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ABSTRACTS
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The impact BREXIT, Contemporary American Policies and Asian Diplomacy, and Unrest on Sub-sahara African Sustainable Development: Multi-disciplinary Approach

POTENTIAL IMPACT OF CLIMATE CHANGE AND VARIABILITY ON GROUND WATER WITHDRAWAL IN MINNA METROPOLIS NIGER STATE NIGERIA

M. B. Yunusa, Abdulkadir Nasiru, A. S. Abubakar

Geography Department, Federal University Of Technology, Minna

ABSTRACT

This study examined the potential impact of climate change and variability on ground water withdrawal in Minna metropolis Niger State Nigeria. The methods of data analysis include SPI, multiple regression and correlation coefficient. The results of the study reveals that the annual mean temperature have a significant effect on average depths in the water table correlated with 0.371 and the annual mean precipitation which has a negative correlation with the average depths in the water table correlated -0.072 that is groundwater withdrawal have 37.1% dependency on the mean annual temperature and -7.2% dependency on groundwater withdrawal. This indicates that the annual mean temperatures are positively moderate in terms of correlation with groundwater withdrawal and the annual mean precipitation is negatively not moderate in terms of correlation with groundwater withdrawal in Minna metropolis, Minna Niger State. It's therefore recommended that the government of Niger state should come up with a legislative body that will be monitoring the depth of the groundwater as depletion is taking place as a result of withdrawal.

Keywords: Groundwater, Climate change, Minna, and Water withdrawal

Introduction

Ground water is an almost universal source of generally high-quality fresh water. These characteristics promote its widespread development, which can be scaled and localized to demand, obviating the need for substantial infrastructure (Giordano, 2009). Globally, ground water is the source of one third of all freshwater withdrawals, supplying an estimated 36%, 42% and 27% of the water used for domestic, agricultural and industrial purposes, respectively (Döll *et al.,* 2012) In many environments, natural groundwater discharges sustain base flow to rivers, lakes and wetlands during periods of low or no rainfall. Despite these vital contributions to human welfare and aquatic ecosystems, a paucity/scarcity of studies on the relationship between climate and ground water severely restricted the ability of the Intergovernmental Panel on Climate Change (IPCC) to assess interactions between ground water and climate change in both its third (Arnell *et al.,* 2013) and fourth (Kundzewicz *et al.,* 2017) assessment reports. There has since been a marked rise in published research applying local to global scale modeling, as well as ground-based and satellite monitoring, which has considerably enhanced our understanding of interactions between ground water and climate. Here we build on an earlier broad-based overview (Green *et al.,* 2011) of the topic, and examine substantial recent advances. These include emerging knowledge of the direct and indirect (through groundwater use) effects of climate forcing including climate extremes on groundwater resources, as well as feedbacks between ground water and climate, such as the contribution of groundwater depletion to global sea-level rise. Furthermore, we identify critical gaps in our understanding of the interactions between ground water and climate. Climate variability and change influences groundwater systems both directly through replenishment by recharge and indirectly through changes in groundwater use. These impacts can be modified by human activity such as land-use change (LUC) (Green *et al.,* 2011).

A quantitative understanding of the relationship between climate and ground water and the impact of removal is severely constrained by the near absence of very few reliable estimates of groundwater storage in Africa whether aquifers are regional of localized. During a very long dry season or drought, surface water and unchanged groundwater sources (shallow wells and small springs) can fail, leaving behind only those water points drawing from larger groundwater bodies operational. Hence vast springs, deep hand-dug-wells and boreholes can provide consistent access to water throughout seasons, while surface water bodies and unchanged sources become increasingly unreliable. That said, even dependable sources can fail during a drought, even though the actual causes are not always obvious (Arnell *et al.,* 2013). The socioeconomic effects of droughts arise from the interaction between natural conditions and human-induced climate change factors such as changes in land use, land cover, and the demand for and use of water. In some cases, the frequency of occurrence of droughts is aggravated by human induced changes in land cover. Therefore this study examined the potential impact of climate change and variability on ground water withdrawal in Minna metropolis Niger State Nigeria. Minna is located within geographical latitudes 9°31'20"N to 9°41'27"N and longitudes 6°24'59"Eto 6°37'42"E The study area. Minna is located in Niger State. Niger State is one of the second generation states of the Federal Republic of Nigeria.

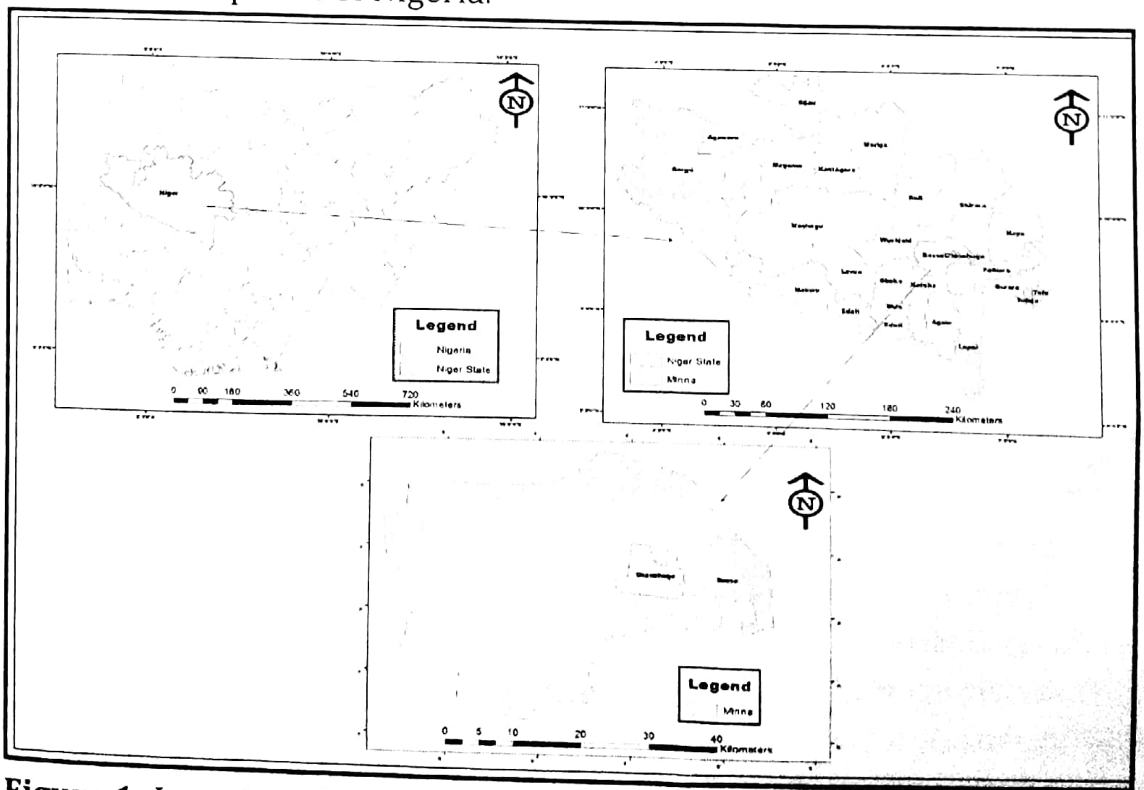

Figure 1: Location of Minna, Niger State

Materials and Methods

The data that was used for this study was obtained from a single source. The data source inlcude mainly the secondary data. The secondary data that was used for this research study include; weather data (maximum and minimum temperature, precipitation), which was used to checkmate the effect of the above mention climatic parameters on ground water withdrawal, also numbers of drilled bores holes per year with their different water tables which will be used to check the effects of anthropogenic activities, population data (i.e. indirect climatic effects) journals, maps, past project works and relevant literatures.

SPI is designed to quantify precipitation deficit and also to analyze the trend in precipitation over the year used (2004 - 2014). It was used to achieve objective one. The formula for the standard precipitation index is give

$$SPI = \frac{X - \bar{X}}{\sigma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Where SPI = Standard Precipitation Index, X= Numbers of Years, $\bar{X}$= Normal base period of average value σ= Standard deviation

Correlation and Multiple Regression: Multiple regression is a statistical technique that is been used when there are more than two variables. It was used to achieve objective two i.e. to evaluate the effect of temperatures and precipitation on the average water table in the study area for the period under study (2004 - 2014).

The formula for the multiple regression was given as

$y = a + b_1x_1 + b_2x_2, y_2$ ....

Where y = water table, X_1 = Temperature, X_2 = precipitation, a = constant, and $b_1$and b_2 = slope of the regression trend

Tables and Graph: This method of analysis was used to achieve objective three, these involve the use of tables and line graphs to assess the trends and patterns in the variation of population growth and the numbers of bore holes that area been dung in the study area within the period of years under study (2005 – 2014).

Time Series Analysis: This was also used to achieve objective three, this was used to examine the trend of population growth and number of bore holes that are been dung for the period under study (2005 - 2014).

i. The regression coefficient (m) of time series analysis will be calculated as follows:

$$m = \frac{n\sum xy-(\sum x\sum y)}{n\sum x2-(\sum x)2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.$$

m = the least square method of the regression coefficient, x = serial number of each of the observed scores, y = population growth and number of bore holes that are been dung, n = number (years), and $\sum$ = summation

ii. The regression coefficient (c) of time series is mathematically expressed by:

$$c = \frac{1}{n}(\sum y - m\sum x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

c = the least square method of the regression coefficient, x = serial number of each of the observed scores, y = population growth and number of bore holes that are been dung, n = number (years), $\sum$ = summation, 1 = constant, T (trend) = mx + c is the regression equation.

Results and Discussions

From the SPI analysis I was able to observed that there is variation in the occurrence of mild droughts in the period under study; like in 2004-2005 the mild drought normally occurs from the months of November to march and same thing applies to the months that are moderately wet (i.e. May and June), very wet months (i.e. July to September), except for the month of July in the year 2004 that is extremely, this is very strong indication for flooding to occur.

But starting from the year 2006-2010 and 2012, it was able to observed that the duration of the mild drought extends from its normal November to March, November to June and this signifies delay in the onset of rainfall and this usually affect the sustainable yield of ground water thereby resulting to fall in the water table and at the same time low yield in the ground water. Same things apply to the moderately wet months which also varies from its normal May to June and October to July and also the very wet months from its normal July to September in 2004 and 2005 to June – September in 2013,

Same thing applies to the extremely wet months which varies from years to years and even it does not occur throughout in some years like 2004, 2005, 2008, 2010, 2012, and 2013. But it occurs in some months of the years such as 2005, 2008, 2009, 2011 and 2014 and its months of occurrence varie4s in the aforementioned years above like in 2005 it surfaces in the months of July, 2006 in September, 2009 in August, 2011 and 2014 in the month of September. It was able to observed that that there are variations in the occurrence of the extremely wet months between the month of July, August and September.

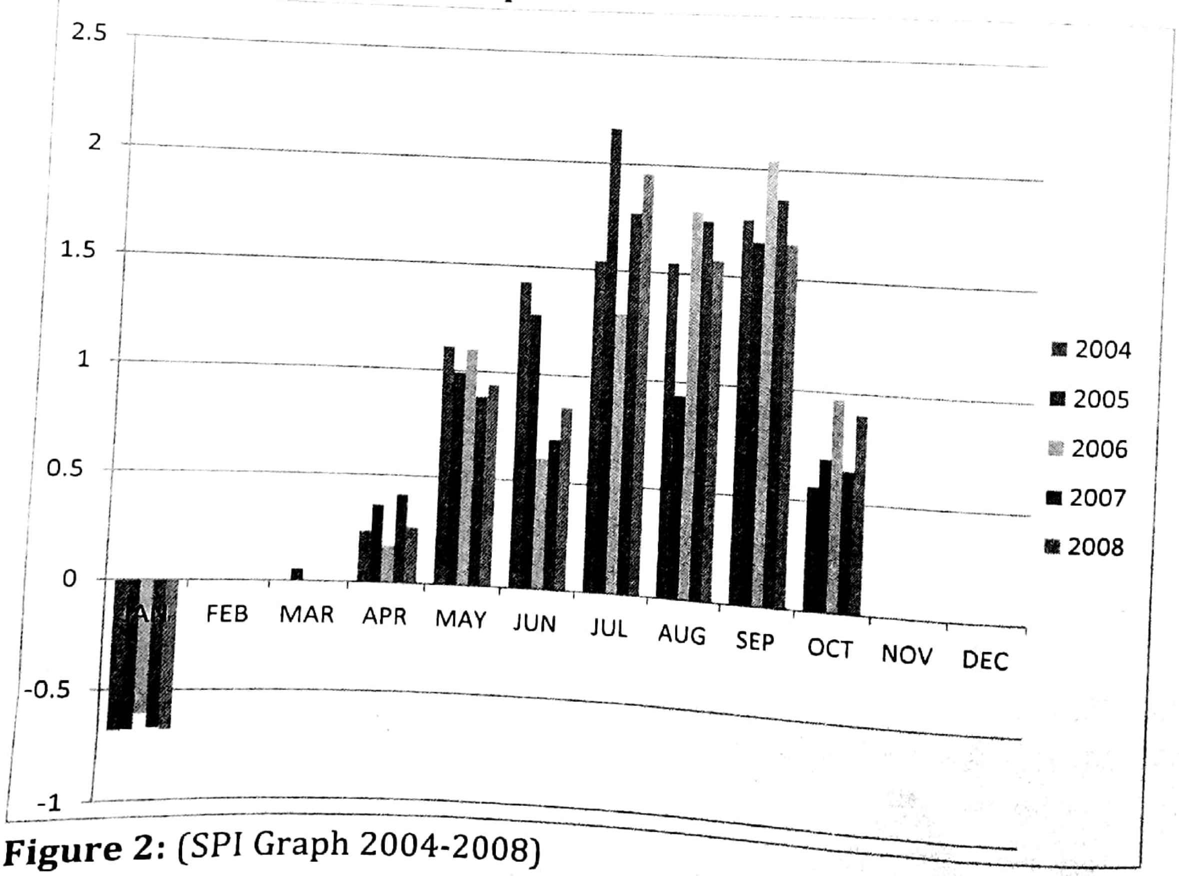

Figure 2: (SPI Graph 2004-2008)

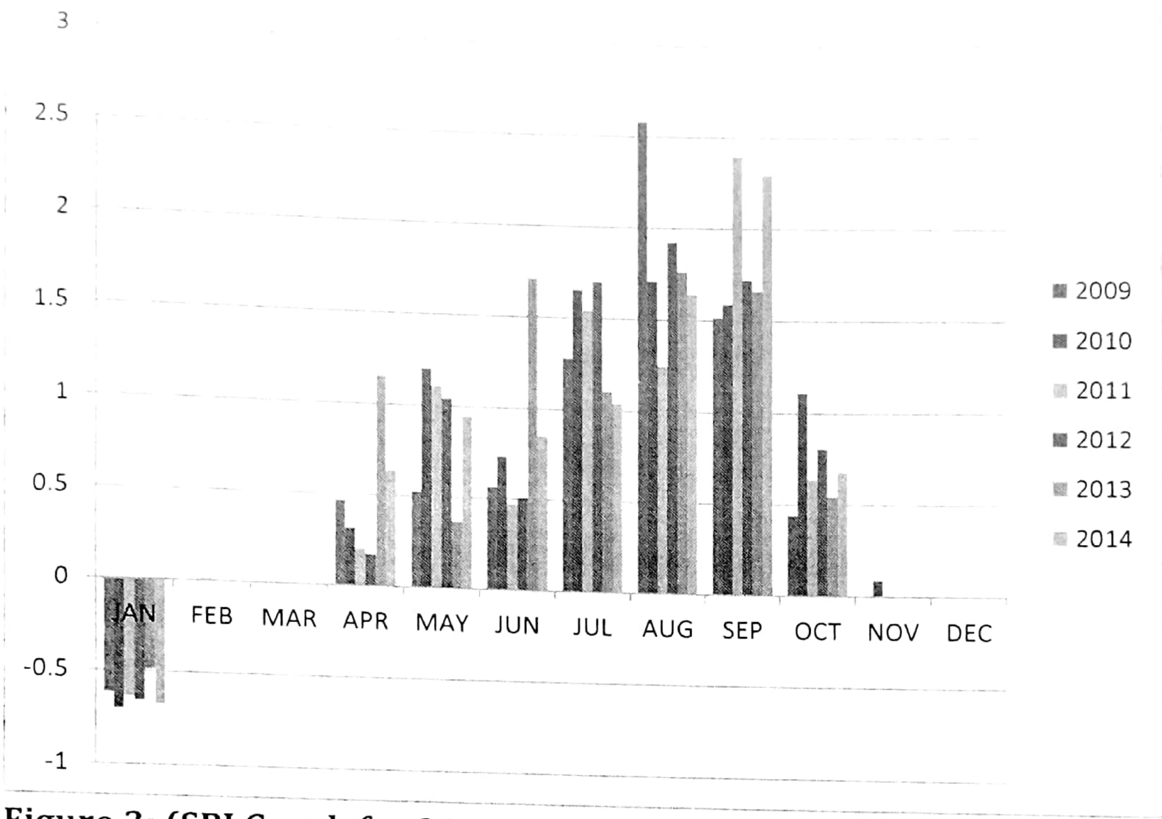

Figure 3: (SPI Graph for 2009-2014)

Table 1: Regression analysis for the groundwater levelsand climatic variables

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.393a	.155	.087	15.14022

a. Predictors: (Constant), AVGPPT, AVGTEMP

The regression analysis computed for the groundwater withdrawal revealed that average depth (water table depth) have coefficient of determination of 0. 087. This indicates that 8.7% of variance in groundwater withdrawal can be explained by the climatic parameters under study (Table 1). The implication is that 91.3% of ground water withdrawal can be explained by other factors not included in the study. Climate variables (mean temperature and mean precipitation) therefore, does have a little impact on groundwater withdrawal. The study has really shown that other factors such as solar radiation, wind velocity, pressure and other human activities (i.e. indirect climatic effects) such as agricultural irrigation activities, domestic activities, construction activities and mining activities may also be responsible for groundwater withdrawal.

The Number of Bore Holes Drilled Analysis

The number of bore holes drilled in Minna, Niger State is presented under analysis, the trend in the number of bore holes that are been drilled on annual basis for the period under study (2005 – 2014) is being revealed in the Figure 4.

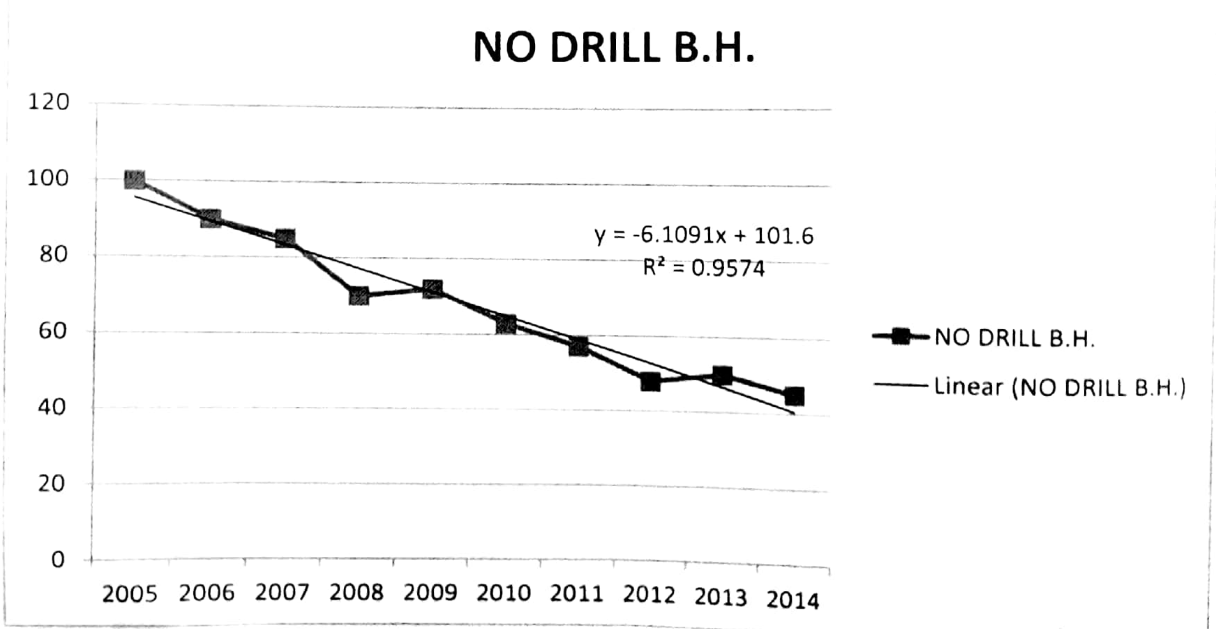

Figure 4: Annual numbers of bore holes drilled trend

The number of bore holes that are been drilled in Minna on annual basis as presented in the Figure 4 above illustrated that, the highest number of bore holes drilled in the period under study was in the year 2005 with 100 bore holes been drilled in the study area (Minna metropolis). Also with the lowest been recorded in the year 2014 with just 45 bore holes, according to one of my respondent at Adex Investment (Mr Reuben Omoja), he said the short fall in the number of bore holes been drilled by their firm is as a result of new competitors in the business and also as a result of instability in the political system in the state.

Conclusions

The results of the study reveals that the annual mean temperature have a significant effect on average depths in the water table correlated with 0.371 and the annual mean precipitation which has a negative correlation with the average depths in the water table correlated -0.072 that is groundwater withdrawal have 37.1% dependency on the mean annual temperature and -7.2% dependency on groundwater withdrawal. This indicates that the annual mean temperatures are positively moderate in terms of correlation with groundwater withdrawal and the annual mean precipitation is negatively not moderate in terms of correlation with groundwater withdrawal in Minna metropolis, Minna Niger State. It's therefore recommended that the government of Niger state should come up with a legislative body that will be monitoring the depth of the groundwater as depletion is taking place as a result of withdrawal.

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