019)

Data obtained from the questionnaire on adaptive capacity was analyzed on the basis of the indicators using Microsoft office excel. The coding of the data was done for households, settlements, Area Councils and finally for FCT. The indicator scores were summarized for all the Area Councils using the same software. Index construction was done by summing up the scores for all indicators to obtain a single group of variables. The development of adaptive capacity index (ACI) using criteria weighting by Marzia *et al*, (2018) was adopted for the study. The overall adaptive capacity index (ACI) is expressed in the equation below.

Adaptive Capacity Index (ACI) = (S.Sw) + (F.Fw) + (P.Pw) + (H.Hw) + (N.Nw)……………………………..(eq 1)

Where, ACI is the overall Adaptive Capacity Index, S is the social capital score and Sw is the weighting, F is the financial capital score and Fw is the weighting, P is the physical capital score and Pw is the weighting, H and N are the human and natural capital scores and the respective weightings (Hw and Nw).

C. Assessing the Adaptive Capacity of Farmers to Climate Variability in the FCT of Nigeria

The overall adaptive scores of indicators were obtained through the questionnaire on adaptive capacity of the farmers. The indicator scores against the Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) options in the questionnaire was divided by the number of questions on each indicator to obtain the average indicator score against the options using Microsoft office excel. Codes 4, 3, 2 and 1 were used to multiply the indicator scores on SA, A, D, and SD columns in the questionnaire respectively. This was done for each of the Area Councils. The individual indicator results for all the Area Councils were then added together and transposed in Microsoft office excel. The result is shown in table 4

Table 4: Overall Score of Adaptive Indicators in FCT Area Councils

Area Councils	Financial	Social	Physical	Human	Natural	Mean
Abaji	894	602	1013	1394	1377	1056
AMAC	963	607	1436	1445	1438	1177.8
Bwari	875	671	1424	1472	1197	1127.8
Gwagwalada	1101	729	1477	1527	1377	1242.2
Kuje	910	508	1264	1381	1472	1107
Kwali	1082	715	1376	1446	1357	1195.2

Source: Field Work (2018).

D. Adaptive Capacity Index andAdaptive Capacity Map.

The assessment of croplands vulnerability to climate variability in FCT was done through the Analytical Hierarchy Process (AHP). According to Bunruamkaew (2012), the AHP is done by breaking down the problem into hierarchy, make comparison among the alternatives in the hierarchy, generate the overall weight for achieving the goal through expert judgement and determine the consistency measures. The consistency measures consist of the consistency index (CI) and the consistency ratio (CR). The consistency ratio is to check the accuracy/acceptability of the judgement. The AHP result is unacceptable when the consistency ratio is higher than 0.1.

Normalization

Since each of the indicators/indices were measured on different scales, it is necessary to carry out standardization to ensure that they are comparable. Based on the methodology developed by the United Nations Development Programme (UNDP, 2019) for the calculation of Human Development Index (HDI) that are reported annually, the values of all the indicators were normalized to values between 0 and 1. If vulnerability increases with increase in the value of the indicator, the normalization is achieved by the formula:

$Yi=Xi-MinXj/ MaxXj-MinXj$……………………..(eq 2)

On the other hand, if vulnerability decreases with increase in the value of the indicator, the normalization is achieved by the formula:

$Yi =MaxXj-Xi / MaxXj-MinXj$…………………....(eq 3)

where, Yi is the normalized value of jth indicator with respect to ith Area Council (i=1, 2…,n), Xi is the actual value of the indicator with respect to ith Area Council, Min Xj and Max Xj are the minimum and maximum values respectively of jth indicator (j=1,2, …,n) among all the Area Councils.

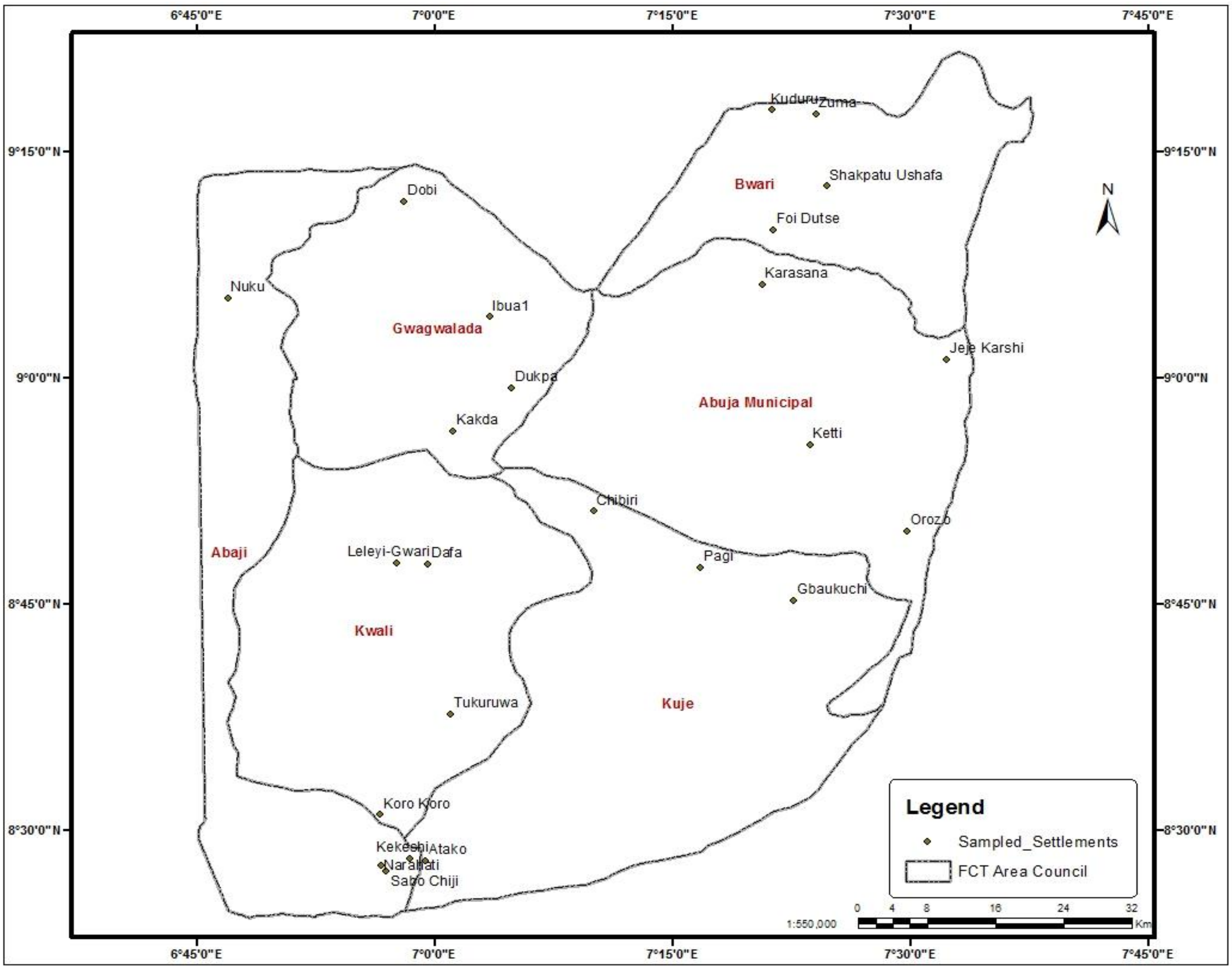

Figure 2: Sampled Farm Settlements in the Study Area*Source: Author, 2018*

E. Assignment of Weights to Indicators and Index Calculation

After standardizing the indicators, they were assigned weights based on their degree of influence on vulnerability. The study adopts the Analytic Hierarchy Process (AHP) in deriving the weights of the indicators of adaptive capacity. As a result of this, a pair-wise comparison approach of AHP was used (Saaty, 2010). The indicator weight was calculated by averaging the indicator values. The consistency measure, otherwise known as eigen value was arrived at using the matrix multiplication function =MMULT() in excel. The consistency index was calculated by subtracting the number of variables (n) from the sum of the eigen value and dividing the result by (n-1).

The formula is given by:

Consistency Index (CI) = (λmax – n)/(n – 1)……..(equ 4)

The consistency ratio was obtained by dividing the consistency index by the random index. The index calculation was done by multiplying the normalized indicator score by the normalized weight of the indicator obtained through the pairwise comparison in AHP.

III. RESULTS AND DISCUSSION

A. Mean Monthly and Annual Temperature

Table 1 shows the mean monthly temperature in FCT Area CouncilsThe study revealed that Kwali and Gwagwalada Area Councils reported the highest temperature of 32.720C in the month of March and 32.260C in the month of April respectively for the study period. Bwari and AMAC Area Councils recorded the least of 22.590C and 23.440C respectively in the month of August of the study period. Abaji and Kuje documented 24.740C and 24.530C in the month of August, 31.760C in April and 31.740C in the month of March respectively. The temperature trend was in the upward direction based on the trend analysis performed on the dataset (Butu and Emeribe, 2019). The highest annual mean temperature was recorded in 2005 (29.150C) and the lowest was in 1992 (26.530C). On the average, Kwali Area Council registered the highest mean temperature of (28.880C) within the period while Bwari (26.040C) recorded the lowest. The mean for the study period was 27.790C (Appendix A3).

B. Temperature Variability

Figure 3 shows the variability in temperature in FCT Area Councils. There was a sharp increase in variability from 1999 through 2006. These years were the warmest years during the study period. The year 1999 was a global indicator of sharp climate shift (Abbadi, 2013). Year 2005 recorded the highest variability in temperature with Abaji, AMAC, Gwagwalada, Kuje and Kwali Area councils having a variability of 1.420C, 1.260C, 1.200C, 1.400C, 1.390C and 1.450C respectively above average. The lowest temperature variability was observed in year 1992 where Abaji, AMAC, Bwari, Gwagwalada, Kuje and Kwali Area councils had a variability of -1.210C, -1.250C, -1.070C, -1.360C, -1.340C and -1.390C respectively below average. The mean temperature for the study period was suitable for all the three arable crops growth and development. The temperature variability in either direction (above or below average), impedes crop growth and development as they are either above or below the threshold temperature range for optimal crop production in all the three crops under investigation. The overall implication of this is reduced yield in year 1992 and 2005.

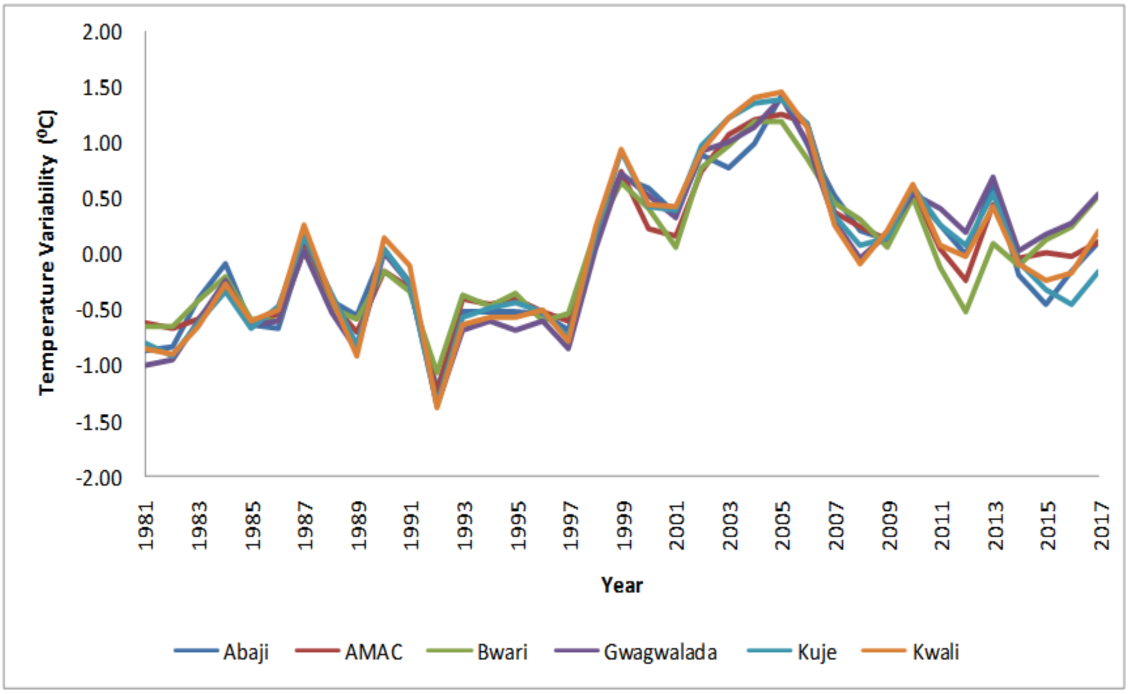

Figure 3: Mean Temperature Variability (^{0}C) in FCT Area Councils*Source: Derived from CFSR data (1981-2017)*

C. Mean Monthly and Annual Rainfall

Table 1 shows the mean monthly rainfall in FCT Area Councils. The months of July through September received the highest rainfall during the study period with the peak in the month of August. Bwari, AMAC and Kuje Area Councils received the highest rainfall from May through October with the peak of 445.02mm, 365.68mm and 304.71mm respectively in the month of August. The months of January and December received the least rainfall of 1.42mm and 0.68mm respectively during the study period. The rainfall per annum was on reducing trend as shown on the trend analysis performed on the rainfall data (Nsubuga and Rautenbach, 2018; Ogallah, 2017). The mean annual rainfall for the study period showed that Bwari Area Council received the highest annual rainfall of 1,932.46mm while Gwagwalada received the least of 1,255.33mm (Appendix A4). The highest mean annual rainfall was recorded in 1988 (2325.42mm) and the lowest was 2000 (570.86mm). The mean for the study period is 1503.11mm. Figure 4 shows

the rainfall variability in FCT Area Councils. Year 1988 recorded the highest variability in rainfall with Abaji, AMAC, Bwari, Gwagwalada, Kuje and Kwali having a variability of 750.29mm, 876.39mm, 1138.56mm, 787.65mm, 746.56mm and 634.37mm respectively above average. The lowest rainfall variability was observed in year 2000 where Abaji,

AMAC, Bwari, Gwagwalada, Kuje and Kwali had a variability of -917.42mm, -1001.67mm, -1294.21mm, -720.82mm, -905.28mm and -754.14mm respectively below average. The mean rainfall for the study period was suitable only for yam production as this was beyond the rainfall requirement for beans and maize production. This made the cropland vulnerable to both beans and maize. The rainfall variability above average impedes crops growth and development as they are above the threshold rainfall requirement range for optimal crop production in all the three crops under investigation. The overall implication of this is reduced yield in year 1988. The negative rainfall variability in year 2000 will have a positive impact in the growth, development and production of maize and beans and negative impact on yam production thereby making yam production vulnerable.

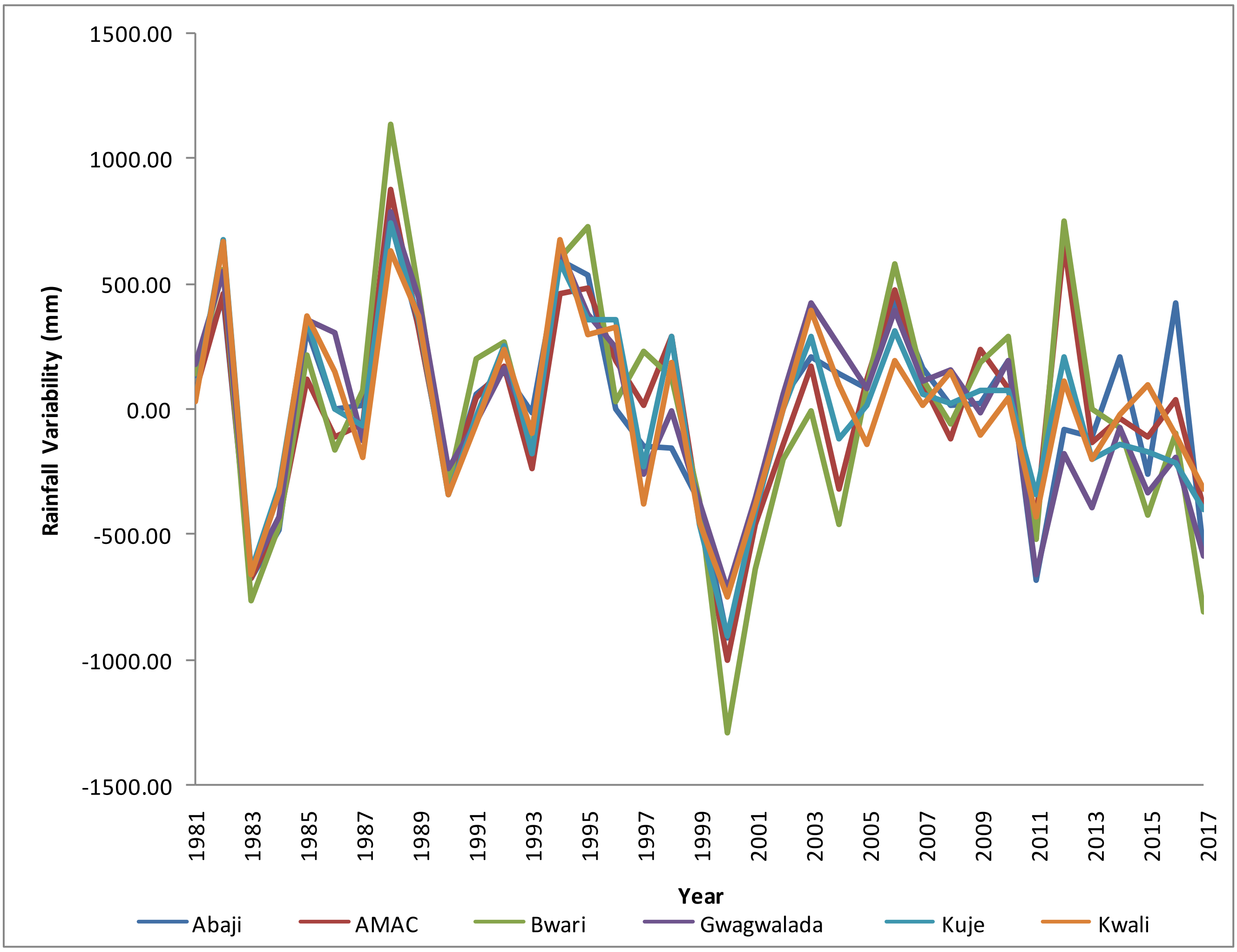

Figure 4: Rainfall Variability (mm) in FCT Area Councils*Source: Derived from CFSR data (1981-2017)*

D. Mean Monthly and Annual RelativeHumidity

Table 1 shows the mean Monthly relative humidity in FCT Area Councils from January to December. The months of July through September received the highest relative humidity during the study period (Ishaya *et al*, 2018) with the peak in the month of August. Bwari, AMAC and Kuje recorded the highest relative humidity from May through September with the peak of 88.12%, 86.71% and 84.78% respectively in the month of August. AMAC is highest in October. The months of January and December reported the least relative humidity of 27.47% and 34. 59% respectively during the study period. The mean annual relative humidity for the study period showed that AMAC documented the highest annual relative humidity of 61.36% while Gwagwalada earned the least of 55.69% (Appendix A5). The highest mean relative humidity was unveiled in 1988 (65.79%) and the lowest was in 2017 (41.56%). The relative humidity variability (figure 5) was high from 1985 through 1997 and low from 1998 through 2006. It was on its lowest in 2015 and highest in 1988 in all the Area Councils. According to (TNAU, 2016) very high or very low relative humidity affects high grain yield. High relative humidity reduces CO2 uptake and evapotranspiration which consequently affects the translocation of food materials and nutrients, increases heat load in plants and facilitates stomata closure. High incidence of insect pest and diseases are also associated with high relative humidity. The above scenario results in crop failure and food insecurity.

Figure 5: Relative Humidity variability (%) in FCT Area Councils*Source: Derived from CFSR data (1981-2017)*

E. Potential Evapotranspiration

Table 1 shows the mean monthly potential evapotranspiration in FCT Area Councils. The months of June through October received the lowest potential evapotranspiration during the study period with the lowest of 2.69mm in the month of August by Abaji andBwari Area Councils. Bwari, AMAC and Gwagwalada recorded the highest potential evapotranspiration from November throughApril with the peak of 6.12mm, 5.96mm and 5.78mm respectively in the month of February. The potential evapotranspiration per annum was on the reducing trend as shown on the trend analysis performed on the potential evapotranspiration data. The mean annual potential evapotranspiration for the study period showed that Bwari reported the highest annual potential evapotranspiration of 4.36mm while Abaji documented the least of 3.87mm (Appendix A6). Year 1983 and 1987 registered the highest potential evapotranspiration of 4.31mm while 1991 recorded the least of 3.98mm. The mean for the study period was 4.16mm (Appendix A6). The potential evapotranspiration variability (figure 6) was on its highest in 1983 and 1985 and on its lowest in 1991. According to (TNAU, 2016) very high or very low potential evapotranspiration affects grain yield. Highpotential evapotranspiration increases CO_2 uptake and facilitates the translocation of food materials and nutrients, reduces heat load in plants and

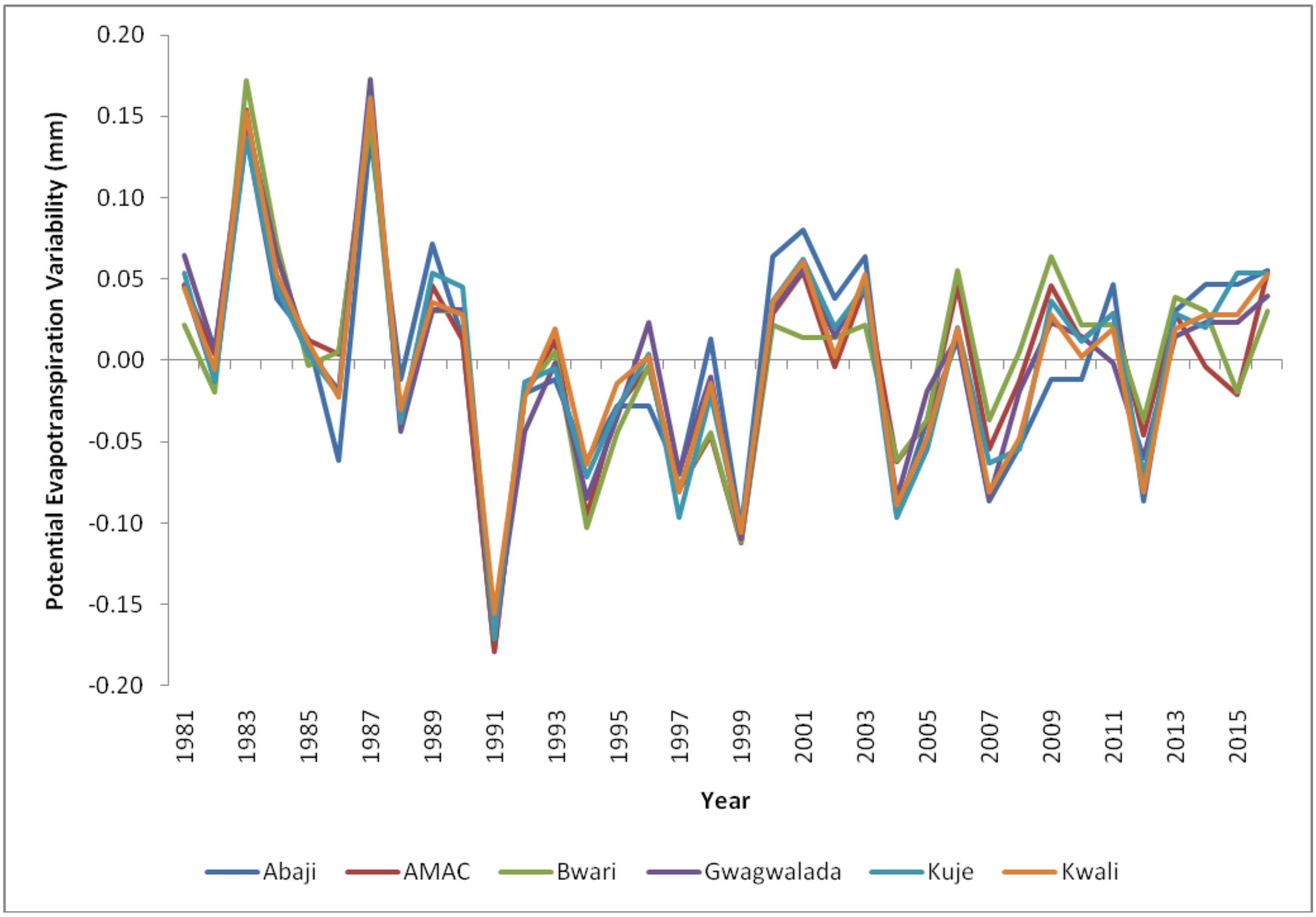

Figure 6: Potential Evapotranspiration Variability in FCT Area Councils*Source: Derived from CFSR data (1981-2017)*

enhances the opening of the stomata, thereby increase crop yield. High potential evapotranspiration reduces the incidence of insect pest and diseases. The higher the potential evapotranspiration, the higher the yield in grains. Low potential evapotranspiration is associated with high relative humidity which results in crop failure and food insecurity. Based on the above, Area Councils with high potential evaporation will have high grain yields while those with low potential evaporation will have low yield under standard condition.

F. Correlation between Selected Climate Variables and Crop Production in FCT (1990-2017)

Figure 7 shows the crop production figures in FCT. Maize and Beans production were observed to be increasing from 1990 to 2017, except for unstable output noticed from 1994 to 1997. Both crops (Maize and Beans) documented their highest production figures in 2014. There was a sharp positive temperature variability shift from 1999 through 2006. This period was accompanied by reduced rainfall as explained by negative rainfall variability (figure 4). This might be the reason for the sudden decline in yam production in 2001. Yam production started steady increase again from 2002 till 2017 but not as high as from 1990 to 2000.

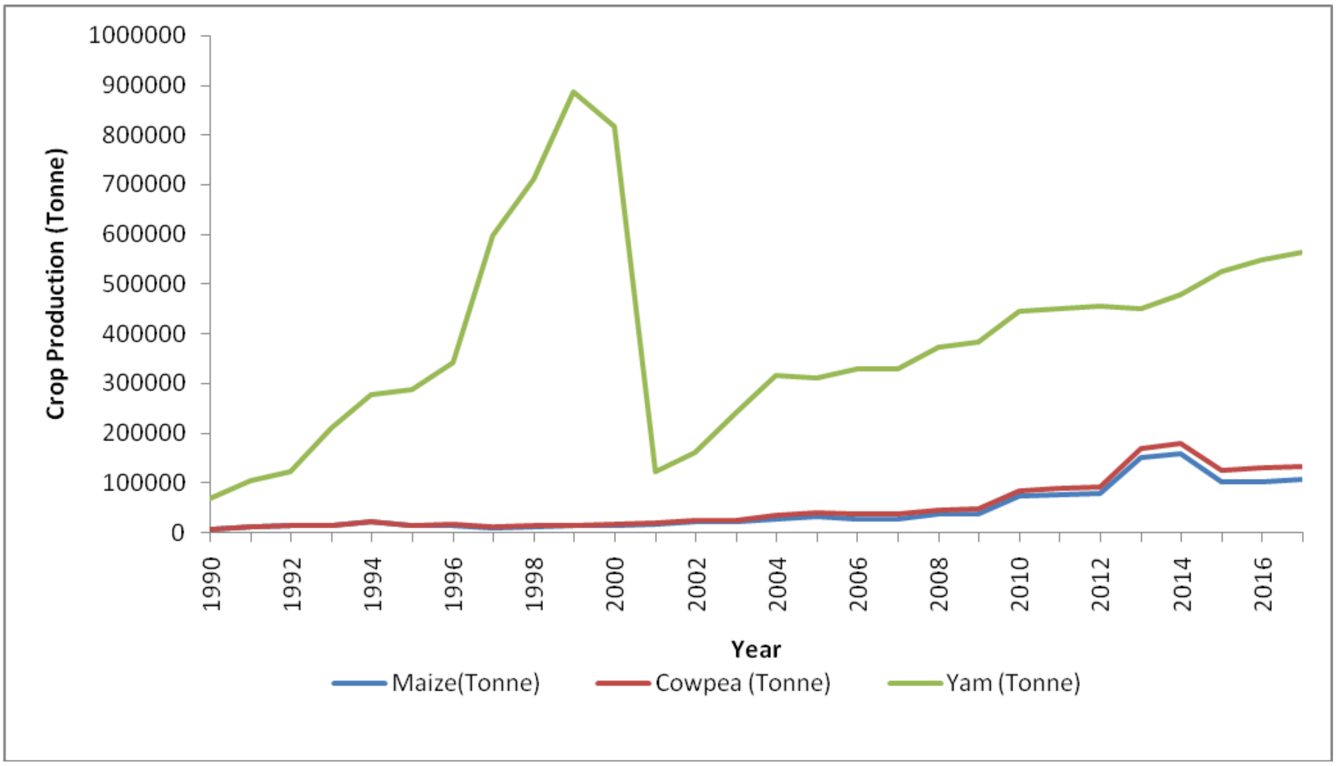

Figure 7: Cereal, Legume and Tuber Production in FCT from 1990-2017

Source: Derived from FCT Agricultural Development Project Crop Production Data

Maize production in FCT varies differently with selected climate variables. It has little or no positive correlation with temperature at a correlation coefficient of 0.048, little or no negative correlation with rainfall at a correlation coefficient of -0.14 and low negative correlation with relative humidity at a correlation coefficient of -0.49. The computed t values of 0.25 against temperature, -0.71 against rainfall and -2.89 against relative humidity were lower than the critical value of 2.05 at 95% confidence level and 26 degree of freedom. This implies that climate variables have no influence on maize production in FCT (Okongor et al, 2021; Mohammed et al, 2014; Hassan, 2012). The observed differences in the raw data are not statistically significant and occur due to chance.

Beans production in FCT also varies differently with selected climate variables in FCT. It has little or no positive correlation with temperature at a correlation coefficient of 0.156, little or no negative correlation with rainfall at a correlation coefficient of -0.158 and highly negative correlation with relative humidity at a correlation coefficient of -0.71. The computed t values of 0.81 against temperature, -0.81 against rainfall and -5.20 against relative humidity were lower than the critical value of 2.05 at 95% confidence level and 26 degree of freedom. This implies that climate variables have no influence on Beans production in FCT (Okongor et al, 2021; Mohammed et al, 2014; Hassan, 2012). The observed differences in the raw data are not statistically significant and occur due to chance. The result challenged the submission of Ojo et al, 2019.

The variation in yam production in FCT was not the same with the climate variables. It has little or no positive correlation with temperature at a correlation coefficient of 0.12, low negative correlation with rainfall at a correlation coefficient of -0.37 and little or no negative correlation with relative humidity at a correlation coefficient of -0.24. The computed t values of 0.64 against temperature, -2.00 against rainfall and -1.25 against relative humidity were lower than the critical value of 2.05 at 95% confidence level and 26 degree of freedom. This implies that climate variables have no influence on yam production in FCT (Okongor et al, 2021; Mohammed et al, 2014; Hassan, 2012). The observed differences in the raw data were not statistically significant and occurred due to chance.

The study corroborated the work of Hassan (2012) and Mohammed et al (2014) which attributed the increasing crop production to length of raining season (LRS) and the population involved in agriculture and contradicted the works of Onu et al, 2014 and Agbola and Fayiga (2016) which analyzed the effect of climate change to be reduced yield of crops. The increased yield could also be linked to the application of modern technology in agricultural production and government policy on agriculture.

G. *Adaptive Capacity of Farmers to Climate Variability in FCT.*

a. Demographic and Income Profiles of FCT Area Councils

The percentage of male household heads are more than the female in all the Area Councils with AMAC and Gwagwalada Area Councils having the highest of 77.5% each. Abaji has the least male household head (57.5%) and the highest percentage in female household head rating (42.5%). The age brackets of 18-45 years are the most active in agriculture in all the Area Councils. This was followed by 45-60 years. In terms of education, farmers in the Area Councils have different levels of education from non-formal to tertiary education. Kuje and Bwari have the highest level of tertiary (27.5%) and secondary (25%) education respectively. Over 70% of farmers in all the Area Councils are married. The maximum income range of farmers are from one hundred to five hundred thousand naira (₦100,000 - ₦500000) per annum with a minimum of 60% of the farmers from each Area Council. About 10% of the farmers from AMAC and Gwagwalada Area Councils are within the five hundred thousand to one million naira (₦500,000 - ₦1,000,000) annual income range. 25% and 2.5% of the farmers from Gwagwalada and Kwali respectively earn above one million naira per annum. Over 80% of farmers in AMAC Area Council do not have croplands of their own while farmers in Gwagwalada, Kwali, Abaji have various sizes of cropland available for crop production.

b. Nature and Distance to Infrastructures in FCT Area Councils

The nature and distance to infrastructures like health, drinking water, educational and commercial institutions influence the vulnerability of farmers as shown in table 5. The farther the distance to infrastructures, the lower the coping capacity of the farmers and the higher their vulnerability. The nature of transportation infrastructures in all the farm settlements visited was very poor. Most of these settlements are accessed through untarred roads. The situation was worse during the raining season. This affected the transportation of farm produce to the markets. Highest percentage of the farmers in all the Area Councils were close to the market, health and drinking water infrastructures at a maximum distance of 3kilometers. Most of the communities have hand pump bore holes.

c. Adaptive Indicator Scores of Farmers in Area Councils

Table 5: Average Score of Adaptive Indicators in FCT Area Councils

Area Councils	Financial/11	Social/8	Physical/14	Human/15	Natural/12
Abaji	81.2727	75.2500	72.3571	92.9333	114.7500
AMAC	87.5455	75.8750	102.5714	96.3333	119.8333
Bwari	79.5455	83.8750	101.7143	98.1333	99.7500
Gwagwalada	100.0909	91.1250	105.5000	101.8000	114.7500
Kuje	82.7273	63.5000	90.2857	92.0667	122.6667
Kwali	98.3636	89.3750	98.2857	96.4000	113.0833
Sum	529.5455	479.0000	570.7143	577.6667	684.8333

Source: Author, 2018.

Table 6: Normalized Score of Adaptive Indicators in FCT Area Councils

Area Councils	Financial	Social	Physical	Human	Natural	**Mean Adaptation/Rank**
Abaji	0.91593	0.57466	1	0.91096	0.34545	**0.7494 (1)**
AMAC	0.61062	0.55204	0.08836	0.56164	0.12364	**0.3873 (4)**
Bwari	1	0.26244	0.11422	0.37671	1	**0.5507 (3)**
Gwagwalada	0	0	0	0	0.34545	**0.0691 (1)**
Kuje	0.84513	1	0.45905	1	0	**0.6608 (2)**
Kwali	0.08407	0.06335	0.21767	0.55479	0.41818	**0.2676 (5)**

Source: Author, 2018.

Table 6 shows the normalized adaptive indicator score in FCT Area Councils. Considering financial assets as indicator of adaptive capacity, Bwari recorded the highest (1.0000) normalized indicator score. This was followed by Abaji (0.9159), Kuje (0.8451), AMAC (0.6106), Kwali (0.0841) and Gwagwalada (0.0000) in reducing trend. Sequel to this, farmers in Bwari, Abaji and Kuje reported high adaptive capacities to climate variability while farmers in AMAC, Kwali and Gwagwalada recorded low adaptive capacity to climate variability. Farmers in Bwari, Abaji and Kuje will have low vulnerabilities while farmers in AMAC, Kwali and Gwagwalada will be highly vulnerable to climate variability. The implication is that farmers in Bwari, Abaji and Kuje had enough financial assets to cope and overcome climate variability thereby having high yield in crop production. Farmers in AMAC would cope moderately and have moderate yield while farmers in Kwali and Gwagwalada would have poor yield based on their inability to cope with climate variability.

Pertaining to social assets, Kuje recorded the highest score (1.0000). This was followed by Abaji (0.5747), AMAC (0.5520), Bwari (0.2624), Kwali (0.0633) and Gwagwalada (0.0000) in reducing trend. This shows that Kuje had the highest social adaptive capacity and will therefore have high crop production. Abaji and AMAC have moderate social adaptive capacities and will therefore have moderate crop production. Bwari, Kwali and Gwagwalada are threatened in terms of social adaptation and consequently will have low crop production.

With respect to physical infrastructure, Abaji had the highest (1.000) while AMAC (0.0884) and Gwagwalada (0.000) had the lowest. As a result of this, farmers in Abaji registered the highest adaptive capacity in terms of infrastructure while AMAC and Gwagwalada received the lowest and were threatened by climate variability. The result authenticated the work of Hassan et al (2011) and Eludoyin et al (2017) on irrigation infrastructure in crop production and contradicted the work of Ishaya et al, 2014 on post adaptation vulnerability of cereals to rainfall and temperature in FCT. Kuje (0.4591), Kwali (0.2177) and Bwari (0.1142) recorded varying degrees of low infrastructural adaptive capacity because of their corresponding low scores. Based on this indicator, Abaji will have high crop production and yield while AMAC and Gwagwalada will have low crop production and yield. Kuje will produce moderately while Kwali and Bwari will have low crop production and yield.

Human asset in terms of education is one of the prominent indicators of adaptive capacity of farmers to climate variability. A locality with high human assets tends to have low adaptive vulnerability. Kuje (1.0000) and Abaji (0.9110) had the highest human assets and therefore highest adaptive capacity to climate variability. AMAC (0.5616) and Kwali (0.5548) recorded moderate human assets and the corresponding moderate adaptive capacity. Bwari (0.3767) and Gwagwalada (0.0000) got the lowest score and the corresponding lowest human adaptive capacity. Hence, the result supported the work of Dasgupta et al (2014). In terms of crop production and yield, Kuje and Abaji will have the highest while Bwari and Gwagwalada will have the lowest crop yield.

Natural asset like land and water are gifts of nature. A locality with high natural capital tends to have low adaptive cropland vulnerability. In FCT, Bwari (1.0000) recorded the highest natural asset and therefore the highest adaptive capacity. Kwali (0.4182), Gwagwalada (0.3455) and Abaji (0.3455) scored low in natural assets and have varying degrees of vulnerabilities. AMAC (0.1236) and Kuje (0.0000) had the lowest scores and were therefore highly vulnerable. This finding attested to the work of Reidsma et al, 2007 on farm performance in Europe. This implies that croplands in Bwari have high adaptive capacity and the corresponding high crop yield while croplands in AMAC and Kuje have low adaptive capacity and therefore low yield. Kwali, Gwagwalada and Abaji have moderate yields.

The mean adaptive capacity of farmers in FCT showed that, croplands in Abaji unveiled the highest adaptive capacity (0.7494) followed by croplands in Kuje (0.6608). Moderate adaptation was recorded in croplands in Bwari (0.5507) while low adaptations were recorded in AMAC (0.3873) and Kwali (0.2676). Lowest adaptation was witnessed in Gwagwalada (0.0691). This study challenged the work of Huai (2016) in Australia. The implication of this is that Abaji and Kuje will adjust to climate variability by using their assets and do not need external assistance while AMAC, Kwali and Gwagwalada will require expert support to recover from climate variability. Bwari require some level of external assistance to overcome the climate variability. AMAC, Kwali, Gwagwalada and Bwari will have low yields without the required external assistance. Abaji and Kuje will use their assets to recover from climate variability and restore their crop yields.

d. Farmers Adaptive Vulnerability to Climate Variability

Table 7: Pairwise Comparison Matrix of Adaptive Indicators and Judgment

Assets	Financial	Social	Physical	Human	Natural	Total
Financial	1.00	3.00	3.00	3.00	3.00	13.00
Social	0.33	1.00	0.14	0.20	0.33	2.01
Physical	0.33	7.00	1.00	0.33	5.00	13.67
Human	0.33	5.00	3.00	1.00	3.00	12.33
Natural	0.33	3.00	0.20	0.33	1.00	4.87
Sum	2.33	19.00	7.34	4.87	12.33	45.88

Source: Author, 2018.

Table 8 Calculated Weight, Eigen Value, Consistency Index and Consistency Ratio of Adaptive Capacity Indicators.

Assets	Finance	Social	Physical	Human	Natural	**Weight**	**Eigen Value**	**CI**	**CR**
Financial	0.4286	0.1579	0.4086	0.6164	0.2432	**0.3709**	**1.1822**	**0.0239**	**0.0213**
Social	0.1429	0.0526	0.0195	0.0411	0.0270	**0.0566**	**1.2947**		
Physical	0.1429	0.3684	0.1362	0.0685	0.4054	**0.2243**	**0.7153**		
Human	0.1429	0.2632	0.4086	0.2055	0.2432	**0.2527**	**0.9288**		
Natural	0.1429	0.1579	0.0272	0.0685	0.0811	**0.0955**	**0.9746**		
Sum							**5.0956**		

Source: Author, 2018.

Table 9: Normalized Adaptive Capacity Index of FCT Area Councils from 1981-2017.

Area Councils	Financial *Weight	Social *Weight	Physical *Weight	Human *Weight	Natural *Weight	**Adaptive Index/Rank**
Abaji	0.33976	0.03253	0.22427	0.23016	0.03300	**0.17194 (1)**
AMAC	0.22650	0.03125	0.01982	0.14190	0.01181	**0.08626 (4)**
Bwari	0.37094	0.01486	0.02562	0.09518	0.09551	**0.12042 (3)**
Gwagwalad	0.00000	0.00000	0.00000	0.00000	0.03300	**0.00660 (6)**
Kuje	0.31349	0.05661	0.10295	0.25266	0.00000	**0.14514 (2)**
Kwali	0.03119	0.00359	0.04882	0.14017	0.03994	**0.05274 (5)**

Source: Author, 2018.

e. Adaptive Capacity Map of FCT Area Councils

Table 9 shows the normalized adaptive index of farmers in FCT which was used to produce the vulnerability map. The index indicates that, farmers in Abaji (0.17194) documented the highest adaptation capacity followed by farmers in Kuje (0.14514). High adaptation capacity was revealed for farmers in Bwari (0.12042). Low adaptation was recorded in AMAC (0.08626) and Kwali (0.05274) and the least adaptation was registered in Gwagwalada (0.00660). Figure 8 shows the adaptive capacity map of FCT Area Councils. In terms of this component of vulnerability, Gwagwalada was the most vulnerable and Abaji the least. Kwali was high while AMAC was low in terms of adaptive vulnerability; Kuje and Bwari reported low vulnerability. The three crops will produce moderately at moderate adaptation while their production will be marginal and optimal at very low and very high adaptations respectively. Crop production will be optimum in Abaji, marginal in Gwagwalada and moderate in Bwari.

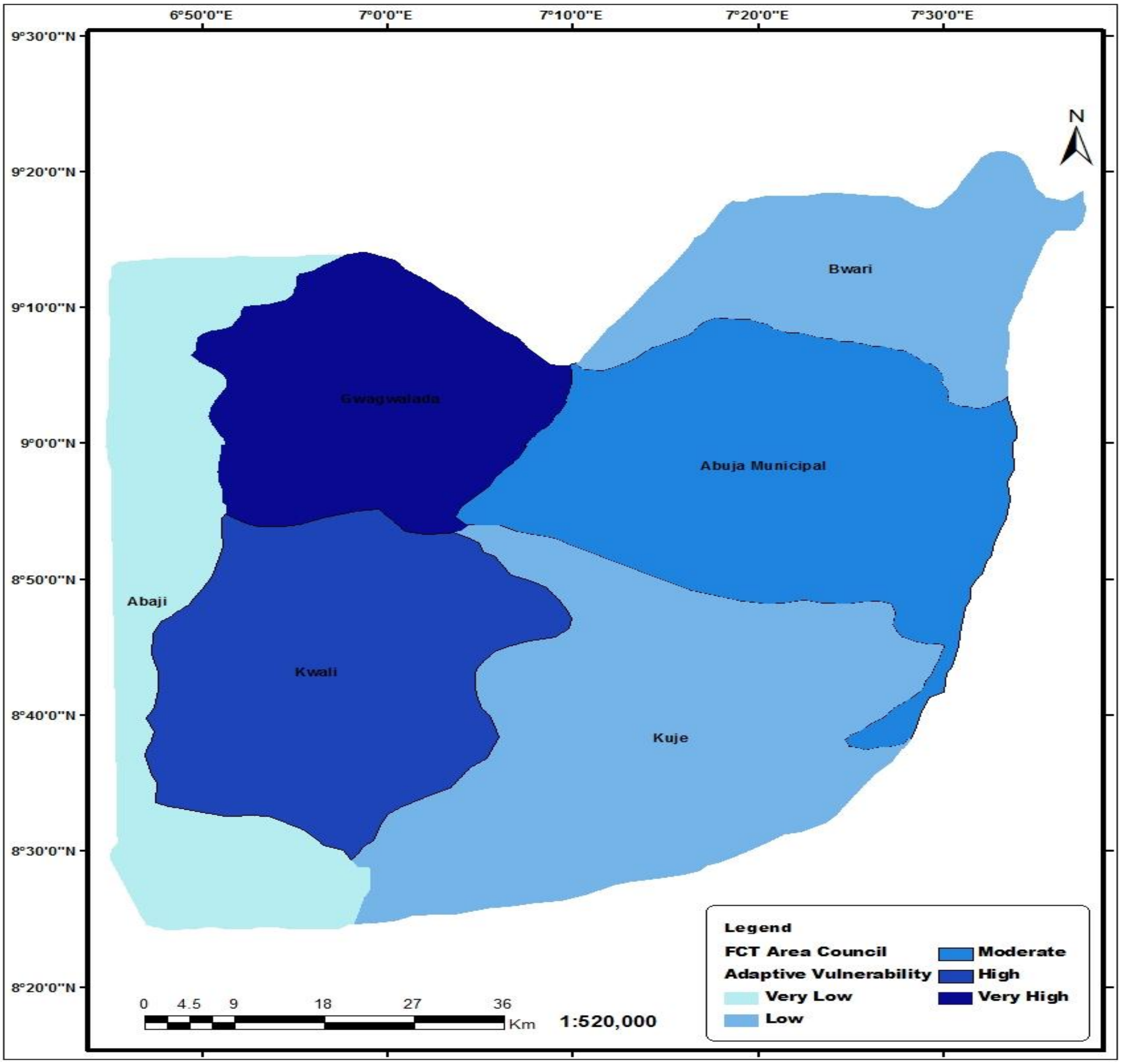

Figure 8: Adaptive Vulnerability of FCT Area Councils to Climate Variability.*Source: Author, 2018.*

IV. CONCLUSION

The result showed that Abaji Area Council recorded the highest adaptive capacity while Gwagwalada Area Council has the lowest adaptive potential. The overall implication of these findings is that farmers in Gwagwalada with very high vulnerability are in urgent need of assistance on the modalities of boosting their adaptive potentials. They need expert support in human, physical, financial, social and natural capital development to be able to overcome the impact inherent in climate variability. The same applies to farmers in AMAC and Kwali. Bwari with moderate vulnerability requires some level of external assistance to overcome the variability, while Kuje will adjust and prevail to the given variability by using their assets and do not need external assistance. Abaji does not require any level of external assistance. The study also demonstrated the capability of Geoinformation in transforming different variables of adaptation into map.

Agriculture should be heavily subsidized in FCT in terms of providing irrigation infrastructures to farmers to reduce over reliance on rain fed agriculture. Microcredit scheme should also be made available to farmers to boost their agricultural production output. Diversification into off-farm activities by farmers should be encouraged so that they can have enough financial assets to boost their farm activities in times of failure and overcome the adverse effects of climate variability. Sensitization and engagement of farmers on climate variability to enhance their understanding about vulnerability and adaptive capacity.

REFERENCES

[1]G. R.Abbadi, N. K.Tripathi, P. Soni, T.Tipdecho, A.Phalke (2013). Temporal climate trend of Ping Basin of Thailand and implications for Mekong Region. *Journal of Earth Science and Climate Change 4*: 146. doi:10.4172/2157-7617.1000146.

[2]T. W. Abraham and W. M.Fonta (2018). Climate change and financing adaptation by farmers in Northern Nigeria. *Financial Innovation,* 4(11). https://link.springer.com/article/10.1186/s40854-018-0094-0

[3]P.Agbola,A.O.Fayiga(2016). Effects of Climate change on agricultural production and rural livelihood in Nigeria. *Journal of Agricultural Research and Development* Vol. 15, No. 1

[4]B.Anabaraonye, J.Chukwuma,C. J.Okafor (2019). Educating farmers and fishermen in rural areas in Nigeria on climate change mitigation and adaptation for global sustainability. *International Journal of Scientific & Engineering Research*, 10(4),1391-1398.

[5]S. C. Aondoakaa(2012). Effects of climate change on agricultural productivity in the Federal Capital Territory (FCT), Abuja, Nigeria. *Ethiopian Journal of Environmental Studies and Management EJESM* Vol. 5 no.4 (Suppl.2)

[6]G. Atedhor(2015). Agricultural vulnerability to climate change in Sokoto State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development. Vol 15*(2).

[7] A M. Ayanshola, S. O. Jacob, A. W.Salami and S. O. Bilewu (2015). Evaluation of impacts of climate change and urbanization on the water supply of Abuja, *Nigeria. Journal of Sustainable Development in Africa* Volume 17, No.7 ISSN: 1520-5509

[8]S.Bathiany,V.Dakos,M. Scheffer,T. M.Lenton (2018). Climate models predict increasing temperature variability in poor countries. Sci. Adv. 4, eaar5809

[9]O. B.Bello, O. T.Janiya, M. K. A.Wahab, M. S.,Afolabi, F.Oluleye, S. A.Ig,J.Mahmud,M. A. Azeez, S. Y.Abdulmaliq (2012). Evidence of climate change impacts on agriculture and food security in Nigeria. *International Journal of Agriculture and Forestry, 2*(2): 49-55, DOI: 10.5923/j.ijaf.20120202.08

[10] K. Bunruamkaew(2012). How to do AHP analysis in Excel.

I. W Butuand C. N.Emeribe(2019). Spatial patterns of climatic variability and water budget over Sudan Savannah Region of Nigeria. African Journal of Environmental Science and Technology. Vol. 13(12), pp. 464-480, December 2019 DOI: 10.5897/AJEST2019.2726 Article Number: 3815D8062330

[11] N. E.Ebele and N. V.Emodi (2016). Climate change and its impact in Nigerian economy. *Journal of Scientific Research & Reports*, 10(6), 1-13. http://www.journaljsrr.com/index.php/JSRR/article/view/21917/40737

I. Elisha, E.Lawrence,B. A.Sawa (2017). Evidence of climate change and adaptation strategies among grain farmers in Sokoto State, Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT), 11(3),

[12] Z. A.Elum, D M.Modise,G. Nhamo (2017). Climate change mitigation: the potential of agriculture as a renewable energy source in Nigeria. *Environmental Science and Pollution Research*, 24, 3260–3273. https://www.ncbi.nlm.nih.gov/pubmed/27933500

[13] FAO (2015). The impact of disasters on agriculture and food security, FAO, Rome: http://www.fao.org/3/a-i5128e.pdf. In*: FAO Submission to the UNFCCC - Executive Committee of the Warsaw International Mechanism for Loss and Damage under the Work Plan AA7* (d).

[14] FAO (2019). FAO's work on climate change, United Nations Climate Change

[15] Federal Ministry of Environment (2020). Third National Communication (TNC) of the Federal Republic of Nigeria under the United Nations Framework Convention on Climate Change (UNFCCC).

I. E, Gbode,E.Oluwafemi, O. E.Adeyeri,K. P.Menang, J. D. K.Intsiful, V. O.Ajayi,A.Jerome, J. A, Omotosho,A.A..Akinsanola (2018). Observed changes in climate extremes in Nigeria

[16] L.Gizachew and A. Shimelis (2014). Analysis and mapping of climate change risk and vulnerability in central rift valley of Ethiopia, Ethiopia.

[17] H.Haider (2019). *Climate change in Nigeria: Impacts and responses.* K4D Helpdesk Report 675. Brighton, UK: Institute of Development Studies.

[18] J.W. Hansen, D. Araba, J.Hellin,R. Goslinga(2017). A roadmap for evidence-based insurance development for Nigeria's farmers. CCAFS Working Paper no. 218. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

[19] S. M. Hassan (2012),An Analysis of the Impacts of Rainfall Variability and Crop Zones Classification for the Federal Capital Territory, Nigeria

[20] O. Idekiand V.E. Weli(2019) Analysis of rainfall variability using remote sensing and GIS in North Central Nigeria. *Atmospheric and Climate Sciences,* 9, 191-201. https://doi.org/10.4236/acs.2019.92013

[21] IPCC (2014). Climate change 2014: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.*Cambridge University Press, Cambridge*, United Kingdom and New York, NY, USA.

[22] IPCC (2018) Global Warming of 1.5°C[https://www.ipcc.ch/sr15]

[23] IPCC (2019). Special Report on climate change and land

[24] S.Ishaya and S.M Hassan (2013) Analysis of Growing Season Rainfall and Temperature Variability in the Federal Capital Territory of Nigeria. *Nigeria Journal of Tropical Geography. Vol. 4*(2) Pg 471-490.

[25] S. Ishaya,M. A Apochiand A H Mohammed (2018). Climate Change Perception among Geography and Biology Teachers in Gwagwalada Area Council of the Federal Capital Territory of Nigeria. *Annals of Ecology and Environmental Science* Volume 2, Issue 4

[26] S.Ishaya and S.M Hassan and S. E.James (2014). Post-adaptation vulnerability of cereals to rainfall and temperature variability in the Federal Capital Territory of Nigeria. *Ethiopian Journal of Environmental Studies and Management*. Pg. 532-547.

[27] N. P.Jellason, R N.Baines,J.Conway, C. Ogbaga (2019). Climate change perceptions and attitudes to smallholder adaptation in Northwestern Nigerian Drylands. *Social Science*, 8(31). https://app.dimensions.ai/details/publication/pub.1111649369?and_facet_journal=jour.1137264

I. A. Madu(2016). *Rurality and climate change vulnerability in Nigeria: Assessment towards evidence based even rural development policy*. Paper presented at the 2016 Berlin Conference on Global Environmental Change, 23-24 May 2016 at Freie Universität Berlin.

[28] R.Mahmood,S.Jia,W. Zhu (2019) Analysis of climate variability, trends, and prediction in the most active parts of the Lake Chad basin, Africa. *Scientific Report*

[29] S. Marzia, J. Mysiaka, S. Santato (2018). Comparing adaptive capacity index across scales: The case of Italy. Journal of Environmental Management

A. B.Mohammed, D. M.Zakari, N. I. Megudu, I. Sandra (2014). Impact of climate change on yam production in Abuja, Nigeria.*International Journal of Science, Environment and Technology*, Vol. 3, No 2

[30] National Academy of Science and Royal Society (2020). Climate Change: Evidence & Causes, An overview from the Royal Society and the US National Academy of Sciences

[31] O. Nkechi, A. Alphonsus, EEkenedirichukwu(2016). Mitigating climate change in Nigeria: African traditional religious values in focus. *Mediterranean Journal of Social Sciences*, 7(6), 299-308. https://www.mcser.org/journal/index.php/mjss/article/view/9612

[32] NOAA (2018). Climate variability vs climate change

[33] F. W.Nsubuga andH. Rautenbach (2018), Climate change and variability: a review of what is known and ought to be known for Uganda. International Journal of Climate Change Strategies and management Vol. 10 No. 5, pp. 752-771 Emerald Publishing Limited 1756-8692

[34] S. S.Ogallah,S.Wandiga,D.Olago,S. Oriaso (2017). Impacts of Climate Variability and Climate Change on Agricultural Productivity of Smallholder Farmers in Southwest Nigeria. *International Journal of Scientific & Engineering Research* Volume 8, Issue 10.

[35] O.I.Ojo, A.O.Olaniyan, A.S.Gbadegesin, M.F. Ilunga (2019). Assessment of Climatic Variability Effect on Millet Production and Yield. In: Leal Filho W. (eds) Handbook of Climate Change Resilience. Springer, Cham. https://doi.org/10.1007/978-3-319-71025-9_188-1

[36] G. Okongor, C. Njoku, P. Essoka and J. Efiong (2021). Climate variability and yam production: Nexus and projections. *Sarhad Journal of Agriculture*, 37(2): 406-418. DOI| https://dx.doi.org/10.17582/journal.sja/2021/37.2.406.418

I. B.Oluwatayoand A. O. Ojo(2016). Awareness and adaptation to climate change among yam-based farmers in rural Oyo state, Nigeria. *The Journal of Developing Areas*, Vol 50 No. 2

II. J. Onwutuebe(2019). Patriarchy and Women Vulnerability to Adverse Climate Change in Nigeria. https://doi.org/10.1177/2158244019825914SAGE

[37] T. L.Saaty(2010). Principia mathematicadecernendi: Mathematical principles of decision making. Pittsburgh, Pennsylvania: *RWS Publications*. ISBN 978-1-888603-10-1.

[38] M.S.Shiru, S.Shahid, N.Alias, E. S.Chung (2018). Trend analysis of droughts during crop growing seasons of Nigeria. *Sustainability*, 10(3), 871. https://doi.org/10.3390/su10030871

[39] L Tankoand B. S. Y.Muhsinat (2014). Arable farmers' perception to climate change in Abuja, Federal Capital Territory, Nigeria. *Journal of Agriculture and Crop Research* Vol. 2 (8), pp. 152-159.

[40] UNDP (2019). Human Development Report: Beyond income, beyond averages, beyond today; Inequalities in human development in the 21st century

[41] P.Vesco, M.Kovacic,M.Mistry,M. Croicu (2021). Climate variability, crop and conflict: Exploring the impacts of spatial concentration in gricultural production. *Journal of Peace Research* DOI: 10.1177/0022343320971020

[42] WMO 2020. State of the Climate in Africa 2019. No 1253

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APPENDIX

A 1 Maximun Temperature (^{0}C)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	34.34	32.51	31.54	34.62	33.83	35.04	33.65
1982	33.85	31.92	31.13	34.06	33.20	34.48	33.11
1983	35.11	32.80	32.18	35.16	34.32	35.40	34.16
1984	35.83	33.32	32.65	35.99	34.80	36.23	34.80
1985	34.74	32.64	31.93	35.16	34.04	35.42	33.99
1986	34.63	32.55	31.76	35.10	34.09	35.42	33.93
1987	35.36	33.26	32.43	35.54	34.79	36.03	34.57
1988	34.29	32.34	31.51	34.53	33.72	34.86	33.54
1989	34.76	32.62	31.95	34.94	34.12	35.29	33.95
1990	35.54	33.24	32.37	35.91	34.93	36.24	34.70
1991	34.92	32.60	31.74	35.29	34.22	35.69	34.08
1992	33.69	31.69	30.97	33.99	33.14	34.37	32.97
1993	34.54	32.58	31.87	34.73	33.88	35.05	33.78
1994	34.35	32.34	31.50	34.58	33.80	34.96	33.59
1995	34.25	32.26	31.46	34.47	33.80	34.87	33.52
1996	34.42	32.35	31.51	34.62	33.83	35.04	33.63
1997	34.14	32.16	31.44	34.43	33.62	34.94	33.46
1998	35.75	33.59	32.85	36.03	35.16	36.52	34.98
1999	37.14	35.09	34.13	37.79	36.99	38.29	36.57
2000	37.05	34.81	34.16	37.43	36.46	37.81	36.29
2001	36.56	34.13	33.30	37.02	36.06	37.45	35.75
2002	36.90	34.84	33.96	37.51	36.66	38.04	36.32
2003	37.03	35.33	34.40	37.75	37.06	38.32	36.65
2004	37.20	35.68	34.93	38.01	37.28	38.51	36.93
2005	37.64	35.45	34.47	38.24	37.24	38.79	36.97
2006	37.00	34.89	34.03	37.51	36.50	37.87	36.30
2007	36.37	34.12	33.45	36.45	35.54	36.72	35.44
2008	35.90	34.02	33.39	36.04	35.18	36.23	35.13
2009	35.44	33.03	32.37	35.79	34.53	35.91	34.51
2010	36.05	33.76	33.10	36.33	35.21	36.60	35.18
2011	36.33	33.72	32.70	37.14	35.36	36.74	35.33
2012	35.65	33.04	31.99	36.36	34.78	36.12	34.66
2013	36.05	33.49	32.31	36.55	34.98	36.21	34.93
2014	35.02	33.07	32.17	35.74	34.44	35.63	34.35
2015	35.47	33.55	33.35	36.40	34.54	36.00	34.88
2016	35.22	33.47	33.03	36.33	34.65	36.05	34.79
2017	36.23	34.03	34.04	37.19	35.05	36.68	35.54
Mean	35.53	33.41	32.65	35.97	34.91	36.21	34.78

A 2 Minimum Temperature (^{0}C)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	20.80	19.63	19.22	20.86	20.56	21.02	20.35
1982	21.35	20.13	19.63	21.51	20.97	21.46	20.84
1983	20.98	19.42	19.07	21.12	20.43	21.04	20.34
1984	20.87	19.45	19.02	21.01	20.53	20.99	20.31
1985	20.88	19.46	18.99	21.05	20.63	21.12	20.36
1986	20.93	19.75	19.12	21.17	20.96	21.32	20.54
1987	21.67	20.25	19.71	21.98	21.52	22.22	21.23
1988	21.76	20.16	19.61	21.88	21.56	22.11	21.18
1989	21.00	19.37	18.98	20.81	20.22	20.61	20.17
1990	21.42	19.82	19.42	21.57	21.15	21.79	20.86
1991	21.44	20.18	19.66	21.63	21.23	21.83	20.99
1992	20.77	19.20	18.97	20.76	20.15	20.61	20.08
1993	21.29	20.00	19.49	21.39	20.95	21.41	20.75
1994	21.50	20.15	19.64	21.69	21.21	21.65	20.97
1995	21.59	20.33	19.90	21.65	21.32	21.74	21.09
1996	21.38	20.00	19.38	21.65	21.11	21.69	20.87
1997	21.37	20.03	19.58	21.34	20.88	21.23	20.74
1998	21.51	20.11	19.65	21.52	21.19	21.72	20.95
1999	21.13	19.80	19.25	21.13	20.85	21.32	20.58
2000	21.02	19.02	18.76	21.07	20.37	20.81	20.17
2001	21.02	19.57	18.91	21.10	20.70	21.14	20.41
2002	21.75	20.03	19.69	21.81	21.26	21.54	21.01
2003	21.39	20.22	19.63	21.73	21.35	21.87	21.03
2004	21.65	20.13	19.54	21.73	21.42	22.04	21.08
2005	22.08	20.45	20.00	22.03	21.51	21.87	21.32
2006	21.86	20.83	19.77	21.97	21.82	22.14	21.40
2007	21.55	20.02	19.57	21.61	21.12	21.54	20.90
2008	21.39	19.86	19.32	21.37	20.98	21.33	20.71
2009	21.70	20.63	19.85	22.02	21.74	22.24	21.36
2010	21.94	20.79	20.02	22.22	21.99	22.40	21.56
2011	21.08	19.75	19.13	21.16	21.14	21.17	20.57
2012	21.23	19.88	19.06	21.51	21.36	21.59	20.77
2013	22.10	20.78	19.98	22.30	22.09	22.37	21.60
2014	21.49	20.26	19.71	21.80	21.40	21.95	21.10
2015	20.50	19.85	19.00	21.43	20.80	21.25	20.47
2016	21.37	19.88	19.56	21.67	20.43	21.34	20.71
2017	20.87	19.60	19.09	21.38	20.64	21.48	20.51
Mean	21.34	19.97	19.43	21.50	21.07	21.54	20.81

A 3 Mean Temperature (^{0}C)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	27.570	26.072	25.381	27.740	27.198	28.029	26.998
1982	27.601	26.025	25.382	27.784	27.085	27.973	26.975
1983	28.040	26.109	25.624	28.141	27.377	28.222	27.252
1984	28.349	26.386	25.834	28.500	27.663	28.608	27.557
1985	27.814	26.052	25.462	28.106	27.332	28.271	27.173
1986	27.781	26.152	25.439	28.137	27.522	28.371	27.234
1987	28.516	26.756	26.071	28.760	28.154	29.125	27.897
1988	28.023	26.251	25.562	28.208	27.638	28.488	27.362
1989	27.883	25.995	25.463	27.875	27.170	27.949	27.056
1990	28.480	26.534	25.891	28.740	28.043	29.015	27.784
1991	28.184	26.391	25.701	28.458	27.724	28.762	27.537
1992	27.227	25.445	24.973	27.373	26.648	27.491	26.526
1993	27.918	26.290	25.678	28.058	27.420	28.230	27.266
1994	27.927	26.247	25.572	28.131	27.505	28.308	27.282
1995	27.921	26.296	25.683	28.057	27.560	28.304	27.304
1996	27.902	26.172	25.446	28.134	27.472	28.363	27.248
1997	27.756	26.095	25.509	27.887	27.252	28.086	27.098
1998	28.626	26.851	26.251	28.772	28.177	29.118	27.966
1999	29.135	27.445	26.688	29.460	28.918	29.806	28.575
2000	29.033	26.915	26.456	29.253	28.415	29.312	28.231
2001	28.793	26.851	26.106	29.063	28.381	29.299	28.082
2002	29.326	27.439	26.826	29.660	28.961	29.790	28.667
2003	29.209	27.774	27.017	29.743	29.208	30.095	28.841
2004	29.424	27.909	27.236	29.869	29.346	30.274	29.010
2005	29.859	27.952	27.237	30.134	29.377	30.327	29.148
2006	29.431	27.862	26.901	29.740	29.159	30.005	28.850
2007	28.960	27.070	26.510	29.026	28.332	29.130	28.171
2008	28.646	26.942	26.356	28.702	28.077	28.779	27.917
2009	28.574	26.830	26.108	28.904	28.131	29.077	27.937
2010	28.993	27.272	26.561	29.279	28.603	29.500	28.368
2011	28.706	26.734	25.915	29.150	28.251	28.956	27.952
2012	28.442	26.460	25.525	28.930	28.070	28.855	27.714
2013	29.075	27.135	26.142	29.429	28.536	29.292	28.268
2014	28.258	26.663	25.942	28.770	27.921	28.789	27.724
2015	27.981	26.700	26.172	28.913	27.670	28.628	27.677
2016	28.293	26.673	26.295	29.003	27.535	28.699	27.750
2017	28.548	26.813	26.565	29.282	27.845	29.080	28.022
Mean	28.438	26.691	26.040	28.734	27.991	28.876	27.795

A 4 Annual Rainfalls (mm)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	1497.48	1732.90	2074.21	1433.99	1538.46	1331.50	1601.42
1982	1809.40	2127.71	2488.69	1808.12	2173.34	1975.26	2063.75
1983	682.20	990.38	1169.07	609.11	849.33	641.94	823.67
1984	876.09	1224.38	1466.85	825.17	1190.25	967.19	1091.66
1985	1680.16	1787.38	2149.78	1614.30	1860.43	1678.61	1795.11
1986	1361.94	1557.97	1767.40	1558.74	1501.84	1451.68	1533.26
1987	1372.04	1606.14	2007.78	1130.33	1433.35	1110.14	1443.30
1988	2112.20	2542.70	3071.02	2042.98	2243.76	1939.84	2325.42
1989	1688.60	1989.33	2403.37	1698.34	1860.55	1673.55	1885.63
1990	1053.22	1362.56	1624.62	1013.85	1154.11	960.95	1194.88
1991	1422.33	1711.04	2135.99	1201.05	1468.35	1242.48	1530.21
1992	1506.63	1834.74	2203.39	1420.28	1752.02	1540.95	1709.67
1993	1342.01	1426.91	1778.49	1168.51	1317.46	1210.45	1373.97
1994	1954.25	2126.84	2535.42	1895.10	2087.72	1981.69	2096.83
1995	1896.53	2145.77	2661.16	1633.46	1860.54	1601.46	1966.49
1996	1359.09	1860.48	1960.97	1503.42	1854.04	1631.92	1694.99
1997	1208.31	1679.85	2161.96	995.72	1269.15	925.66	1373.44
1998	1204.65	1952.94	2057.75	1249.49	1790.43	1489.06	1624.05
1999	989.11	1249.50	1565.18	881.66	1041.92	849.43	1096.13
2000	444.49	664.65	638.25	534.51	591.92	551.33	570.86
2001	935.23	1206.84	1291.06	900.71	1092.59	916.43	1057.14
2002	1405.78	1527.79	1734.41	1317.99	1498.02	1300.14	1464.02
2003	1565.05	1835.25	1923.08	1679.47	1790.80	1695.10	1748.12
2004	1501.75	1351.24	1472.21	1505.75	1379.43	1397.19	1434.60
2005	1442.03	1788.76	2018.80	1336.81	1514.70	1160.92	1543.67
2006	1802.10	2144.70	2516.44	1651.41	1813.38	1496.80	1904.14
2007	1527.26	1770.29	2054.16	1368.37	1558.14	1316.43	1599.11
2008	1376.64	1548.53	1875.36	1411.80	1523.84	1450.76	1531.16
2009	1380.60	1900.69	2118.87	1242.19	1573.15	1202.93	1569.74
2010	1550.27	1751.21	2219.53	1445.95	1570.81	1349.50	1647.88
2011	677.03	1225.78	1414.16	597.35	1160.20	873.51	991.34
2012	1278.19	2328.49	2686.34	1078.35	1711.34	1414.32	1749.51
2013	1250.52	1530.93	1930.41	861.65	1301.55	1103.33	1329.73
2014	1566.83	1629.95	1856.96	1178.68	1356.74	1284.75	1478.98
2015	1100.51	1558.51	1509.05	920.36	1328.16	1402.13	1303.12
2016	1783.67	1704.81	1839.30	1062.62	1286.21	1197.24	1478.98
2017	786.42	1275.73	1119.45	669.60	1098.34	985.83	989.23
Mean	1361.91	1666.32	1932.46	1255.33	1497.20	1305.47	1503.11

A 5 Relative Humidity (%)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	60.84	66.02	65.48	62.45	65.77	64.06	64.10
1982	61.99	66.67	66.50	63.43	66.91	65.06	65.09
1983	58.55	64.46	63.17	60.35	64.27	62.14	62.16
1984	55.90	62.22	61.73	57.34	61.78	59.55	59.75
1985	58.98	64.56	64.19	60.22	63.96	62.01	62.32
1986	60.45	65.98	65.78	61.49	65.06	62.84	63.60
1987	60.36	65.62	64.75	61.76	65.41	63.42	63.56
1988	62.06	67.81	66.77	64.18	67.93	65.98	65.79
1989	57.94	63.11	62.37	59.82	62.88	61.55	61.28
1990	58.95	65.63	64.84	60.66	64.85	62.32	62.87
1991	61.18	67.07	66.81	62.42	66.35	63.72	64.59
1992	60.21	65.46	65.13	61.49	65.61	63.30	63.53
1993	61.09	66.74	66.62	62.30	65.21	63.35	64.22
1994	60.63	65.55	65.33	61.95	66.79	63.59	63.97
1995	61.92	66.62	66.44	63.55	66.52	65.05	65.02
1996	61.04	66.37	66.08	62.97	66.17	64.92	64.59
1997	60.86	66.95	66.71	62.27	66.17	63.77	64.46
1998	55.91	61.40	60.70	57.69	61.24	59.00	59.33
1999	53.14	58.98	58.62	54.83	58.41	56.48	56.74
2000	50.27	57.51	56.51	52.15	57.08	54.83	54.73
2001	51.42	58.20	57.51	53.22	57.30	54.99	55.44
2002	52.69	58.86	58.54	53.82	57.28	55.31	56.08
2003	53.95	58.66	58.07	55.02	58.54	56.90	56.85
2004	52.52	56.97	56.76	54.16	57.72	55.90	55.67
2005	53.55	59.60	59.27	54.81	58.73	56.51	57.08
2006	55.95	61.70	61.60	57.83	61.21	59.29	59.60
2007	56.35	62.24	61.60	58.07	61.90	59.91	60.01
2008	55.47	61.02	60.30	57.35	60.91	59.14	59.03
2009	58.74	65.08	64.40	60.38	65.09	62.54	62.70
2010	57.47	63.37	62.68	58.99	62.93	60.80	61.04
2011	55.02	60.44	60.62	56.29	60.74	59.18	58.71
2012	58.07	64.15	64.16	59.53	63.94	62.15	62.00
2013	58.78	64.67	65.06	60.07	64.37	62.38	62.55
2014	48.68	54.45	53.99	52.59	54.84	54.10	53.11
2015	36.52	41.28	40.39	43.69	45.41	45.91	42.20
2016	37.29	43.12	40.28	43.53	45.26	45.31	42.47
2017	35.90	41.66	39.58	42.60	44.42	45.23	41.56
Mean	55.69	61.36	60.79	57.71	61.32	59.53	59.40

A 6 Potential Evapotranspiration (mm)

Year	Abaji	AMAC	Bwari	Gwagwalada	Kuje	Kwali	Mean
1981	3.92	4.34	4.38	4.29	4.17	4.11	4.20
1982	3.86	4.30	4.34	4.23	4.10	4.06	4.15
1983	4.01	4.45	4.53	4.38	4.25	4.22	4.31
1984	3.91	4.34	4.43	4.29	4.16	4.12	4.21
1985	3.88	4.31	4.36	4.23	4.12	4.08	4.16
1986	3.81	4.30	4.37	4.21	4.09	4.04	4.14
1987	4.01	4.45	4.51	4.40	4.28	4.23	4.31
1988	3.86	4.26	4.33	4.18	4.08	4.03	4.12
1989	3.94	4.34	4.39	4.26	4.17	4.10	4.20
1990	3.88	4.31	4.39	4.26	4.16	4.09	4.18
1991	3.69	4.12	4.19	4.06	3.94	3.91	3.98

1992	3.85	4.28	4.34	4.18	4.10	4.04	4.13
1993	3.86	4.31	4.37	4.23	4.11	4.08	4.16
1994	3.81	4.20	4.26	4.14	4.04	4.00	4.08
1995	3.84	4.27	4.32	4.19	4.08	4.05	4.13
1996	3.84	4.29	4.36	4.25	4.12	4.07	4.15
1997	3.80	4.22	4.28	4.16	4.02	3.98	4.08
1998	3.88	4.25	4.32	4.22	4.09	4.05	4.13
1999	3.77	4.18	4.25	4.12	4.01	3.96	4.05
2000	3.93	4.33	4.38	4.26	4.15	4.10	4.19
2001	3.95	4.35	4.38	4.28	4.18	4.13	4.21
2002	3.91	4.29	4.38	4.24	4.13	4.07	4.17
2003	3.93	4.34	4.38	4.28	4.16	4.12	4.20
2004	3.78	4.23	4.30	4.14	4.02	3.98	4.07
2005	3.83	4.26	4.33	4.21	4.06	4.02	4.12
2006	3.88	4.34	4.42	4.24	4.13	4.08	4.18
2007	3.78	4.24	4.33	4.14	4.05	3.98	4.09
2008	3.82	4.28	4.37	4.21	4.06	4.02	4.13
2009	3.86	4.34	4.43	4.25	4.15	4.09	4.19
2010	3.86	4.31	4.38	4.24	4.13	4.07	4.16
2011	3.92	4.33	4.38	4.23	4.14	4.08	4.18
2012	3.78	4.25	4.33	4.17	4.04	3.98	4.09
2013	3.90	4.33	4.40	4.24	4.14	4.08	4.18
2014	3.92	4.29	4.39	4.25	4.13	4.09	4.18
2015	3.92	4.28	4.34	4.25	4.17	4.09	4.17
2016	3.93	4.35	4.39	4.27	4.17	4.12	4.20
Mean	3.87	4.30	4.36	4.23	4.11	4.06	4.16