European Journal of Agriculture and Forestry Research

Vol.6, No.2, pp.1-15, April 2018

Published by European Centre for Research Training and Development UK (www.eajournals.org)

ECONOMIC ANALYSIS OF AGGREGATE AGRICULTURAL LAND RESOURCES QUALITY IN NIGERIA

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ABSTRACT: *Nigeria is endowed with abundant agricultural land resources of varying biophysiographic features. Providing adequate varied quality foods and raw materials to sustain Nigeria's growing population and agro-industries were respectively very critical. Agricultural land resources performance indices were crop yields per hectare among others and several factors spurred land quality degradation that subsequently unpeded it's productivity leading to the nation's food supply deficits for over five decades. The enigma that prompted this research effort was that the extent by which Nigeria's aggregate agricultural land resources quality degraded were not known. The overall objective of this study was to capture the real changes in the nation's agricultural land resources quality in terms of soil fertility and productivity. The nation's aggregate soil fertility was scaled using crop numeraire to capture the agricultural land resources quality index while F-Statistics was used to test the hypothesis. The observed productivity gains corresponded to land quality index suggesting that arable lands were highly responsive to both intended and unintended on-farm cultural practices and component technology inputs. The highest (5.0363) and least (2.8140) observed agricultural land quality occurred in the years 1974 and 2010 respectively. Greater variability (14.6%) in land quality occurred in the period 1980-1989 while the land quality dispersion around the mean was higher in the period 1970-1979. The nation's land resources quality showed a downward slowdown demand curve and estimates of the mean absolute percentage error were 7.4% and 0.33% respectively for the original forecast error and Chi-Square forecast error. Comparatively, the criterion functions of the two forecasts generated a relative land quality index prediction of 94%. This implied that the original forecast error had a mean square error of 94% that of the Chi-Square. Hence the Chi-Square results were adjudged to have better performance. The observed F-value, 9.4004^{ns} was not statistically significant at 5% level. Hence the acceptance of the null hypothesis that there were no significant difference in land quality across Nigeria for the five decade years. The highest positive amplitude of the land quality movement and land quality were observed in 1973 and 1974 respectively while the two peak periods of highest negative amplitudes of land quality movements occurred at the close of 1974 and 1983 respectively. Comparatively, changes in land quality index (17.8%) were more consistent than agricultural land degradation rate of change (160.4%).*

KEYWORDS: Agricultural Land Quality, Numeraire Crops, Land Degradation and Productivity.

INTRODUCTION

Nigeria is located between latitude 4^0 01' and 13^0 09' North and longitude 2^0 02' and 14^0 30' East with a population of about 140,020,952 people (NBS, 2006) .The country is endowed

ISSN: 2054-6319 (Print), 2054-6327(online)

with abundant land resources of about 941,849 Km^2 and a potential productive arable land resources of about 520,000 Km^2. The nation's diversity in biophysiographic features is such that the land summit areas are of various representations ranging from flat land facets through plateau to hilly sloping facets (NBS, 1999a; FMANR, 1974 and ODNRI, 1989). Providing adequate quality varied foods and raw materials to sustain Nigeria's growing populations and industries were respectively very critical. The diversity of nutrients in high quality foods required to sustain a healthy productive population were ultimately sourced from crops and livestock (Belitz,Grosch and Shieberle,2008.,Ehigiator,Ariyo and Imasuen,2015.,Nwachukwu and Onwuka,2011.,Paul,2011.,Uwaegbute,2011 and William,2011) . The livestock depended largely for their food nutrients on crops that absolutely sourced their nutrients from the soil and or land resources. The components of agricultural land resources were largely the soil, river systems, vegetations, microclimates and intangible assets among others. That is, agricultural land has natural, artificial and intangible components. Embodied in the basic natural components of agricultural land resources were micro and macro plant nutrients in varying amounts, quality and degree of availability to crops in assimilable forms relative to agroecological regions (Adikuru,Okafor,Anyanwu and Ihem,2016.,Brady and Ray,2014).

Nigerian government since 1960 among various regimes, adopted either radical approach or evolutionary approach and or a combination of the two policy approach to agricultural development. Agricultural projects must be physically possible, economically feasible and institutionally permissible and their spillover benefits and or externalities must also be positive (Erakhrumen and Okon,2015). Thus, agricultural land performance indices were yield per hectare and or land productivity, products nutritional quality, level of plant tissue contamination, physical quality of products, level of waste and level of environmental pollution among others (Barbara,2012.,Ekhuemelo and Akeh,2015.,Ibe,2011). Several factors impeded the overall on-farm outputs and land resources performance. One of such critical factors was the agricultural land resources quality degradation (Narayanam,2011.,Madu,Mohammed and Mshelia,2013.,Fatima,Jeroen and David,2012). Land and soil degradations over time were reflected in the declining rates of crops actual yields per hectare, which in most cases prompted on-farm income slowdown. Land resources quality degradation was largely attributed partly to the shift to huge application of inappropriate on-farm technologies by the elite farmers and the continuous adoption of unimproved inefficient agricultural technologies by the majority of the farmers. These posed a great threat to agricultural land quality and productivity across the nation's agro-ecology. The impact of accelerated natural and human induced agricultural land quality degradation on food supplied was enormous prompting severe food crisis in Nigeria. However, arable land quality degradation could have been prevented and or well managed using appropriate on-farm technologies. The Nigerian agricultural land resources degradation was assessed and evaluated to ascertain the actual and potential soil quality degradation to avert persistent food crisis (Adejobi and Babatunde, 2012).

Problem Statement

Agricultural land resources quality was very critical in sustainable on-farm production and agroecological protection. Nigeria's food crisis persisted for over four decades largely due to on-farm output supply deficits generated by accelerated land quality degradation. Agricultural experts offered various explanations for the persistent farm output supply slowdown as the nation's public policies discriminated against agriculture. However, the

ISSN: 2054-6319 (Print), 2054-6327(online)

major problems captured which prompted these research efforts were that the extent and the direction of movements of Nigerian agricultural land quality degradations were not known. It was therefore very imperative to capture the magnitude and movement of the aggregate agricultural land quality degradation in Nigeria for better understanding and possible improved policy formulation (Cortney,2016.,Daneji,2011.,John,Samuel,Werner,and James,2014.,Obi and Esu,2015).

Objectives of the study

The overall objective of this study was to capture the real changes in Nigeria's agricultural land resources quality in terms of soil fertility and productivity. Specifically, the objectives were to:

i. measure the magnitudes of actual aggregate soil fertility and or quality of Nigeria's agricultural land resources using numeraire crop techniques;

ii. capture Nigeria's agricultural land resources quality movements;

iii. and to make appropriate agricultural policy recommendations.

Hypothesis

There were no significant differences in Nigeria's agricultural land resources quality index among the five decades of time.

Justification

Nigerian agricultural sector was characterized by dwindling on-farm outputs and miserable overall sector performance. The declining agricultural land resources quality was one of the actual and potential sources of the nation's weak agricultural base. This therefore, required urgent public policy attention and analysis. Hence, this research effort was therefore intended for better understanding of Nigerian agricultural land resources quality trend path and it's possible policy implications. The results were therefore very critical in modeling crops and livestock production in Nigeria for policy analysis. The research outputs were further expected to provide policy options that have the potency to drive agricultural land quality positively to sustain higher productivity levels (Sara and Satya,996;Okpara,2011).

The impact of traditional and improved technologies applications on agricultural land resources in Nigeria were highly unpredictable and the ultimate consequences appeared to have profound policy implications, hence this study. Therefore, the overall output of this effort, is imperative for policy makers, scholars and farmers. Economic analysis of agricultural land quality movements is a plausible prelude to field and laboratory arable land quality assessment and evaluation. Hence, the results were of immense value to soil scientists, agronomists, government and investors in agricultural sector in Nigeria (Ozor, 2014).

METHODOLOGY

Nigerian agricultural land resources were heterogeneous both in land facets summit and quality across the regions and they received varied agricultural inputs and cultural practices

ISSN: 2054-6319 (Print), 2054-6327(online)

between 1970 and 2017. The qualities of agricultural land resources were mechanically tied to the soil fertility basically to capture an index of aggregate land quality. This implied that soil productivity provided a direct measurement of soil fertility and or land quality. Therefore, real changes in agricultural land numeraire provided a real measure of changes in land quality and soil fertility over time which were scaled to obtain the aggregate agricultural land quality measure in numeraire hectare (Philip,Johanne and Anderson,1991).In this context, the crop that has maintained the highest crop yield value in metric tonnes in each year in Nigeria was selected as the numeraire crop and subsequently the land under its cultivation was designated the cropland numeraire. Then, the yields of other croplands gave fractions of the numeraire cropland yield. Thus, their relative yields counted as the same fraction of quality of the numeraire cropland. This translated agricultural lands in Nigeria into a national cropland of constant quality and it eliminated difficulties of measuring land use intensity usually associated with unweighted land service flow computations (Peterson, 1987). Secondary data such as crop yields were collected from relevant government agencies for analysis.

Simple descriptive statistics such as mean, percentages, standard deviation and coefficient of variation were employed for the analysis. High resolution graphical representations were used to further elucidate the results. The hypothesis was tested using chi-square (Paul and Theodore,1994;Pillan and Bagavathi,2012 and NBS,2006) and the rates of changes in the numeraire cropland quality were estimated as:

$$\theta_{lt} = \left[\frac{\beta_{2t}-\beta_{1t}}{\Delta\delta}\right] = \frac{\Delta\beta}{\Delta\delta} \qquad \text{……Eq [1]}$$

Where θ_{lt} was the rate of agricultural land quality degradation (θ_{lt} < O) and or improvement (θ_{lt} >O). While β_{1t} was the previous cropland quality status and β_{2t} was the current cropland quality status and $\Delta\delta$ were the changes in time measured in years. The evaluation of one-step forecast (f_{1t}) of the agricultural land resources quality index (LQI) was based on:

$$\varepsilon_{1t} = x_t - f_{1t} \qquad \text{….Eq [2]}$$

Where t = 1, 2, 3, 4 ….49 and the average land quality measures based on four forecast of errors were:

[1] The quadratic error function and or mean square error [MSE] expressed as:

$$MSE = \frac{1}{n}\sum_{n=1}^{n}[y-\hat{y}]^2 \qquad ...Eq.[3]$$

[ii] The absolute error function and or the mean absolute error [MAE] was expressed as :

$$MAE = \frac{1}{n}\sum_{n=1}^{n}|Y-\hat{y}| \qquad ...Eq.[4]$$

Thus, expressing Eq [4] in terms of percentage of the agricultural land resources quality index [LQI], then the mean absolute percentage error [MAPE] was expressed as:

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$$MAPE = \frac{100}{n}\sum_{n=1}^{n}\frac{|Y-\hat{y}|}{Y} \qquad ...Eq.[5]$$

[iii] and the root mean square error [RMSE] was thus measured and expressed as:

$$RMSE = \sqrt{\sum_{n=1}^{n}\frac{[y-\hat{y}]^2}{n}} \qquad ...Eq[6]$$

RESULTS AND DISCUSSION

The results that follow, gave a fair analysis of the changes in numerical quality magnitudes of Nigerian aggregate agricultural land resources. Table 1 showed the variations in agricultural land quality index [LQI] and or soil fertility across the five decades.

Table 1 Nigerian Agricultural Land Quality Index [LQI] From 1970-2017

Year	1970-1979	1980-1989	1990-1999	2000-2009	2010-2017
	3.1182	4.3510	3.6890	3.1490	2.8140
	3.3464	4.4330	3.3130	3.0480	2.8200
	3.7260	4.6040	3.0930	3.0100	2.8230
	4.1553	4.5820	3.1640	2.9180	2.8240
	5.0363	3.3213	3.1040	2.9020	2.8270
	3.5733	3.2044	3.1870	2.8900	2.8290
	4.1525	3.2710	3.1940	2.8610	2.8300
	4.2075	3.4990	3.1940	2.8440	NA
	4.2090	3.6490	3.1940	2.8310	NA
	4.5300	3.8680	3.0590	2.8250	NA
Total	**40.0545**	**38.7827**	**32.1910**	**29.278**	**19.767**
Mean	**4.0055**	**3.8783**	**3.2191**	**2.9278**	**2.8239**

Source: Field data analysis 2017

Notes: NA = Not available

The agricultural land resources quality was tied to the soil fertility that was a function of several factors. The aggregate Nigerian agricultural land resources quality index [LQI] captured were as shown in Table 1 and further explained as shown in Fig.1.

ISSN: 2054-6319 (Print), 2054-6327(online)

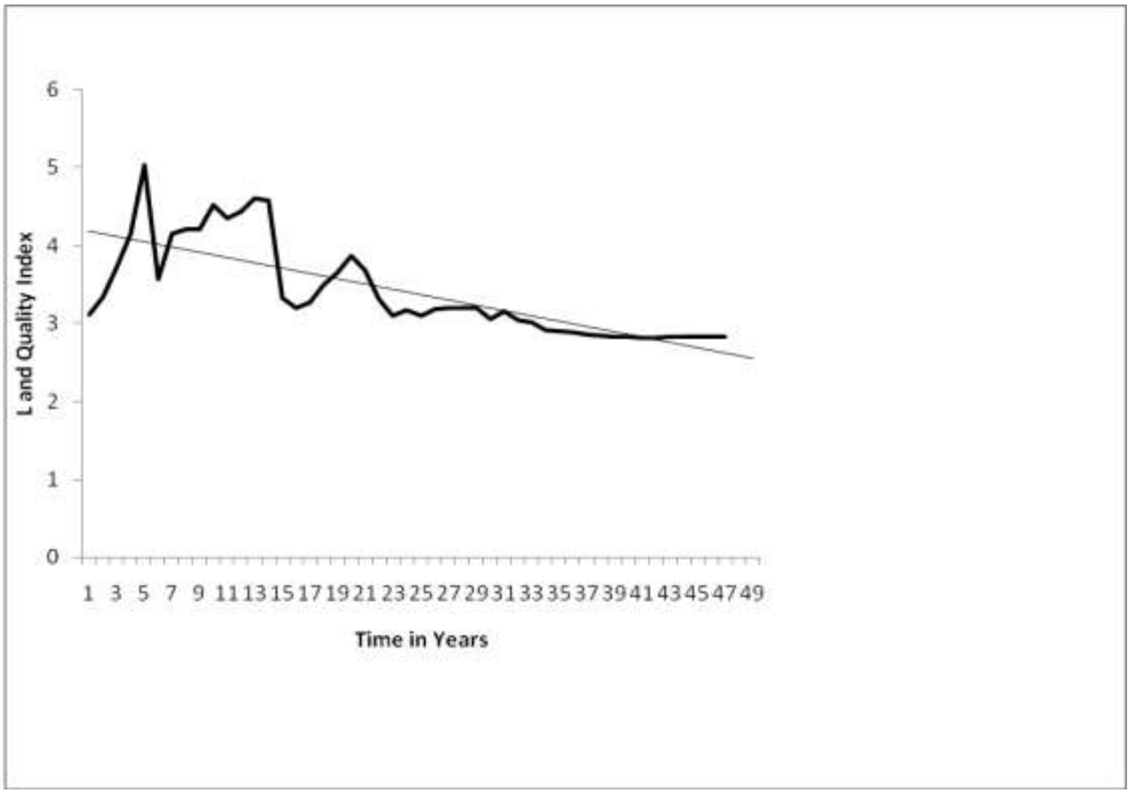

Fig.1 Nigerian Agricultural Land Resources Quality Index [LQI].

Amplified agricultural land quality index yielded a corresponding boast in productivity gains and vice versa. Hence, numeraire cropland yields in metric tonnes were the real parameter estimates of agricultural land quality with respect to the soil fertility. These parameter estimates were highly responsive to varying amounts of cultural management practices and the component technology inputs in crop and pasture production. Therefore, the results in Table 1 and Fig.1 gave a true measure of the combined average changes of several variables that influenced the quality and fertility of Nigerian aggregate agricultural land resources. The results showed that the incidence of the highest and the least observed agricultural land quality index [LQI] occurred in the periods 1970-1979 and 2010-2016 respectively.

Fig.1 showed a downwards slope and Nigeria's agricultural land quality index [LQI] of 5.0363 in 1974 was the highest quality index observed across the years in the five decades. This incidence of high cropland quality and fertility was attributed to the accrued soil fertility from crop farmlands that were kept fallow from 1966-1970 during the Nigerian-Biafran civil war. The land quality index declined to 3.5733 in 1975 and gradually rose to an index of 4.6040 in 1982 when it gradually fell to remain almost constant from 2007 to 2016. Table 2 showed the statistics of the Nigerian agricultural land quality index across the decades.

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Table 2 Statistics of the Nigerian Agricultural Land Resources Quality Index [LQI].

Parameters	1970-1979	1980-1989	1990-1999	2000-2009	2010-2017
Total LQI	40.055	38.78	32.19	29.28	19.77
Mean	4.006	3.878	3.219	2.928	2.824
Std Dev.	0.573	0.566	0.179	0.107	0.005
C.V	14.3%	14.6%	5.6%	3.7%	0.2%

Source: Field data analysis 2017

Notes: LQI = Agricultural Land Quality Index

C.V = Coefficient of Variation

Std Dev. = Standard Deviation

The LQI slowdown was consistently highly pronounced in the period 2010-2017 but its variability was great in 1980-1989 period compared to other periods as shown in Table 2. The standard deviation showed the dispersion of the series of LQI values around the mean as it defined the square root of the LQI variance. Efforts were made to shed light on the degree of precision, plausibility and validity of the LQI captured in the analysis. The results of the original one step error forecast that measured the performance of the LQI evaluation in Nigeria were as follows:

The quadratic error function measured as mean square error [MSE] was,

$$MSE = \frac{1}{n}\sum_{n=1}^{n}[y-\hat{y}]^2 = \frac{20.2883}{49} = 0.4140$$

Again, the absolute error function measured as the mean absolute error [MAE] was

$$MAE = \frac{1}{n}\sum_{n=1}^{n}|y-\hat{y}| = \frac{24.35}{49} = 0.4969$$

And expressing this in terms of percentage of the agricultural land resources quality index [LQI], the mean absolute percentage error [MAPE] was,

$$MAPE = \frac{100}{n}\sum_{n=1}^{n}|y-\hat{y}| = \frac{100\ x580.15}{160.05\ x49} = 7.4\%$$

This result further showed that the statistics of the error magnitudes were on the average 7.4% of the agricultural land quality index [LQI] predicted. This further suggested that 92.6%

of the random variables of LQI were explained. Therefore, the root mean squared error [RMSE] was thus measured and computed as

$$RMSE = \sqrt{\sum_{n=1}^{n} \frac{[y-\hat{y}]^2}{n}} = \sqrt{0.4140} = 0.6434$$

The MSE, MAE, MAPE and RMSE described the operational error forecasting system and these were compared to the performance of the chi-square statistics having the following error estimates:

$$MSE = \frac{1}{n}\sum_{n=1}^{n}[y-\hat{y}]^2 = \frac{21.6572}{49} = 0.442$$

Again, the mean absolute error was,

$$MAE = \frac{1}{n}\sum_{n=1}^{n}|y-\hat{y}| = \frac{25.52}{49} = 0.521$$

And the mean absolute percentage error [MAPE] was therefore,

$$MAPE = \frac{100}{n}\sum_{n=1}^{n}|y-\hat{y}| = \frac{100\ x25.52}{160.05\ x49} = \frac{2552}{7842.45} = 0.33\%$$

The MAPE of the Chi-Square showed a prediction that the error magnitude was on the average of 0.33% of the agricultural land quality index predicted. Further, the results of the root mean square error [RMSE] estimate was

$$RMSE = \sqrt{\sum_{n=1}^{n} \frac{[y-\hat{y}]^2}{n}} = \sqrt{0.442} = 0.665$$

However, the comparison of the criterion functions of the two forecasts generated a measure of the relative land quality [RLQ] of the predictions. Thus, this was expressed as,

$$\frac{MSE[1]}{MSE[2]} = \frac{0.4140}{0.442} = 0.94\ or\ 94\% \qquad \dots Eq[7]$$

The results showed that the original forecast had a mean squared error that was 94% that of the alternative Chi-Square. Therefore, any of the results can be used for decision making, since their ratio was approximately about one or unity. Table 3 provided the summary of the parameters estimated.

Table 3. Summary of The Error Forecasts and Other Parameters

Functions	MSE	MAE	MAPE	RMSE	Cal F-value	Tabular F-value
Chi-Square	0.442	0.521	0.33%	0.665	9.4004^{ns}	9.488
Original Forecast	0.414	0.497	7.4%	0.643	-	-

Source: Field data analysis 2017

Notes: ns = Not statistically significant at 5%

Table 3. Showed the parameter estimates of the error forecasts and the chi-square F-values. Given the characteristics of the problem, this evaluation provided the forecast performance of the two functions. The MSE, MAE, MAPE and RMSE generated salutary statistics that characterized the two competing operational error forecasting systems. Comparing the parameters through the four criteria, the function that yielded the least criteria statistics was adjudged to have better performance.

Hence, by each of the criterion, especially the MSE, MAE and RMSE, the original forecast outperformed the chi-square alternative function. However, the MAPE of the Chi-Square [0.33%] suggested that the Chi-Square performed more efficiently because the statistics of the error magnitude of the Chi-Square was on the average the least [0.33%] of the agricultural land resources quality index predicted. The comparison of the criterion functions of the predictions as shown in Eq [7] which measured the relative land resources quality [RLQ] predicted showed that the original forecast error had a mean square of 94% relative to the Chi-Square. This implied that the square root of the mean square error ratio was 0.9695 by which it takes to return to the original units of measurement. Therefore, this provided a measure of the extent to which the Chi-Square was superior to the original forecast.

Table 3. Further showed the results of the Chi-Square test of the null hypothesis and or the goodness of fit statistics that measured the deviation between the actual and expected agricultural land quality index among the five decades period [1970-1979, 1980-1989, 1990-1999, 2000-2009 and 2010-2019] under investigation. The observed F-Value, 9.4004^{ns} was less than the Tabular F-Value, 9.488 at 5% level of significance. Hence, the acceptance of the null hypothesis that there were no significant difference in agricultural land quality index in Nigeria among the five decade years. This further implied that the observed differences in agricultural land quality index from one decade to another were largely due to fluctuations in agricultural land quality index which could easily have occurred by chance. This suggested that in a simplified assumption, that the rate of agricultural land quality degradation was uniform in one direction across the Nigerian agricultural land resources from one decade to another. The agricultural land quality index movements [LQIM] were examined and the result was as shown in Fig.2.

ISSN: 2054-6319 (Print), 2054-6327(online)

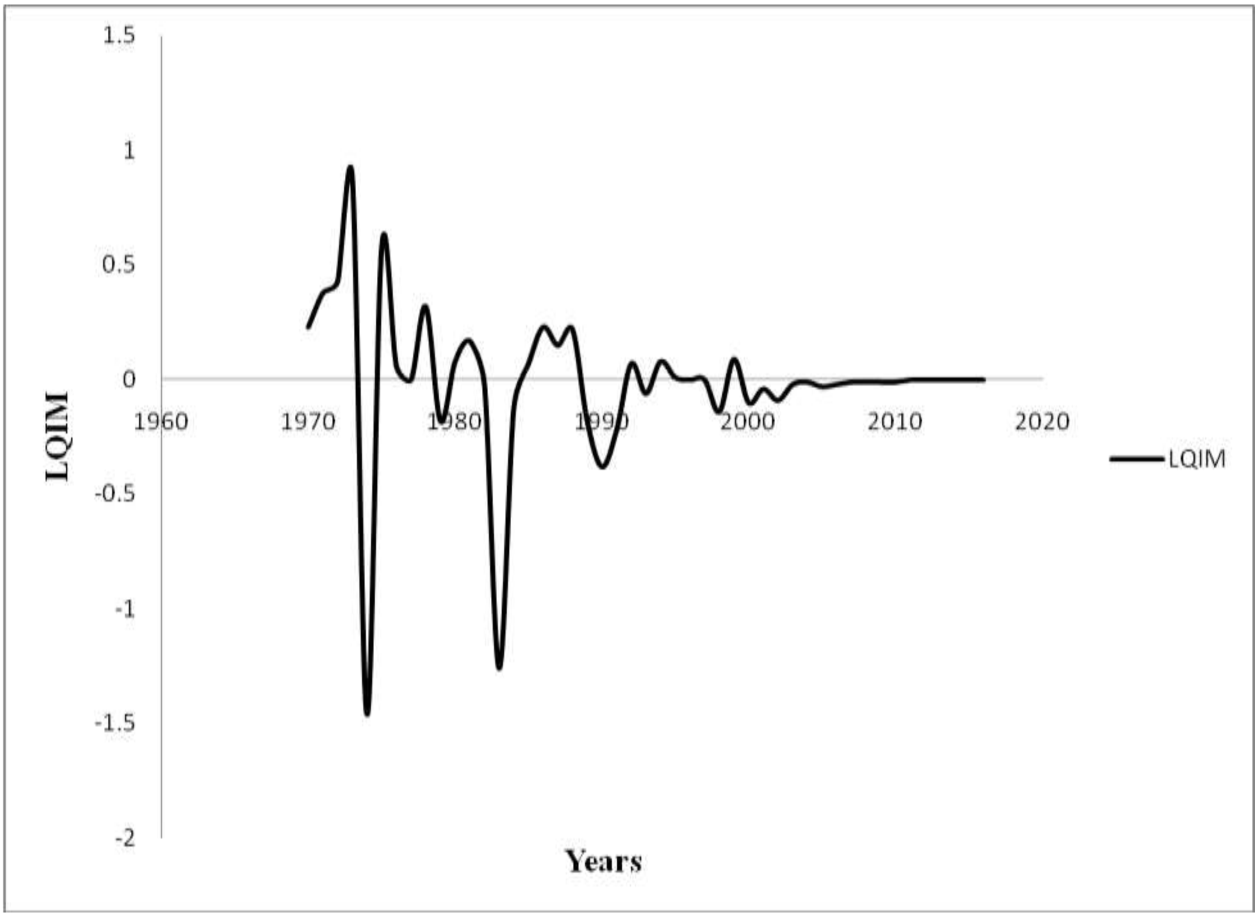

Fig.2 Agricultural Land Quality Index Movements.

Fig.2 showed the agricultural land quality index movement [LQIM] across the five decade periods. The highest positive amplitude of the LQIM was observed in 1973 leading to the observed highest agricultural land quality index [LQI] in 1974 as shown in Fig.1 and Fig.2 while the two peak periods of the highest negative amplitudes of the LQIM occurred at the close of 1974 and 1983 respectively. The LQIM fluctuated and finally remained constant from 2003 to 2016. Fig.3 showed a downward slope curve of the land degradation rate of change (LDRC).

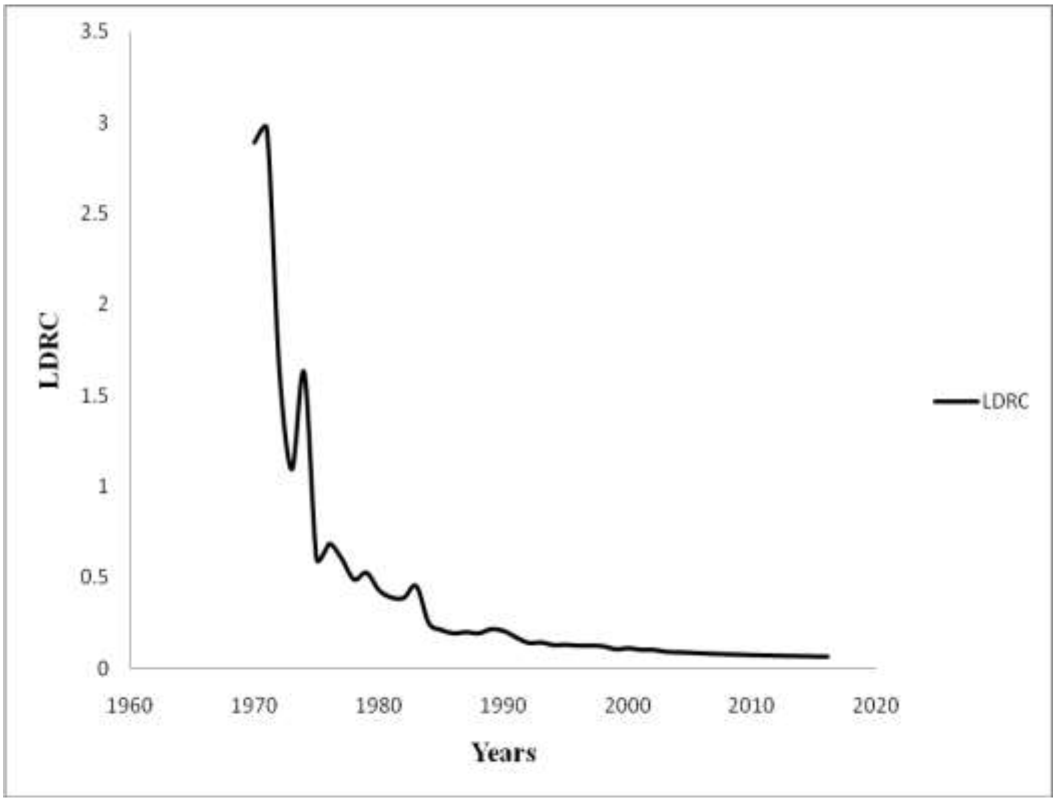

Fig.3 Agricultural Land Resources Degradation Rate of Change [LDRC].

Fig.3 showed the agricultural land resources degradation rate of change [LDRC]. The LDRC and the LQI were compared and the results were as shown in Table 4.

Table 4: Statistics of the Aggregate LQI and LDRC for Five Decades

Variables	Mean	Standard Deviation	Coefficient of Variation (%)
LQI	3.41	0.6029	17.68
LDRC	0.39795	0.6384	160.41

Source: Field data analysis 2017

Notes:

a. LQI = Land quality index.

b. LDRC = Land degradation rate of change.

The results in Table 4, showed that the agricultural land resources quality [LQI] was more consistent compared to the agricultural land resources degradation rate of change [LDRC]. That is, the variability of the land degradation rate of change was great compared to the land quality index. The observed greater variability of the LDRC was largely attributed to the volatility of the natural and human induced land quality degradation efforts (Emeasoba, 2012., George, 2010., Ian and Colin, 2002., Imasuen, Chokor and Orhue, 2015., james, 2007.,

ISSN: 2054-6319 (Print), 2054-6327(online)

Juma and Ojwang, 1996., Lawal, Omotesho and Adewumi, 2010., Nkeme and Ndaeyo, 2011., Osayande, Oviasogie, Orhne, Irhemu, Maidoh and Oseghe,2015.,Steven and John,2005).

SUMMARY

The results captured gave a true measure of the combined average changes in agricultural land resources quality in Nigeria. The highest average (4.006) and the least average (2.824) land quality index were observed in the periods 1970-1979 and 2010-2016 respectively. The results further showed that the land quality index remained about the same from 2010-2016 (Table 1 and Fig. 1). The variability of the land quality index was highly pronounced in the periods 1980-1989.However, there were no statistical significant difference in agricultural land quality index in Nigeria among the five decades period studied. Thus, the observed differences in arable land quality index largely occurred by chance. Again, the highest positive land quality index movement(LQIM)) was observed in 1973 while the two peak periods of negative amplitudes of arable land quality index movements were observed at the close of 1974 and 1983 respectively as shown in Fig.2 (Ozor and Umunnakwe,2014.,Ujah,Eboh,Nzeh and amaechi,2014). The results further suggested that Nigeria is currently experiencing consistent severe gradual land resources quality degradation that poses a long-term threat to the nation’s food supply, farmers’ income and rural households’ well-being. This perceived arable land deterioration across the nation created a highly pronounced widespread economic and social conundrum. Hence, there is urgent need to reverse the enigma using appropriate policy instruments and technologies that can guarantee a sustainable on-farm business in Nigeria.

CONCLUSIONS AND RECOMMENDATIONS.

These agricultural land and soil debasement assessments were intended to capture the extent by which the Nigerian arable lands degraded, which had far-reaching consequences on farmers’ crop outputs, income and economic well-being. The perceived results further suggested that huge public investments on agricultural land resources reclamation and rehabilitation were required to resolve the actual and potential land abasement in Nigeria (Ansel, Charles and Paul, 2006.,Paul,1991.,William,2011.,William and Alan,2008.,Yusuf,Odofin and Afolabi,2016).

There were needs to consistently employ modern advanced technology in remote sensing, modeling, mapping and characterization of Nigerian agricultural land use, vegetation and land quality evaluation. Advanced land use technology applications involving comprehensive baseline mapping and consistent interval monitoring is expected to generate balanced agricultural land conservation policies and techniques that can resolve adverse conflicting on-farm land use practices. Consequently, this practice will ensure a sustained increase in the capacity of the arable land to provide ecosystem goods and services over a reasonable period of time for the nation. Land quality improvement policies must be guided by long-term economic gains and on-farm cultural practices that promote the conservation of the agricultural land resources quality (Basudeb, 2013.,Frank,Peter,Sara and Jeremy(eds),2008.,John and Ronald,2003).

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ISSN: 2054-6319 (Print), 2054-6327(online)