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Quantitative Assessment of Yam Based Farmers' Perception on Climate Change in Edo State, Nigeria

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Abstract: Using data collected from 250 yam based farming households in the Edo state, Nigeria, the study demonstrated the quantitative assessment of yam based farmers' perception on climate change. Farmers' perceptions on three important climatic variables in agricultural production (temperature, rainfall and wind intensity) were quantified using a quasi-arbitrary ordinal weighting system. The results revealed first demand indices for temperature, rainfall and wind intensity as 0.87, 0.38 and 0.84 respectively while the first supply indices for temperature, rainfall and wind intensity were 0.27, 0.22 and 0.14 respectively. The study indicated significant increase and decrease in temperature and rainfall respectively. The study also affirmed that climate change contributed significantly to reduction in yam production in the study area. The study recommends the need for programmes geared towards providing farmers with effective adaptation strategies which would help provide a buffer against adverse climatic conditions.

Keywords: Perception, Climate Change, Quasi-arbitrary Ordinal Weighting System, Demand and Supply Indices

1. Introduction

Climate change is emerging as the most important environmental problem facing modern society. Increases in atmospheric stocks of greenhouse gases (GHG), including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), due to human activities have been linked to global climate change [8]. The fourth assessment report of the IPCC in 2007 [8] emphasized that there will be changes in the frequency and intensity of some weather events and extreme climate events which will likely challenge human and natural systems much more than gradual changes in mean conditions. According to this report, it is virtually certain (more than 99% probability of occurrence) that most land areas will have warmer and fewer cold days and nights. It is also very likely that most areas (between 90 to 99% probability of occurrence) will have warmer temperature, more frequent heat waves and heavy precipitation events. More drought, tropical cyclone, and incidence of extreme high sea level are also likely.

Agriculture is particularly vulnerable to climate change due to its dependence on natural weather patterns and climate cycles for its productivity. There is a growing literature focused on predicting and quantifying the impact of climate change on agricultural systems in many areas around the world. A few degrees of warming will generally increase temperate crop yields while in the tropics, yields of crops near to their maximum temperature tolerance and dry land crops will decrease. A large decrease in rainfall would have even greater adverse effect on yields. In addition, degradation of soil and a decrease in water resources resulting from climate change are likely to have negative impacts on global agriculture [7].

However, with adaptation, crop yields will likely be less affected by climate change. Quantifying the economic impact and assessing perception of climate change on agriculture is receiving increasing attention in the literature. It has been estimated that a 2.5 degrees (°C) or more temperature increase would cause a decline in crop yield and prompt food prices to increase because growth in global food demand is faster than expansion of global food capacity [12].

Nigeria is not at the cutting edge to cope with sudden climate change shocks, the country is dependent on foreign support and therefore any adverse climate change will have

catastrophic effect on food security in the country. For Nigeria, climate change poses great challenges to livelihoods and the economic development of the people. This is because, after petroleum and its products, the country depends on agriculture as a major engine for economic growth and development [14]. Like other developing countries, the challenge of climate change and global warming is enormous in Nigeria due to widespread poverty. Consequently, a better understanding of farmers' perceptions regarding long-term climatic changes, its effect on agricultural production and current adaptation measures will be important to inform policy for future successful adaptation of the agricultural sector in the country.

Climate change has affected the yield of a lot of food crops in Nigeria particularly yam production. It is also evident that yam production in Nigeria has declined over the past 40 years from 27 million tonnes per annum in 1961 to 6.7 million tonnes per annum in 2001 [6]. This decrease can however be attributed to a number of factors such as fungal diseases, plant viruses, declining soil fertility and stress caused by climate change [1]. This decline in average yield per hectare has been rather drastic dropping from 14.9% in 1986 -1990 to 2.5% in 1999 [5]. Because of this decline, Bill and Melinda Gates foundation recently released $12.2 million for the purpose of increasing yam production both in yield and net output by 40% in Ghana and Nigeria. The yam project was tagged ''Yam Improvement for Income and Food Security and Food Security in West Africa '' (YIIFSWA) [1].

The perception of farmers to climate change variable characteristics and the effect, however, affect the strategies to be adopted for yam production in order to achieve YIIFSWA objectives. In addition to the above, some government agencies have been working assiduously to increase the consciousness of the public on climate change and its effect, however, more efforts need to be made in order to sensitize and prepare quite a sizeable number of individuals who are still oblivious of the changing climate around them.

The paper is aimed at analyzing the perception of yam based farmers on climatic change in Edo state. Specifically, the study concentrated on three climatic variables, namely: air temperature, rainfall and wind intensity which are the three important climatic variables not only in yam production but in crops generally. The study is also an effort to measure and quantify the perception of yam based farmers on climatic change (rainfall, air temperature and wind intensity) in Edo state. While there have been comments here and there on the decline and irregularity in annual rainfall, and increase in air temperature; this study is a way of presenting the perceptions of yam based farmers on these important climatic variables empirically as well as identifying various coping strategies being adopted to ameliorate the negative effect of climatic change on yam production in the study area.

2. Methodology

The study was carried out in Edo State. The state lies roughly between longitude 06^0 $04^{'}$ E and 06^0 $43^{'}$ E and latitude 05^0 $44^{'}$N and $07^0 34^{'}$N. Edo is geographically located in central southern Nigeria which is bounded in the North and East by Kogi State, in the south by Delta State and in the west by Ondo State. The Northern part of Edo State shares the same savannah conditions with Northern Nigeria. The South, Central and part of the North also share the rain forest conditions with the rest of Southern Nigeria. Edo State has a tropical climate characterized by two distinct seasons: the wet and dry seasons. The wet season occurs between April and October with a break in August, and an average rainfall ranging from 150 cm (59") in the extreme north of the State to 250 cm (98") in the south. The dry season lasts from November to April with a cold harmattan spell between December and January. There are eighteen local government areas in Edo state. Edo state is known for the cultivation of maize, groundnut, guinea corn, soybeans, cassava, yam, vegetables, fruits, oil palm, cocoa, rubber, pharmaceutical herbs and ornamental trees, among others.

2.1. Data

The study utilized primary data. The primary data were obtained from respondents in the study area through the use of structured questionnaire. The study considered 250 yam based farmers in the study area. The information collected encompassed socio-economic characteristics of respondents. These are age, sex, marital status, household size, farming experience and years of formal education as well as perception on climatic variables and methods of adaptation to climate change. A multistage (three – stage) sampling procedure was employed to sample yam farmers from the three agro ecological zones (the north, the south and the central). In the first stage of sampling, Edo north and Edo central were randomly selected from the three agro ecological zones. From the selected zones, ten local government areas known for yam production were purposively selected from a total of 18 local government areas in the state (second stage sampling). In each local government, a village was randomly selected based on the reasonably high number of yam based farmers in the state representing the third stage of sampling. The last stage involved a random selection of 25 farmers from the chosen villages and this gave a total of 250 farmers. This was necessary for equal representation of the yam based farmers in the selected villages.

2.2. Method of Analysis

The descriptive statistics and index from quasi ordinal weighting matrix system reflecting farmers' perceptions were used to achieve the objective of the study. The descriptive analysis involved the use of percentages and charts to show the various perception of farmers based on the observed change in climatic variables as well as the corresponding effect on yam production. Also, descriptive statistics was used to analyze the socio-economic characteristics of respondents and to profile the various adaptation strategies employed by yam based farmers to mitigate the adverse

effect of climate change in the study area.

Following Reed *et al.* (1991) [13], the quasi-arbitrary ordinal weights were used to assess and quantify farmer's perception. This approach uses a relatively simple index that provides an indication of how well certain climatic characteristics meet farmers' perception. The implementation involves application of quasi-arbitrary ordinal weights in which farmers rank the perception of climatic parameters such as air temperature, wind intensity and precipitation. Reed *et al.* (1991) showed that by choosing weights meeting certain conditions, the proposed indices are robust, and when calculated under different sets of weights, these indices are highly correlated. Each farmer was asked to judge each attribute along two scales: First, how they ranked the change in the selected climatic variables (increased, stay the same, decrease) and second, their perception of the effect of the change in climatic variables on yam production (very severe, severe and not severe) [13].

For instance, if a farmer perceives that the effect of climate change is very severe, it implies a situation of crop failure to germinate, crop loss to erosion and spoilage of yam seeds, severe explains a situation of disease and pest infestation while not severe portrays reduction in crop yield and destruction of stakes. Thus for N farmers, each ranking the characteristics according to their observed changes and resultant effect on yam production, the response matrix is as shown in Table 1 below:

Table 1. Response matrix.

Farmers' Perception	Observed change in climatic variables			Row total
	Increase	Constant	Decrease	
Very severe	n_{11}	n_{12}	n_{13}	r_1
Severe	n_{21}	n_{22}	n_{23}	r_2
Not severe	n_{31}	n_{32}	n_{33}	r_3
Column total	c_1	c_2	c_3	

Where:

$$n_{11} + n_{12} + n_{13} = r_1$$

$$n_{11} + n_{21} + n_{31} = c_1$$

Each entry in the matrix in Table 1 (n_{ij}), represents the number of farmers who ranked a particular attribute based on their perception of its change, j, and its effect on yam production, i. The bottom row entries, c_j, are the total number of farmers who ranked the climatic variable according to the change observed. The far right column entries, r_i, are the total number of farmers who ranked the effect of the observed change on yam production as very severe, severe or not severe. Given the above, the following must hold.

$$\sum c_j = \sum r_j = \sum\sum n_{ij} = N \qquad (1)$$

The weighting matrix is presented in Table 2. The far right column in the table indicates the row weights, s. These are the weights assigned to the effect of the change in climatic variables on crop production. The bottom row shows the demand weights, d, assigned to farmers' perception of the change in a particular climatic variable. Each cell in the matrix is derived as:

$$w_{ij} = s_i d_j \qquad (2)$$

Reed *et al.* (1991) [13] proposed certain restrictions be imposed on the weights, so the following inequalities hold:

$$w_{1j} > w_{2j} > w_{3j} \; for \; all \; j \qquad (3)$$

The above inequality implies that regardless of the extent of change in climatic parameter, the more adversely the farmer perceives the effect of the change in the climatic parameter under consideration, the higher the weight is.

Table 2. Weighting matrix 1.

	Increase	Stay the same	Decrease	*Supply weight*
Very severe	w_{11}	w_{12}	w_{13}	s_1
Severe	w_{21}	w_{22}	w_{23}	s_2
Not severe	w_{31}	w_{32}	w_{33}	
Demand weight	d_1	d_2	d_3	s_3

$$w_{1i} > w_{2i} > w_{3i} > 0 \text{ for all i which is rated very severe or severe} \qquad (4)$$

Inequality condition in Eq. (4) states that whenever the perceived effect of the change in a climatic parameter is rated very severe or severe, the weight should be positive and it decreases in value as the change in the climatic variable decreases.

$$w_{1i} < w_{2i} < w_{3i} < 0 \text{ for all i which is rated not severe} \qquad (5)$$

Inequality Eq. (5) implies that weights for the effect rated as not severe should be negative and increasing as the change in the climatic variable reduces.

The above inequalities imply the following restrictions are established when constructing the supply and demand weights:

$$s_1 > s_2 > 0 > s_3 \qquad (6)$$

$$d_1 > d_2 > d_3 > 0 \qquad (7)$$

All demand weights, d_j, are positive, while the supply weight for a climatic characteristic ranked as not severe is negative. The above weighting scheme ensures that the highest (lowest) weights will be given to those observation considered very severe or severe (not severe).

Given the response weighting matrices, the three following indexes were calculated.

$$D = \frac{1}{d_1 N}\sum_{j=1}^{3} d_j c_i \qquad (8)$$

The Demand Index (D) is a measure of how farmers perceived the change in particular climatic characteristic. A value of 1 indicates that all farmers perceive an increase in the climatic variable under consideration. If not, the minimum value of the index will be calculated as $(d_3/d_1) > 0$, and is attained when all farmers perceive a decrease in the climatic variable of interest.

$$S = \frac{1}{S_1 N} \sum_{j=1}^{3} s_j r_i \qquad (9)$$

The Supply Index (S) is a measure of the perception of farmers on how severe a characteristic affects crop production. A maximum value of 1 indicates that all farmers perceive the effect of a characteristic observed as being very severe. The minimum value of the index will be calculated as $(s_3/s_1) < 0$, and this depend on the weight chosen. The minimum value will be attained if all farmers perceive the effect of the characteristic as not severe.

$$A = \frac{1}{W_{11} N} \sum_{j=1}^{3} \sum_{i=1}^{3} w_{ij} n_{ij} \qquad (10)$$

The Attainment index (W) provides a measure of how well farmers' perceptions of the observed climatic variable characteristics match farmers' perceptions of how severe the observed effect is observed. The maximum value carried by A is 1, and implies a perfect match. In such a situation, all farmers rank the observed change in climatic variable as increase and rank the observed effect as very severe. The minimum value of the index depends on the Supply weights, Si, chosen, and is calculated to be

$$S_3/S_1 < 0$$

It is essential to ascertain consistency and correctness of the weights assigned for computation. Two or more weights should be assigned for this purpose. Hence, to test the robustness of the results with respect to the set of weights chosen, following the suggestion of Reed *et al.* (1991) [13], the results of the attainment index using the different combinations of weight were compared using Pairwise and Spearman rank correlation coefficients for each set. The Spearman correlation coefficients measure the consistency in ordering the scores, while the Pairwise correlation coefficients measure the linear relationship between the different scores. The purpose of these correlation coefficients is to show the level of significance, degree of robustness and confidence in the results.

3. Results and Discussion

The study revealed that 87.6% of the households were headed by male (see figure 1 below) while 12.45% were headed by female. Also, 45.2% of the head of households were above 50 years. The percentage of household heads within the age bracket of 31 – 40 years was 18.8% (see table 3 below). The average household size in the study area was 7.7. Specifically, the result showed that 59.2% of the

respondents had household size ranging from 5 – 10 while 20.4% of the respondents had household sizes ranging from 1- 4 and above 10 respectively.
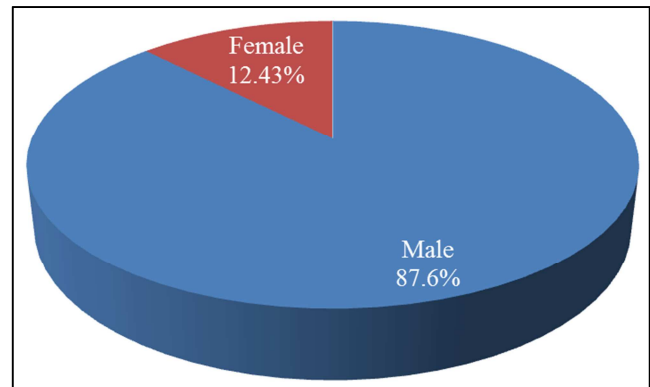
Source: Computed from field survey (2012).

Figure 1. Gender Distribution of Head of Households.

The average year of formal education attended by respondents was 8.0 years. The result below (see table 3) shows that 34.8% of the respondents had 1- 6 years of formal education while 19.5% had no formal education.

Table 3. Socioeconomic Characteristics of Sampled Farmers.

	Characteristic	Frequency	Percentage (%)
1.	*Sex of Household head*		
	Male	219	87.60
	Female	31	12.43
2.	*Age (year) of Household Head*		
	Less than 30	26	10.40
	31 - 40	47	18.80
	41 - 50	64	25.60
	Above 50	115	45.20
	Average: 48.4		
	Standard Deviation: 13.03		
3.	*Year of Formal Education*		
	0	49	19.50
	1 - 6	87	34.80
	7 – 12	80	32.00
	Above 12	34	16.83
	Average: 8.0,		
	Standard Deviation: 5.74		
4.	*Household size*		
	Less than or equal 4	55	20.40
	5 - 10	140	59.20
	Above 10	55	20.40
	Average: 7.7		
	Standard Deviation: 4.4		

Source: Computed from field survey (2012).

Figure 2 below presents the distribution of farmers' perceptions on climatic change based on the three identified climatic variables (air temperature, rainfall and wind intensity). As indicated in the figure, 78% of the farmers in study area were aware of continuous increase in air temperature while 67 percent of farmers perceived a steady decline in precipitation over the years. The farmers' perceptions on wind intensity show that 57.2% and 22.4% of the respondents observed an increase and decrease in wind

intensity respectively. These results agree with [14, 10, 2,11].
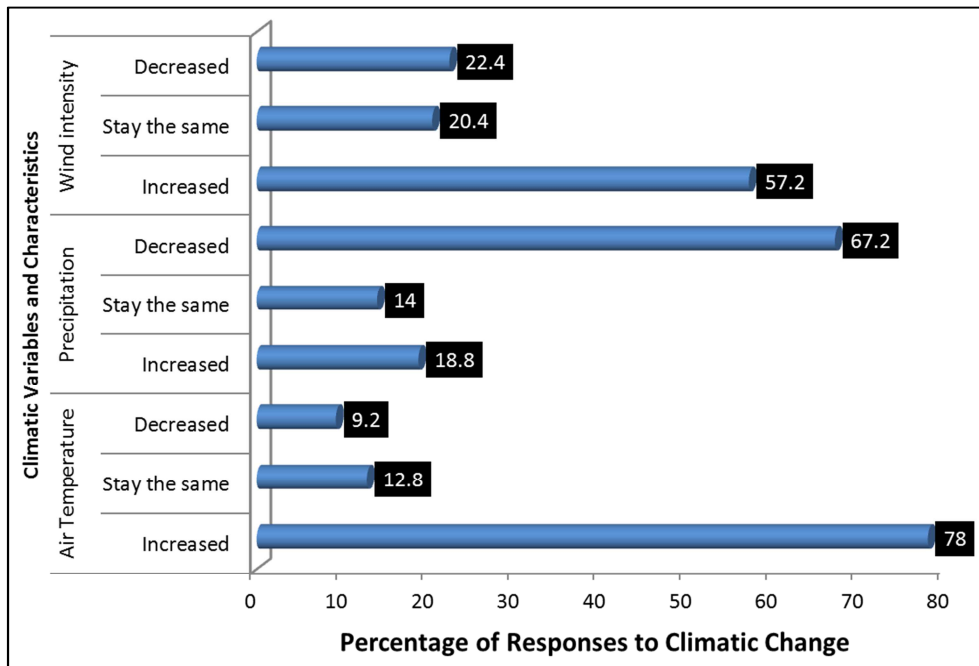
Source: Computed from field survey (2012).

Figure 2. Distribution of Farmers' Perception on Climatic Change.

Based on the perceptions expressed by farmers on air temperature, rainfall and wind intensity which are important climatic variables in crop production, table 3 below shows the of effects of these farmers' perceptions on yam production. The severity of effect that corresponds to the change in a given climatic variable is ranked by the sampled farmers as very severe, severe and not severe.

Table 4. Farmers' Perceptions on the effect of climatic change on yam Production.

Climatic variables	Effects	Percentages
	Very severe	28.80
Air Temperature	Severe	44.00
	Not severe	31.20
	Very severe	32.40
Precipitation	Severe	24.40
	Not severe	43.20
	Very severe	18.00
Wind intensity	Severe	35.60
	Not severe	46.40

Source: Computed from field survey (2012).

The table shows that majority of the farmers ranked the effect of the change in both precipitation and wind change as not severe (43.2% and 46.4% respectively) while air temperature was ranked as severe (44.0%) on yam production. This is an indication that the effects of rainfall and wind intensity were not very pronounced. Many factors might have contributed to these perceptions, among which are the adoptions or non adoption of coping strategy as well as the type of coping strategy being used where adoption is taking place. Table 4 below shows the adaptation methods or

strategies employed by the sampled farmers. The table shows that majority of the farmers perceived at least one change in climatic attributes. However, about 0.136 (proportion) of the sampled farmer did not adopt any adaptation measure to mitigate the negative effect of climate change. This may be attributed to lack of awareness on the part of concerned farmers to different coping strategies or the unwillingness to change because they perceived that each change comes with own challenges and as such farmers tend to rationalize input.

(i). Estimation of farmers' perception of climate change using quasi-arbitrary method

Using Equations (6) and (7), three sets of weights were used to calculate the indices (demand, supply and attainment indices) for the climatic variables- temperature, rainfall and wind intensity). Also, the robustness of the results obtained for the above indices was verified. These weights including the response matrix are shown in appendices 1 and 2.

Table 5. Demand indices.

	Indices	Temperature	Precipitation	Wind intensity
1.	Max value	1	1	1
	Index	0.87	0.38	0.84
	Min value	0.25	0.20	0.50
2.	Max value	1	1	1
	Index	0.92	0.62	0.73
	Min value	0.5	0.5	0.25
3.	Max value	1	1	1
	Index	0.92	0.63	0.82
	Min value	0.20	0.5	0.40

According to Reed *et. al,* (1991) [13], a value of 1, which is the highest value obtainable, indicates that all the farmers' perceived that the climatic variable under consideration has

increased while the minimum value shows that all the farmers perceive a decrease. From the above, the first demand index is 0.87 and since this value is quite high (close to 1), it implies that majority of the farmers (not all) perceived an increase in temperature. This result agrees with studies carried out by [2, 14]. The demand indices 2 and 3 were included to test for consistency. Given the above values and following the conditions given by [13], the same conclusion can be drawn that majority of the farmers perceived an increase in temperature and this therefore shows that the results are consistent across all the three weighting schemes. For precipitation, as shown in set 1, the demand index of 0.38 with a minimum value of 0.20 implies that a greater part of the sampled farmers perceived a decrease in precipitation. The same conclusion can be drawn from the second and third indexes. Considering wind intensity, the first demand index has a value of 1 which indicates that all the farmers' perceive that wind intensity has increased while the minimum value (0.50) shows that all the farmers perceive a decrease in wind intensity. Since the value (0.84) is quite high (closer to 1), it can be concluded that majority of the farmers perceived an increase in wind intensity. The same conclusion can be deduced for the second and third indices.

The supply indices which measure the extent of severity of the effect of the change in climatic variables on yam production are shown in table 6 below. The extent of severity of the change was ranked by each farmer as severe, not severe and very severe.

Table 6. Supply indices.

	Indices	Temperature	Precipitation	Wind intensity
1.	Max value	1	1	1
	Index	0.27	0.221	0.144
	Min value	-0.2	-0.33	-0.33
2.	Max value	1	1	1
	Index	0.29	0.29	0.09
	Min value	-0.33	-0.20	-0.33
3.	Max value	1	1	1
	Index	0.34	0.22	0.22
	Min value	-0.17	-0.33	-0.17

For temperature, as shown in the table above, the first supply index is 0.27. Compared to the maximum value which is 1 (implying that all farmers perceived the effect of temperature change as very severe), the supply index is in between the maximum value (1) and the minimum value (-0.2). By implication, it can be said that most of the sampled farmers perceived the effect of the change in precipitation as severe. The same conclusion can be drawn for the second and third indexes. For precipitation, the first supply index, as shown in the table above, is 0.221 and having a minimum value of –0.33. Following the conditions given by [13], it therefore implies that majority of the farmers in the sampled area perceived that the effect of precipitation on yam production was severe. The same conclusion was drawn for the second and third index. The result in table 6 also shows that the supply index for wind intensity is 0.144 with a minimum value equal to -0.33. It

therefore implies that not all farmers ranked the effect of the increase in wind intensity as not severe. The same conclusion was reached for the second and third indexes.

The attainment matrix presented in table 7 provides a measure of how well farmers' perceptions of the observed change in the climatic variables match farmers' perception of how severe the observed effect is.

Table 7. Attainment matrix.

Indices	Temperature	Precipitation	Wind intensity
Max	1	1	1
Index	0.24	0.224	0.12
Min	-0.2	-0.33	-0.33

The table above shows attainment matrix for temperature, precipitation and wind intensity respectively. For temperature, the attainment index is 0.24 and this denotes that there is no perfect match. This implies that not all farmers ranked the observed change in temperature as increase and not all farmers ranked the effect of the change as very severe. Also, since the attainment value is not equal to the minimum value (-0.2), it shows that not all the farmers ranked the observed change as decrease and ranked the effect of the observed change as not severe. This implies that not all the farmers' rankings were the same; there were variations in their perceptions of the change in the temperature and its corresponding effect on yam production. For precipitation, the minimum value of the attainment index depends on the supply weights, s_i, given, and it is calculated to be $\left(\frac{s_3}{s_1} \right) < 0$.

From the above calculation, the value is -0.33. Given that the attainment index is 0.224, it denotes that there is no perfect match. In such a situation, not all farmers ranked the observed change in precipitation as increase and ranked the effect of the observed change in precipitation as very severe. For wind intensity, since the attainment index is not equal to 1 or the minimum value $\left(\frac{s_3}{s_1} \right) = -0.33,$ it implies that there is no perfect match between the ranking of the observed change in wind intensity and its related effect. This means that not all the farmers ranked the observed change in wind as increase and very severe and not all farmers ranked their perception on wind change as decrease and not severe. The implication of this result is that farmers' perceptions on wind change are varied and are not concentrated in a particular ranking of wind intensity attribute or characteristic.

(ii). Robustness of the indices

Using equations (6) and (7), four sets of weights were used to calculate the indices and the robustness of the results verified. The indices are said to be robust if reasonable changes in one or both sets of marginal weights do not cause major changes in the rankings given by the indices. This was examined by using 8 idealized 3x3 response matrices from which demand, supply, and attainment indices were calculated. The response matrices used are given in Appendices 13 – 20. The sets of demand and supply weights are given in table 8.

Table 8. *Supply and demand weights used in robustness analysis.*

Supply Weights
$S^A: \begin{bmatrix} 5 \\ 1 \end{bmatrix}$ $S^B: \begin{bmatrix} 3 \\ 1 \end{bmatrix}$ $S^C: \begin{bmatrix} 6 \\ 2 \end{bmatrix}$ $S^D: \begin{bmatrix} 6 \\ 1 \end{bmatrix}$

Demand Weights
$D^A: \begin{bmatrix} 5 \\ 2 \end{bmatrix}$ $D^B: \begin{bmatrix} 3 \\ 3 \end{bmatrix}$ $D^C: \begin{bmatrix} 5 \\ 2 \end{bmatrix}$ $D^D: \begin{bmatrix} 5 \\ 4 \end{bmatrix}$

This study examined 4 sets of demand weights and 4 sets of supply weights. It follows that the weight combination given by D^A and S^B is referred to as W^{AB}, and so on. Result of the attainment indices using the different combinations of weights were compared using Pairwise and Spearman correlation coefficients.

Table 9. *Correlations between attainment scores by different weighting formulae.*

	W^{AA}	W^{AB}	W^{AC}	W^{AD}	W^{BA}	W^{BB}	W^{BC}	W^{BD}	W^{CA}	W^{CB}	W^{CC}	W^{CD}	W^{DA}	W^{DB}	W^{DC}	W^{DD}
W^{AA}	1	0.97	1.00	0.97	0.98	0.96	0.56	0.96	0.99	0.98	0.97	0.97	1.00	0.97	1.00	0.97
W^{AB}	0.99		0.95	0.99	0.94	0.98	0.56	0.97	0.94	0.99	0.90	0.98	0.98	1.00	0.96	0.99
W^{AC}	0.99	0.98		0.94	0.98	0.94	0.55	0.94	0.99	0.96	0.99	0.95	0.99	0.94	1.00	0.95
W^{AD}	0.88	0.92	0.85		0.92	0.96	0.52	0.97	0.93	0.98	0.89	0.98	0.97	0.99	0.95	1.00
W^{BA}	0.98	0.96	0.99	0.81		0.97	0.65	0.97	1.00	0.97	0.99	0.97	0.98	0.94	0.98	0.95
W^{BB}	0.99	1.00	0.98	0.92	0.96		0.66	0.99	0.96	1.00	0.92	0.98	0.97	0.99	0.96	0.98
W^{BC}	0.36	0.38	0.38	0.34	0.40	0.38		0.64	0.61	0.61	0.59	0.60	0.58	0.58	0.58	0.57
W^{BD}	0.95	0.99	0.95	0.93	0.93	0.99	0.40		0.96	0.99	0.93	1.00	0.97	0.97	0.95	0.98
W^{CA}	0.98	0.96	0.99	0.81	1.00	0.96	0.40	0.93		0.96	0.99	0.97	0.99	0.94	0.99	0.95
W^{CB}	0.99	1.00	0.98	0.92	0.96	1.00	0.38	0.99	0.96		0.93	0.99	0.99	1.00	0.97	0.99
W^{CC}	0.98	0.96	0.99	0.81	1.00	0.96	0.40	0.93	1.00	0.96		0.93	0.97	0.90	0.98	0.91
W^{CD}	0.95	0.99	0.95	0.93	0.93	0.99	0.40	1.00	0.93	0.99	0.93		0.98	0.98	0.96	0.99
W^{DA}	1.00	0.99	0.99	0.88	0.98	0.99	0.36	0.95	0.98	0.99	0.98	0.95		0.98	1.00	0.98
W^{DB}	0.99	1.00	0.98	0.92	0.96	1.00	0.38	0.99	0.96	1.00	0.96	0.99	0.99		0.96	0.99
W^{DC}	1.00	0.99	0.99	0.88	0.98	0.99	0.36	0.95	0.98	0.99	0.98	0.95	1.00	0.99		0.96
W^{DD}	0.95	0.99	0.95	0.93	0.93	0.99	0.40	1.00	0.93	0.99	0.93	1.00	0.95	0.99	0.95	

* The coefficients in bold are the pairwise correlation coefficients while the coefficients in times new roman font are spearman correlation coefficients.

Table 9 above gives the Pairwise and Spearman rank correlation coefficients of the attainment indices for the 8 idealized response matrices. The Spearman correlation coefficients (non-parametric correlation) talks about consistency in the ordering of attainment scores while pairwise correlation coefficient (parametric correlation) measures the strength of the linear relationship between the scores. The result shows that, for both the Spearman and Pairwise correlation coefficients, most of their values are high between zero and one, and are also highly significant ($p<0.01$). The suggested conclusion, therefore, is that there is a considerable and reasonable degree of robustness and confidence in the results obtained for the various indices (supply and demand weight used), provided those variations are over a realistic range.

4. Conclusion and Recommendation

The study focused on matching farmers' perception on climate change characteristic to their effects on yam based production in Edo state, Nigeria. The empirical findings revealed that most of the farmers in the study area were aware that temperature and wind intensity are increasing and the level of precipitation is declining. The study presented an internally consistent approach to the evaluation of farmers' perception on climate change by quantifying the qualitative characteristics and the effects of these changes on yam production by presenting them on an ordinal scale as well as matching of the two characteristics. These have been shown to be relatively simple to construct and applywhile retaining

a high degree of robustness. Development and adoption of strategies, options and improved technologies play a critically importantrole in improving agricultural productivity. Adoption studies have consistently emphasized that for any choice that would be made by farmers, perception of the current situation and the anticipated situation play an important role. Hence, the methodology proposed by Reed *et al.* (1991) [13], permits one to move beyond this to include, in a quantitative manner, the perceptions of farmers about the characteristics of climate change observed and what they perceive to be the effect of these changes on yam production. This paper has shown that such perceptions are critically important in influencing community, state and national decision. Perception of any attribute is based on feeling which is not quantifiable on an ordinal scale. The use of the method analysed in this paper can be incorporated in researches that will better the life of farmers.

Quantifying farmers' perceptions in the manner suggested in the paper potentially makes the method more palatable to station-based researchers used to cardinal types of analysis. As revealed by the study, the sharp increase and decrease in temperature and rainfall (two important climatic factors in crop production) respectively; are indications that climate change would have contributed significantly to reduction in yam production in the study area; this situation therefore creates the need for programmes or efforts geared towards providing farmers with effective adaptation strategies which would help provide a buffer against adverse climatic conditions.

Appendix

Appendix 1

Table A1. Response Matrix Showing Perception of Farmers to Wind Intensity.

Perceived Effect	Observed Change in Wind Intensity			
	Increase	Constant	Decrease	Row Total
Very severe	29	4	12	45
Severe	49	18	22	89
Not severe	65	28	23	116
Column total	143	50	57	250

Source: Computed from field survey, May - June 2012

Appendix 2

Table A2. Response Matrix Showing Perception of Farmers to Temperature.

Perceived Effect	Observed Change in Air Temperature			
	Increase	Constant	Decrease	Row Total
Very severe	49	10	3	62
Severe	85	11	14	110
Not severe	62	10	6	78
Column total	196	31	23	250

Source: Computed from field survey, May - June 2012

Appendix 3

Table A3. Response Matrix Showing Perception of Farmers to Rainfall.

Perceived Effect	Observed Change in Rainfall			
	Increase	Constant	Decrease	Row Total
Very severe	17	8	56	81
Severe	11	7	43	61
Not severe	19	19	70	108
Column total	47	34	169	250

Source: Computed from field survey, May - June 2012

Appendix 4

Table A4. Weighting Matrix for Temperature.

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	20	10	5	$s_1 = 5$
Severe	4	2	1	$s_2 = 1$
Not severe	-4	-2	-1	$s_3 = -1$
Demand weight	$d_1 = 4$	$d_2 = 2$	$d_3 = 1$	

Source: Computed from field survey, May - June 2012

Appendix 5

Table A5. Temperature Weighting Matrix Test I.

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	12	9	6	$s_1 = 3$
Severe	4	3	2	$s_2 = 1$
Not severe	-4	-3	-2	$s_3 = -1$
Demand weight	$d_1 = 4$	$d_2 = 3$	$d_3 = 2$	

Source: Computed from field Survey, May - June 2012

Appendix 6

Table A6. *Temperature Weighting Matrix Test II.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	30	24	12	$s_1 = 6$
Severe	10	8	4	$s_2 = 2$
Not severe	-5	-4	-2	
Demand weight	$d_1 = 5$	$d_2 = 4$	$d_3 = 2$	$s_3 = -1$

Source: Computed from field survey, May - June 2012

Appendix 7

Table A7. *Weighting Matrix for Precipitation.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	30	12	6	$s_1 = 6$
Severe	5	2	1	$s_2 = 1$
Not severe	-10	-4	-2	
Demand weight	$d_1 = 5$	$d_2 = 2$	$d_3 = 1$	$s_3 = -2$

Source: Computed from field survey, May - June 2012

Appendix 8

Table A8. *Precipitation Weighting Matrix Test I.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	20	10	5	$s_1 = 5$
Severe	4	2	1	$s_2 = 1$
Not severe	-4	-2	-1	
Demand weight	$d_1 = 4$	$d_2 = 2$	$d_3 = 1$	$s_3 = -1$

Source: Computed from field survey, May - June 2012

Appendix 9

Table A9. *Precipitation Weighting Matrix Test II.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	24	12	6	$s_1 = 6$
Severe	4	3	2	$s_2 = 1$
Not severe	-12	-4	-2	
Demand weight	$d_1 = 4$	$d_2 = 3$	$d_3 = 2$	$s_3 = -2$

Source: Computed from field survey, May - June 2012

Appendix 10

Table A10. *Weighting Matrix for Wind Intensity.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	12	9	6	$s_1 = 3$
Severe	4	3	2	$s_2 = 1$
Not severe	-4	-3	-2	
Demand weight	$d_1 = 4$	$d_2 = 3$	$d_3 = 2$	$s_3 = -1$

Source: Computed from field survey, May - June 2012

Appendix 11

Table A11. *Wind Intensity Weighting Matrix Test I.*

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	24	12	6	$s_1 = 6$
Severe	4	2	1	$s_2 = 1$
Not severe	-8	-4	-1	
Demand weight	$d_1 = 4$	$d_2 = 2$	$d_3 = 1$	$s_3 = -2$

Source: Computed from field survey, May - June 2012

Appendix 12

Table A12. Wind Intensity Weighting Matrix Test II.

Perceived Effect	Increase	Constant	Decrease	Supply weight
Very severe	30	24	12	$s_1 = 6$
Severe	10	8	4	$s_2 = 2$
Not severe	-5	-4	-2	$s_3 = -1$
Demand weight	$d_1 = 5$	$d_2 = 4$	$d_3 = 2$	

Source: Computed from field survey, May - June 2012
Fictive Data Used in Robustness Analysis.

Appendix 13

Table A13. Three by three (3 x 3) idealized response matrix for experiment 1.

Experiment 1	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	0	0	0
2	0	250	0	0
3	0	0	0	0
Total	0	250	0	250

Source: Computed from field survey, May - June 2012

Appendix 14

Table A14. Three by three (3 x 3) idealized response matrix for experiment 2.

Experiment 2	Perception on Climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	250	0	250
2	0	0	0	0
3	0	0	0	0
Total	0	250	0	250

Source: Computed from field survey, May - June 2012

Appendix 15

Table A15. Three by three (3 x 3) idealized response matrix for experiment 3.

Experiment 3	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	0	250	250
2	0	0	0	0
3	0	0	0	0
Total	0	0	250	250

Source: Computed from field survey, May - June 2012

Appendix 16

Table A16. Three by three (3 x 3) idealized response matrix for experiment 4.

Experiment 4	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	0	0	0
2	250	0	0	250
3	0	0	0	0
Total	250	0	0	250

Source: Computed from field survey, May - June 2012

Appendix 17

Table A17. Three by three (3 x 3) idealized response matrix for experiment 5.

Experiment 5	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	125	125	0	250
2	0	0	0	0
3	0	0	0	0
Total	125	125	0	250

Source: Computed from field survey, May - June 2012

Appendix 18

Table A18. Three by three (3 x 3) idealized response matrix for experiment 6.

Experiment 6	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	125	0	125	250
2	0	0	0	0
3	0	0	0	0
Total	125	0	125	250

Source: Computed from field survey, May - June 2012

Appendix 19

Table A19. Three by three (3 x 3) idealized response matrix for experiment 7.

Experiment 7	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	0	0	0
2	100	50	100	250
3	0	0	0	0
Total	100	0	100	250

Source: Computed from field survey, May - June 2012

Appendix 20

Table A20. Three by three (3 x 3) idealized response matrix for experiment 8.

Experiment 8	Perception on climatic Characteristics			
Perception of the Effect	1	2	3	Total
1	0	0	0	0
2	0	0	0	0
3	100	50	100	0
Total	100	50	100	250

Source: Computed from field survey, May - June 2012

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