FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

EVIDENCE-BASED SUSTAINABLE AGRICULTURAL DEVELOPMENT IN NIGERIA THROUGH ECONOMETRIC MODELLING OF CREDIBLE DATA

By

JOB NDA (kotsu-gbangba) NMADU
BSc, MSc, PhD (ABU), Dip.
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INAUGURAL LECTURE SERIES 45

14TH JULY, 2016

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Agriculture, Economics, Agricultural Economics

Agriculture is art and science of crop and livestock (including fisheries and micro-livestock) production and processing for the use of man (Nmadu & Amos, 2011) and it is the oldest profession of man dating back to the early post-creation era (Dake, 1991). Marketing, financing, and a host of support services are the integral part of successful agricultural activities (Nmadu & Amos, 2011). Agriculture has been the mainstay of Nigerian economy in spite of the huge oil revenues and indeed is the sector that will bring about sustainable development, poverty eradication, self-sufficiency and food security to Nigeria (Adamu & Idisi, 2014; Chukwunonso, 2014). As a science, agriculture is made up of a number of branches. These branches include the following:

* Crop Science, Plant Science
* Agronomy
* Animal Science
* Soil Science *and Land Management*
* Crop Protection
* Fisheries Study
* Agricultural Engineering
* Agricultural Economics
* Agricultural Extension
* Agricultural Education etc.
  (Nmadu & Amos, 2011)

Economics which is derived from two Greek words 'oikos' and 'nemein' meaning "household management" is a branch of the Social Sciences which deals with how people choose to use their limited resources (land, labour, capital and entrepreneurship/management[1]), which have alternative use, to produce, distribute, exchange and consume goods and services. Production of goods and services is only complete when what is produced gets to the ultimate consumer. Economics is the study of social behavior guiding in the allocation of scarce resources to meet the unlimited needs and desires of the individual members of a given society (O'Sullivan & Sheffrin, 1998).

Economics is a very wide and versatile subject and include the following branches:

* Microeconomics
* Macroeconomics
* Monetary economics
* Finance and banking
* International economics
* Applied economics
    * Agricultural Economics (Socio-economics)
        - Farm management
        - Production Economics
        - Econometrics
        - Agribusiness Management
        - Agricultural marketing
        - Price analysis
        - Resource Development
        - Agricultural policy
        - Agricultural finance
        - International Agriculture
    * Environmental economics
    * Resource Economics
    * Land economics
    * Development Economics etc.

(Nmadu & Amos, 2011)

Agricultural economics is a branch of agriculture and economics, which uses basic agricultural and economic principles to ensure optimum agricultural production. Farmers have scarce resources (land, labour, capital and entrepreneurship/management) and these resources have alternative uses. The Agricultural Economist therefore develops models and systems of alternative resource allocation to agricultural production and then advises the farmers appropriately. Agricultural economics also studies the interdependence between agriculture and the general economy as wells as foreign economies with a view to establishing superior resource allocation models for sustainable agricultural production. In

a bid to do all these, the agricultural economist tries to answer four basic questions:

i. What types of agricultural goods or service should be produced for the ultimate consumers,
ii. How the agricultural goods or service should be produced,
iii. How much of these agricultural goods or service should be produced, and
iv. For whom should these agricultural goods or service be produced?

(Nmadu & Amos, 2011; Reddy, Ram, Sastry, & Devi, 2010)

An Agricultural Economist is also referred to as a Socio-Economist because as part of the modelling process, we also relate the economic activity of the farmer to his social and cultural behaviour. For example, we often want to determine how a farmer's marriage status, educational achievement, gender, religious inclination, family status, his farm location, his mode of transportation to his farm etc. affects his farm performance and efficiency. The socio-economist carefully observes the farmer in his farm and settlement patterns and deduces how they could either impede or encourage his agricultural production activities as well as his performance and level of efficiency. (Nmadu & Amos, 2011; Amos & Nmadu, 2004; Nmadu & Marcus, 2013, Ajah & Nmadu, 2012; Nmadu & Nwawulu, 2015; Nmadu, Sallawu, & Omojeso, 2015).

Most people are often confused where to draw the dividing line between an Agricultural Economist and an Agricultural Extensionist. First, the two are not option of each other but are parallel lines of specialisation. Second, the Extensionist is mainly concerned about dissemination of research and other agricultural information to the farmers during which he undertakes to know farmers reaction and his ability and speed of accepting new ideas. Therefore, even though the two were always traditionally housed within a department, their line of specialisation is very much unique of each other (Kudi, Bako, & Atala, 2008; Amos & Nmadu, 2004; Nmadu & Marcus, 2013; Onemolease & Alakpa, 2009; Agwu & Akinnagbe, 2008; Genius, Koundouri, Nauges, & Tzouvelekas, 2013).

Development, sustainable development, development economics, development planning

Development (Kates, Parris, & Leiserowitz, 2005; Todaro & Smith, 2011) can be defined as the systematic use of scientific and technical knowledge to meet specific objectives or requirements. More specifically, it is the application or improvement of techniques and or technology to the production of new goods or services. Development takes quite a different meaning in different disciplines and has numerous synonyms. For example: improvement progress, advancement, broadening elaboration, evolution, deepening, growth, alteration, change, modification, maturing, expansion, enlargement just to mention a few.

Sustainable development (Kates *et al.*, 2005) on the other hand is the development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs. Sustainable development has three pillars: economic, social, environmental interacting symbiotically such that the systems continue to function optimally without loss of value as depicted in Fig. 1 (Hayati, Ranjbar, & Karami, 2010; Balasubramanian, 1971; Todaro & Smith, 2011).

Development planning is a multidimensional process which involves establishing nation's means of achieving the stated visions, missions, policies and programmes covering social, human, political, environmental, technological and other factors. It is sometimes used interchangeable with sustainable development (Ikeanyibe, 2009).

Development economics is a branch of economics which deals with economic aspects of the development process in low-income countries focusing on how to promote economic growth in such countries by improving factors like health, education, working conditions, domestic and international policies and market conditions. It examines both macroeconomic and microeconomic factors relating to the structure of a developing economy and how that economy can create effective domestic and international growth. Development economics seeks to

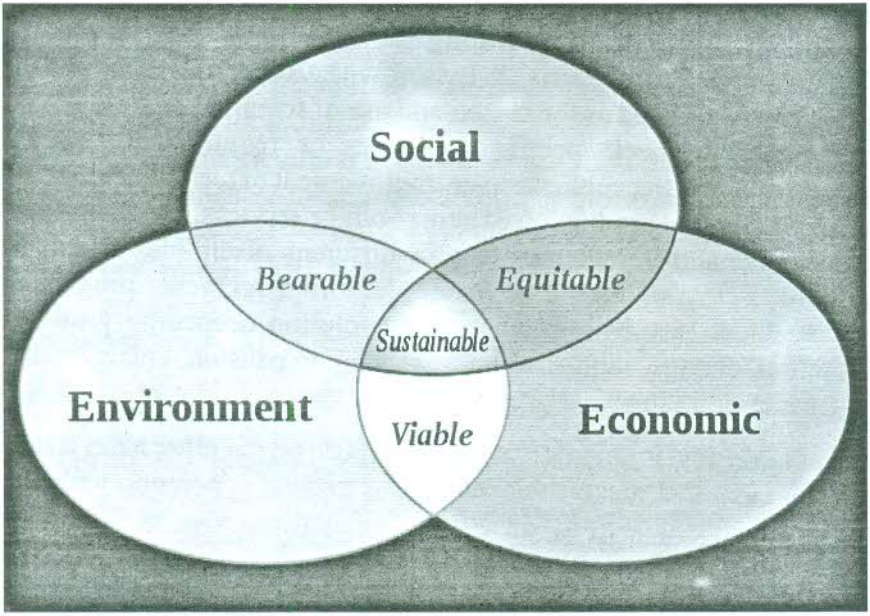


Fig. 1 Interactions between the dimensions of sustainability

determine how poor countries can be transformed into prosperous ones. Strategies for transforming a developing economy tend to be unique, because the social and political background of countries can vary dramatically (Balasubramanian, 1971; van Ittersum *et al.*, 2008; Chikwama, 2010; Dillon, Sharma, & Zhang, 2011; Karodia, 2014; Matunhu, 2013; Nelson, Lamboll, & Arendse, 2008; Oboh & Ekpebu, 2011; Subair, 2009; Tack & Aker, 2014).

From the foregoing, it can be seen clearly that Agricultural Economics and Development Economics are interwoven since the latter is about the development of agriculture from the current subsistence, low technology level to commercial, modern technology level that will bring about food security and remunerative prices thus higher income to farmers, which ultimately means the development of the economy.

Econometrics, econometric modelling

'Econo' 'metrics' or economic measurement is a branch of economics which uses the application of economic theory, mathematics (economics), and statistical inference on economic data to test and quantify economic theories and the solutions to economic problems and to obtain numerical results; or the quantitative analysis of actual economic phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference. Econometrics is a set of quantitative techniques that are useful for making "economic decisions". It involves the setting up of mathematical models (formulated so that its parameters can be estimated if one makes the assumption that the model is correct) describing economic relationships (such as that the quantity demanded of a good is dependent positively on income and negatively on price), testing the validity of such hypotheses and estimating the parameters in order to obtain a measure of the strengths of the influences of the different independent variables. Therefore, the Econometrician

- finds the set of assumptions that are both sufficiently specific and sufficiently realistic to allow him to take the best possible advantage of the data available to him
- helps in trying to dispel the poor public image of economics (quantitative or otherwise) as a subject in which empty boxes are opened by assuming the existence of can openers to reveal contents which any ten economists will interpret in 11 ways
- use the theory and technique of statistical inference as a bridge pier

(Umeh & Asogwa, 2011; Nmadu & Amos, 2011; Greene, n.d.; Greene, n.d.; Greene, 2003; Gujarati, 2004; Lancaster, 2004)

The summary of the methodology of econometrics and steps in estimation is presented on Fig. 2. Here is a recap of processes and procedures of econometrics:

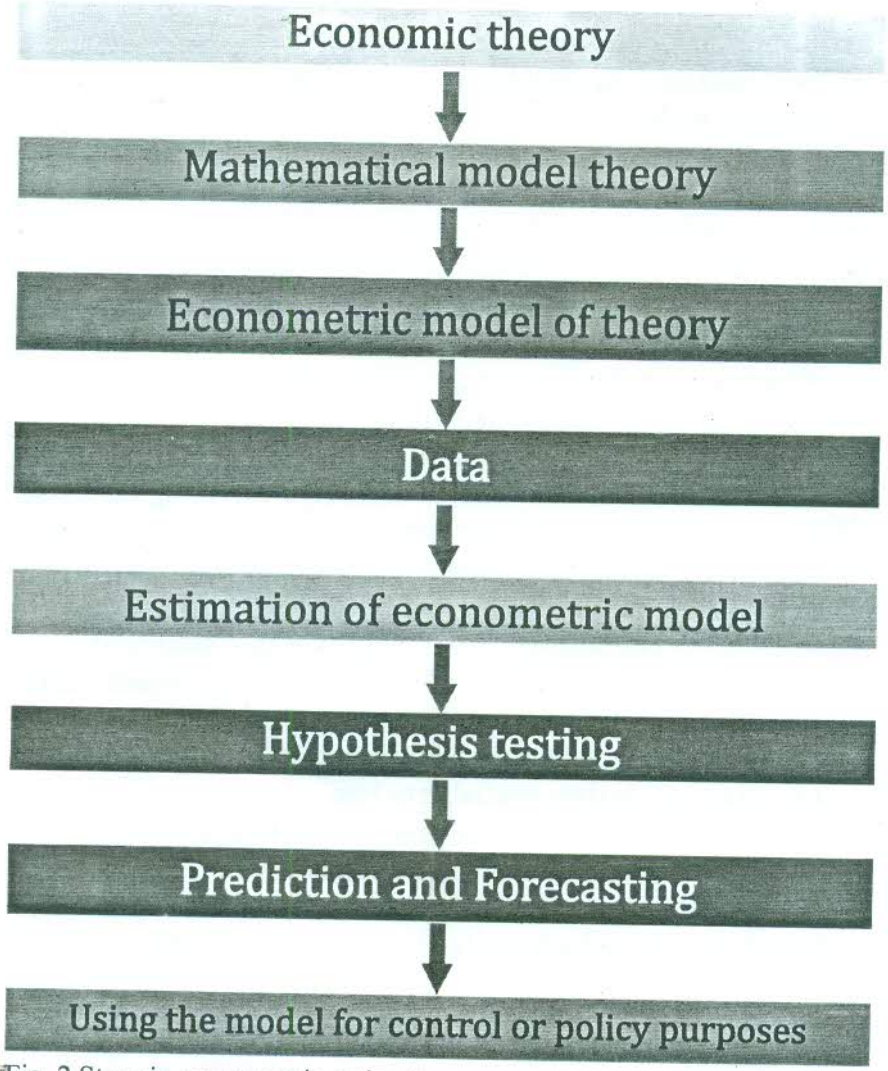


Fig. 2 Steps in econometric estimation

- formulating an economic model appropriate to the questions to be answered;
- reviewing the available statistical models and the assumptions underlying these models, and selecting the form most suitable for the problem at hand;

- **obtaining appropriate data, properly defined and matching the concepts of the economic model;**
- finding suitable computer software to enable the calculations necessary for estimating and testing the econometric model.

Econometrics is broadly divided into theoretical and applied and each of them sub-divided into Classical and Bayesian as shown on Fig. 3.

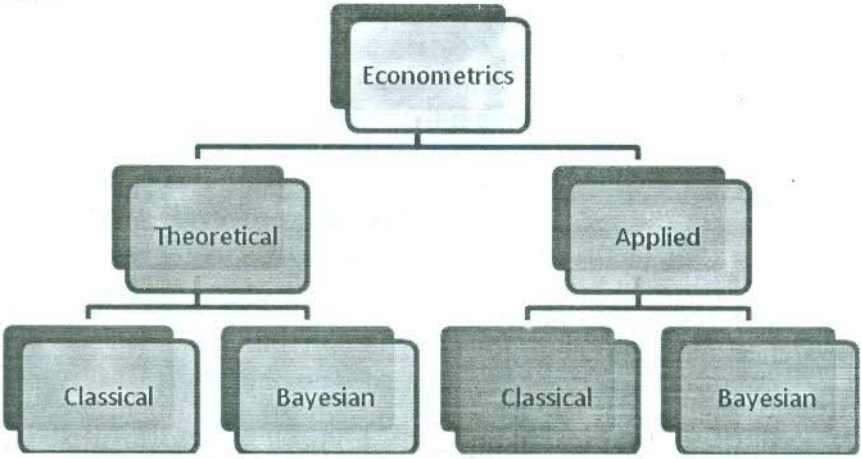


Fig. 3 Types of Econometrics

- Theoretical econometrics is concerned with the development of appropriate methods for measuring economic relationships specified by econometric models. In this aspect, econometrics leans heavily on mathematical statistics. Theoretical econometrics must spell out the assumptions of this method, its properties, and what happens to these properties when one or more of the assumptions of the method are not fulfilled
- Applied econometrics use the tools of theoretical econometrics to study some special field(s) of economics and business, such as the production function, investment function, demand and supply functions, portfolio theory
- Classical (or *frequentist*) methods concentrate on testing hypotheses that are derived from theory, using the data

available, frequentist believes that a population mean is real, but unknown, and unknowable, and can only be *estimated* from the data, knowing the distribution for the sample mean, the frequentist believes that a population mean is real, but unknown, and unknowable, and can only be *estimated* from the data and thereafter constructs a **confidence interval**, centered at the sample mean

- *Bayesian* econometrics (and statistics), on the other hand, stresses the role of the data itself in both development and testing of economic theories, He believes that only the data are real. The population mean is an abstraction, and as such some values are more believable than others based on the data and their prior beliefs. (Sometimes the prior belief is very non-informative, however.) proposes a subjective interpretation of statistics, Bayesian constructs a **credible interval**, centred near the sample mean.

The main tools for carrying out econometric estimations are correlation and regression. However, the correlation estimates are not very strongly relied upon because it does not encompass 'cause and effect'. A correlation estimate gives in indication of the magnitude (positive or negative) of relationship between a set of economic data but does not give any indication of the direction of the relationship. The only consolation is that it can be used to detect problems in the data before further detailed analysis is carried out. The basic formula for calculating correlation coefficients is given in equation (1).

$$r_{X_iX_j} = \frac{\Sigma[(X]_i - \overline{X_i})(X_j - \overline{X_j})}{\sqrt{[(X]_i - \overline{X_i})^2 (X_j - \overline{X_j})^2}} \qquad (1)$$

Where $r_{X_iX_j}$ = correlation coefficient between X_i, X_j for all $i \neq j$, for $i = j$, the coefficient = 1. X_i and X_j are parameters.

Regression analysis is concerned with the study of the dependence of one variable, the dependent variable, on one or more other variables,

the explanatory variables, with a view to estimating and/or predicting the (population) mean or average value of the former in terms of the known or fixed (in repeated sampling) values of the latter. The general purpose of multiple regression analysis is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable. Multiple regression is used to account for (predict) the variance in an interval dependent, based on linear combinations of interval, dichotomous, or dummy independent variables. Multiple regression can establish that a set of independent variables which explains a proportion of the variance in a dependent variable at a significant level, and can establish the relative predictive importance of the independent variables. Power terms can be added as independent variables to explore curvilinear effects. Cross-product terms can be added as independent variables to explore interaction effects. Using hierarchical regression, one can see how variance in the dependent can be explained by one or a set of new independent variables, over and above that explained by an earlier set. Of course, the estimates can be used to construct a prediction equation and generate predicted scores on a variable for further analysis. Regression can be simple (i.e. with only one independent variable) or multiple (more than one independent variables). The regression can be exact or non-stochastic or deterministic or mathematical (when no error term is 'introduced') or statistical or stochastic (when an error term is 'introduced'). Regression model can be full or limited. The regression model is presented in equation (2).

$$Y_i = \alpha + \beta_1 X_{1,i} + \beta_2 X_{2,i} + \ldots\ldots\ldots\ldots + \beta_m X_{m,n} + U_i \quad (2)$$

Where Y_i=Dependent (Explained, Predictand, Regressand, Response, Endogenous, Outcome, Controlled) variable

$X_j - X_m$ = Explanatory (Independent, Predictor, Regressor, Stimulus, Exogenous, Covariate, Control) variables

α= constant or intercept term

β_j = coefficients (slope, partial slope)

n = sample size

m = number of explanatory variables

U_i = error (disturbance, noise, stochastic, random) term

In the estimation process, α, β_j, U_i are the parameters estimated while

Y_i, $X_j - X_m$ are the data supplied by the econometrician. There are a number of regression models some of which are listed below:

- Linear regression (simple, multiple)
- Binary (linear probability model, logit, probit, tobit) regression
- Categorical regression (e.g. multinominal logit model)
- Beta regression
- Quantile regression
- Stochastic frontier regression
- Time series regression/econometrics
- Two-stage least square regression
- Adaptive expectation model
- Partial adjustment model
- Instrumental variables regression
- Dogit Ordered Generalized Extreme Value (DOGEV) regression
- Grafted or spline regression etc.

The type of regression also determines the estimation procedures. The following estimation procedures exist:

- Ordinary least squares (OLS) estimation
- Maximum likelihood estimation (MLE)
- Weighted least squares (WLS) estimation
- Instrumental variables estimation
- Two-stage least squares estimation
- Non-linear estimation – iteration method etc.

(Nmadu, 2000; Nmadu, 2010; Nmadu, Olukosi, Amos, & Musa, 2004; Nmadu & Amos, 2003; Nmadu, Yisa, & Mohammed, 2009; Greene, 2003; Gujarati, 2004; Lancaster, 2004)

Applications of regression analysis exist in almost every field: economics, political science, sociology, psychology, education, the social and natural sciences, medicine, environmental studies etc.

If you observe critically the econometric process, only two of the steps are not very much under the control of the econometrician i.e. data and policy control.

Econometric modelling is the act of building a model for a particular

situation or some economic systems. The modeler, using his skills and knowledge of Economics, Mathematics and Statistics and bearing in mind the 'potentially' available data; lays the foundation of the model and step by step put the model in place. The model can be as simple as containing an explanatory variable, with only one dependent variable and can be as complex as containing several dependent variables and hundreds of explanatory variables. According to Burfisher, (2011)

> *When an economist wants to study the economic behaviour observed in the complex world around us, the first step is often to build an economic model. A model can focus an analysis by stripping down and simplifying real world events into a representation of the motivations of the key players in any economic story. Some amount of context and interesting detail must be left out as the economist distils a model rich enough to explain events credibly and realistically, but simple enough to put the spotlight on the essential actions in the story. When an economist succeeds in building a model, he or she now has a tool that can be manipulated. By playing with this "toy" representation of economic activity, the economist can learn more about the fundamentals behind an event and can study likely outcomes or possible solutions.*

For example, the Table 1 is the output of such a model.

It must be noted that the trend and focus of econometric modelling has shifted from isolated factors or enterprise modelling to sectorial or countrywide modelling of the economic activities and or systems. For example, instead of modelling economic activities of small scale farmers producing maize or any other crop in say, Lavun Local Government Area of Niger State; the current trend is to model countrywide agricultural supply and demand of all crops. This modelling is in the class of computable general equilibrium (CGE) models for which most Nigerian economists, econometricians or researchers lack the skills to develop. This essentially calls for

Table 1: Determinants of poverty status among farmers in Niger and Kogi States

Poverty categories	Y	Extremely poor	Moderately poor	Non poor
State of the household decision maker (Niger=1, Kogi=0)	X1	-41.0119	22.26945	18.74245
			12167.19	2512.688
LGA of the household decision maker (edati=1, others=0)	X2	9.155809	0.849711	-10.00552*
			0.914269	4.413076
LGA of the household decision maker (lavun=1, others=0)	X3	12.10499	-0.20867	-11.89632*
			0.870326	5.32575
LGA of the household decision maker (gbako=1, others=0)	X4	19.00791	-1.07776	-17.93015**
			0.970592	6.555265
LGA of the household decision maker (Bosso=1, others=0)	X5	29.61135	-0.69595	-28.9154**
			1.051714	11.56731
LGA of the household decision maker (paikoro=1, others=0)	X6	13.65439	0.41027	-14.06466*
			0.980475	6.197396
LGA of the household decision maker (gurara=1, others=0)	X7	-12.6919	1.236413	11.4555*
			1.00595	4.864462
LGA of the household decision maker (wushishi=1, others=0)	X8	26.5831	0.219442	-26.8025
			0.881247	2500.698
LGA of the household decision maker (mariga=1, others=0)	X9	-14.3926	3.99363***	10.39894**
			1.443623	3.834182
LGA of th e household decision maker (okene=1, others=0)	X11	-20.0658	16.7109	3.354862
			12167.19	6057.052
LGA of the household decision maker (ijumu=1, others=0)	X12	206.8456	-13.2741	-193.572
			12430.67	3543.079
Age of the household decision maker in years	X15	0.008513	0.020899	-0.02941
			0.025774	0.117485
Gender of the decision maker (Male=1, female=0)	X16	14.34073	-0.18456	-14.1562
			1.071717	15.64212
Marital status of the decision maker (Single=1, others=0)	X18	-18.317	-1.12984	19.44687
			2.702041	8029.274
Marital st atus of the decision maker (Married=1, others=0)	X19	-34.4126	1.319344	33.09324
			2.247733	3885.759
Marital status of the decision maker (Divorce=1, others=0)	X21	-9.5173	-15.6434	25.16074
			13807.82	16812.98
Marital status of the decision maker (Separated=1, others=0)	X22	-30.1136	-13.2227	43.3363
			48986.39	66051.57
Number of male members of the family	X23	0.853676	0.197187	-1.05086
			0.199955	0.998329
Number of female members of the family	X24	2.699281	0.067519	-2.7668*
			0.208141	1.23387
Number of other depe ndents in the family	X25	2.570505	0.185543	-2.756048*
			0.152399	1.255519
Highest educational qualification (Primary=1, others=0)	X26	4.323565	1.081585	-5.40515*
			0.756989	2.808708
Highest educational qualification (secondary=1, others=0)	X27	5.449142	1.32024*	-6.769382*
			0.721586	3.103463
Highest educational qualification (polytechnic=1, others=0)	X28	-7.89545	0.123144	7.772301*
			0.938066	4.151713

Poverty categories	Y	Extremely poor	Moderately poor	Non poor
Highest educational qualification (College of Education=1, others=0)	X29	-14.3567	1.178581 1.186936	13.17812* 5.643476
Highest educational qualification (College of Health Technology=1, others=0)	X31	-7.05923	-8.28121 5951.224	15.34044 5882.474
Highest educational qualification (College of Agriculture=1, others=0)	X32	4.434053	-1.18837 1.437459	-3.24568 3.187421
Highest educational qualification (university=1, others=0)	X33	-5.18114	-0.67232 1.292854	5.853451 3.75519
Highest educational qualification (adult education=1, others=0)	X35	-60.739	26.07216 27303.17	34.66686 27303.18
Highest educational qualification (Quaranic education=1, others=0)	X36	12.85238	0.911009 0.83924	-13.76339*** 4.712586
Highest educational qualification (in-service training=1, others=0)	X37	-24.9025	8.719025 12385.4	16.18344 12343.04
Membership of farmers organisations (yes=1,no=0)	X40	4.38083	0.466634 0.526675	-4.847464* 2.273391
Major occupation of the decision maker (farming=1, others=0)	X41	4.619446	-0.23397 0.551422	-4.385479* 2.102813
other occupations of the decision maker (other occupations=1, farming=0)	X42	-13.1661	-0.05747 0.545885	13.2236* 5.335903
Number of plots of farm lands	X43	-1.43147	0.1105 0.212021	1.320965* 0.63901
Size of Plot 1 in ha	X44	0.030742	-.8712435** 0.347112	0.840502 1.1625
Size of Plot 2 in ha	X45	0.542386	0.302288 0.351589	-0.84467 1.014292
Size of Plot 3 in ha	X46	1.326698	1.341369 1.153529	-2.66807 3.012554
Size of Plot 4 in ha	X47	91.92013	-94.1417 52709.95	2.221553 62264.78
Size of Plot 5 in ha	X48	-85.6259	87.89531 254432.1	-2.26941 138682.4
Method of acquisition of plot 1 (Inheritance = 1, others=0)	X49	-2.22201	0.157617 0.838494	2.064398 3.027951
Method of acquisition of plot 2 (Inheritance = 1, others=0)	X50	12.46317	-0.09016 0.60462	-12.37301** 4.918329
Method of acquisition of plot 3 (Inheritance = 1, others=0)	X51	-6.44709	4.794043 3.52056	1.653049 5.886513
Method of acquisition of plot 4 (Inheritance = 1, others=0)	X52	-31.0326	0.932546 1.424757	30.10003*** 10.54597
Method of acquisition of plot 5 (Inheritance = 1, others=0)	X53	10.21985	-3.65823* 1.762828	-6.56162 14.74941
Distance from settlement to plot 1 in km	X54	-2.11989	.3404913*** 0.122553	1.779394*** 0.604335

Poverty categories	Y	Extremely poor	Moderately poor	Non poor
Distance from settlement to plot 1 in km	X55	-0.16062	0.178617	-0.018
			0.216774	0.441586
Distance from settlement to plot 1 in km	X56	-0.1353	-0.54457	0.679871
			0.587017	0.77654
Distance from settlement to plot 1 in km	X57	12.01951	-2.16545	-9.85405
			2136.024	10735.83
Distance from settlement to plot 1 in km	X58	-31.8727	10.2123	21.66037
			8838.545	13140.29
Distance from plot to Market in km	X59	0.598068	-0.00224	-.5958276*
			0.061598	0.303032
Distance from plot to Market in km	X60	-0.65595	-0.06275	.7187005**
			0.086262	0.273983
Distance from plot to Market in km	X61	-0.05638	-0.3686	0.424973
			0.265712	0.599895
Distance from plot to Market in km	X62	-4.54591	3.18648	1.359432
			2566.521	4188.46
Nature of access road to plot 1 (Motorable all season = 1, Others=0)	X64	6.208551	0.048987	-6.257538*
			0.578118	3.465419
Nature of access road to plot 2 (Motorable all season = 1, Others=0)	X65	0.040747	-0.66852	0.627768
			0.574132	2.145624
Nature of access road to plot 3 (Motorable all season = 1, Others=0)	X66	0.138946	-0.89015	0.751207
			1.252261	2.721557
Nature of access road to plot 4 (Motorable all season = 1, Others=0)	X67	-50.9839	25.65707	25.32686
			24684.07	24684.07
Nature of acc ess road to plot 5 (Motorable all season = 1, Others=0)	X68	42.87858	-9.99264	-32.8859
			29293.64	58713.62
Amount of family labour used in man-days	X69	-0.09165	.0074443*	.0842081***
			0.003271	0.026713
Amount of communal labour utilised in man-days	X71	0.053051	.0144114*	-.0674628*
			0.00761	0.031122
Cost of agro-chemicals in Naira	X72	-0.23064	.1304837***	0.100161
			0.038654	0.065175
Cost of Fertilizer in Naira	X73	0.162023	0.058806	-0.22083
			0.075315	0.289601
Cost of yam stakes in Naira	X75	1.179392	0.186953	-1.36634
			0.420659	1096.128
Amount of equity capital in the enterprise	X76	-0.04748	-0.00043	.0479112***
			0.003079	0.014709
Total farm size in ha	X78	-2.17439	-0.12791	2.302309*
			0.137684	1.087362
Constant		107.0335	-27.9422	-79.0913
			12167.19	4627.39

Source: (Nmadu, Harris, Yisa, Simpa & Sallawu, 2016)

capacity building in this area and a review of the curriculum for training econometricians in Nigeria.

Data, data gathering in Nigeria

Data (also sometimes called variable) is any collected fact from which information is obtained after processing. There are basically two types of data (primary and secondary) defined mainly by the source. Data collected from primary source are those originally collected by the researcher from the origin of the data like field experiments, farmers or farmers' fields, markets, laboratory, sample population, observations etc.

Primary data can be collected through the use of experimental records, farm records, observations, interviews, questionnaires and other means (Andor & Hesse, 2012). Data collected from secondary sources are those that have been collected and kept by someone else or an agency. The secondary sources may be published or unpublished such as

- International and United Nations Agencies e.g. FAO, UNESCO, World Bank, IMF, IITA, etc.
- Government institutions and agencies e.g. CBN, Agricultural Research Institutes, Government Ministries, Parastatals and Agencies (MDAs), National Bureau of Statistics, States' Agricultural Development Project Offices, etc.
- Non-Governmental Organizations (NGOs).
- Published data are those that have been circulated through the acceptable medium. This medium includes Journals, Book of Readings, Conferences, Seminars and Workshops, Textbooks, Magazines and Newspapers, Annual or other forms of reports etc.

Data measurement scales

Measurement scales are simply ways to categorise different types of variables (or types of data) attributed to Stanley Stevens (Stevens, 1946; Anonymous, My Market Research Methods, 2015) and best understood with example. There are four scales namely *nominal* which gives "name," or label to the data; *ordinal* which give

information about the order of choices of the data; *interval* which provide order of values and the ability to quantify the difference between each one; and *ratio* which give order, interval values, plus the ability to calculate ratios since a "true zero" can be defined. Below are the full details of their properties and some examples.

- Nominal or categorical scale
    - data categories are mutually exclusive;
    - data categories have no logical order
    - Categorical data is normally analysed using counting, cross-tabulation into contingency tables and using nonparametric analysis like Chi-square (χ^2) analysis
    - Examples include Gender (male or female), Religion (Islam, Christian, African, Asian etc.), educational level (primary, secondary, tertiary, adult education, Quranic, etc.).

- Ordinal Scale
    - data categories are mutually exclusive;
    - data categories have some logical order;
    - data categories are scaled according to the amount of the particular characteristic they possess
    - Ordinal data can be ranked in ascending or descending order and only nonparametric analysis can be performed with it.
    - Example is the widely used likert-type variable i.e. very likely, likely, not sure, not likely, not very likely or very happy, happy, neutral, unhappy, very unhappy.

- Interval scale
    - data categories are mutually exclusive;
    - data categories have some logical order;
    - data categories are scaled according to the amount of the particular characteristic they possess
    - equal differences in the characteristic are represented by equal distances on the scale
    - zero point is just another point on the scale
    - Arithmetic operations such as addition, multiplication,

division etc. can be performed on interval data hence parametric analysis is allowed such as calculation of means, variances and standard deviation.

- Good examples include temperature, number of extension visits/contacts, number of houses, household size etc.

- Ratio scale
  - data categories are mutually exclusive;
  - data categories have some logical order;
  - data categories are scaled according to the amount of the particular characteristic they possess
  - equal differences in the characteristic are represented by equal distances on the scale
  - zero point represents total absence of the characteristic measured
  - Operations with interval scale are the same with that of interval data. If the data is of ratio scale (continuous variable), the test is conducted around the central tendencies, principally the mean through the use of t test for significance. If the data is categorical or nominal, the discrete values are used to test for independence through the use of χ^2. The t, F-ratio and χ^2 are called test statistics.
  - Examples include height, weight, age, income, etc.

The various mathematical operations that can be performed on the various scales are provided on Table 2.

For a particular fact or information to become a data for econometric analysis, it goes through certain processes. First it is collected using the most appropriate statistical design and entered into the appropriate item in the collection instrument.

Then it is coded and then converted into digital formats (*often into any of the spread sheets software: Lotus 123, Supercalc, Ms-Excel, Quattro Pro etc.*) that will make it available for the software to be used for the econometric analysis. Then the data is 'cleaned' and then 'mined' to obtain information from the bulk indicating what the data is

which will assist in the detailed analysis. It is when all the errors and observed anomalies in the data are corrected satisfactorily that the data becomes credible and econometric analysis commences.

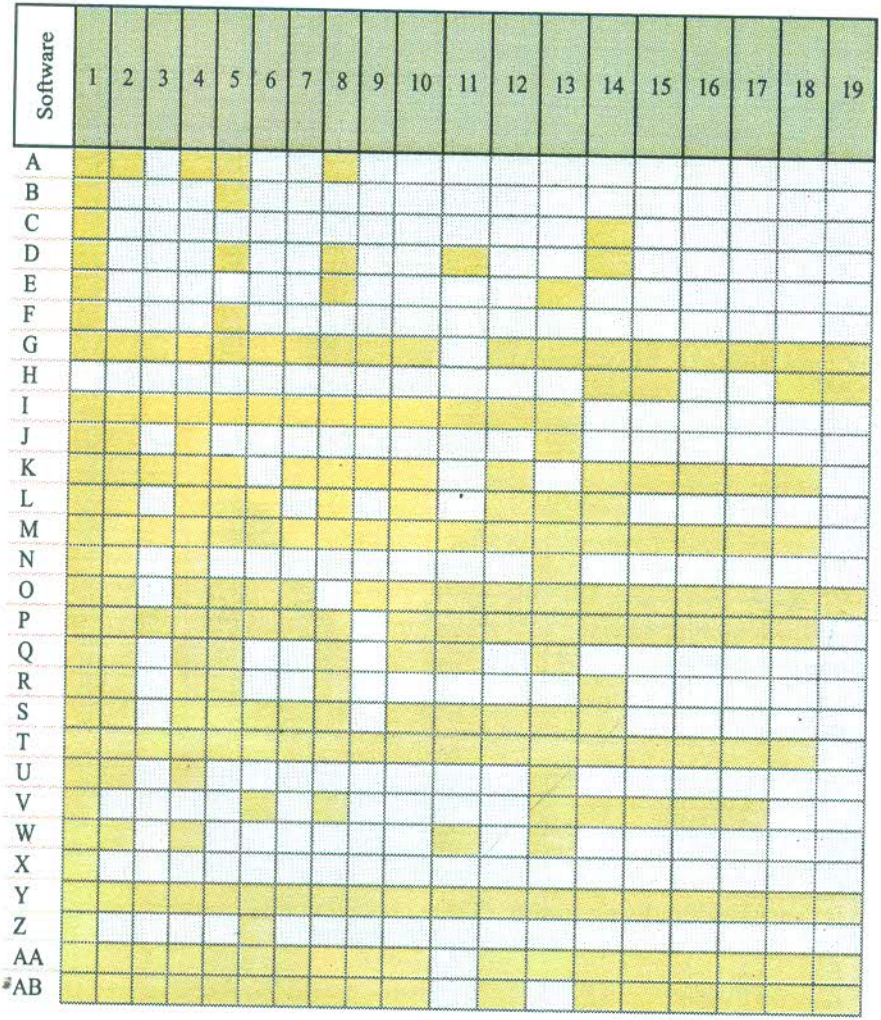
Table 2: Data scales and their various mathematical operations

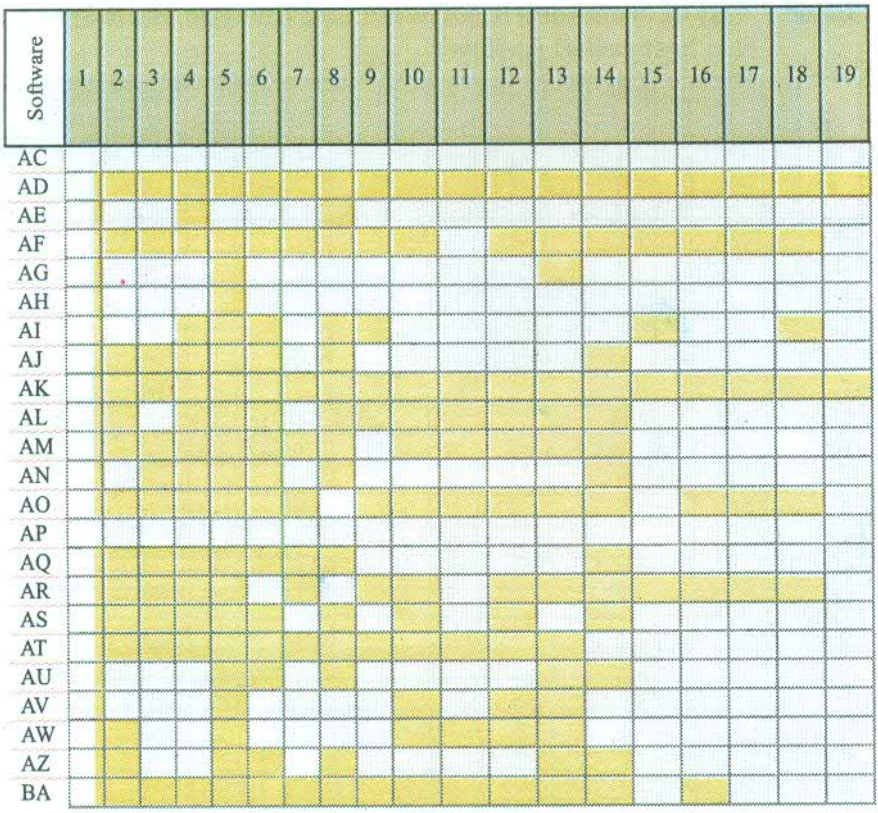
Operation on data	Nominal	Ordinal	Interval	Ratio
Count or frequency distribution				
Mean, Mode				
Order is known				
Can quantify the difference between each value				
Can add or subtract values				
Can multiply or divide values				

There is quite a number of econometric software available for analysis. The choice of which to use depends on a number of factors, including the type of analysis to be undertaken, availability of the software, the capability of the software and other considerations. Presented on Table 3 is a list of commonly available software (Anonymous, American Statistical Association, 2015) and their capabilities.

The process of data collection in Nigeria can be best described as unorganised, uncoordinated and unreliable. In most cases, data is collected only when there is something at stake – grants, academic degrees and a host of other reasons. Data is demand-driven and not supply-driven in Nigeria. Most of the times, there is no commitment on the part of those 'instructed' to collect data. Because of the above-mentioned constraints, most econometric analyses carried out with Nigerian-generated data are not always accepted by top agricultural and econometric journals and or conferences around the world.

Table 3 List of econometric software and the type of analysis it is best suited (yellow)





Key	Software	Key	Econometric Analysis
A	ADaMSoft	1	Ordinary Least Squares (OLS)
B	Analyse-it	2	Weighted Least Squares (WLS)
C	Autobox	3	Two-Stage Least Squares (2SLS)
D	BMDP	4	Non-Linear Least Squares (NLLS)
E	Brightstat	5	Logistic Regression
F	Epi Info	6	General Linear Model (GLM)
G	EViews	7	Least Absolute Deviation (LAD)
H	GAUSS	8	Stepwise Regression
I	GenStat	9	Quantile Regression
J	GraphPad Prism	10	Probit Regression
K	gretl	11	Cox Regression
L	JMP	12	Poisson Regression
M	LIMDEP	13	Multiple Linear Regression (MLR)
N	Maple	14	Autoregressive integrated moving average (ARIMA)

Key	Software	Key	Econometric Analysis
O	Mathematica	15	Generalized Autoregressive Conditional Heteroskedasticity (GARCH)
P	MATLAB+Statistics Toolbox	16	Unit root test
Q	MedCalc	17	Cointegration test
R	Minitab	18	Vector Auto -Regression (VAR)
S	NCSS	19	Multivariate GARCH
T	NLOGIT		
U	NMath Stats	AF	SHAZAM
V	NumXL	AG	SigmaXL
W	Origin	AH	SOCR
X	PSPP	AI	SPlus
Y	R	AJ	SPSS
Z	R Commander	AK	Stata
AA	RATS	AL	Statgraphics
AB	Sage	AM	Statistica
AC	Salstat	AN	StatPlus
AD	SAS	AO	Statsmodels
AE	SciPy		

The implication of using not very correct data to carry out econometric analysis with a view to advance agricultural development in Nigeria is that most of the policy prescriptions are also faulty. And where policy implications are not appropriate, then there can be no development, let alone sustainable development. According to (Menker, 2015):

> *Reliable data is the answer to Africa's $1 trillion agriculture opportunity. It is a truth universally acknowledged that access to reliable data in Africa is a massive challenge. We sit at this interesting intersection between engineering big data design and domain expertise. (There is need) to create data products that a multitude of users – from governments, to the private sector – can use seamlessly. To create efficient agriculture markets, you need high quality data. To increase capital flows in agricultural markets you need really good data, a common language. Part of the challenge the sector is facing, particularly in Africa, is*

that there is information asymmetry when it comes to agriculture. Only a few people in the market have the kind of data that can allow for a better trading relationship between the producer and the market. On top of that there exists little common language to overcome the disconnect. A classification system has been designed where any form of information that has to do with agriculture can map to our classification system so users can match to comparable sets of data.

In a similar vein (Gaye, 2015) asserted that high-quality data are critical to measure progress in growing the economy, reducing poverty and fostering shared prosperity. In addition, the World Bank (Anonymous, The World Bank, 2015) also pointed out that:

> *Despite the huge potential for agriculture on the continent, the sector has not grown as fast. In the 1980s, agricultural GDP growth in sub-Saharan Africa was 2.3% per year. Between 2000-2005 that only increased to 3.8% per year. Part of the reason for this is that the market information available is too fragmented to provide a coherent sense of the state of the sector. If you went to ministries of agriculture in Kenya, Brazil and the US everybody has their own way classifying data. But the potential for growth is there. At the moment the size of continent's agricultural market stands at a little over $300 billion. By 2030, it can grow to a $1 trillion.*

From the above assertions, there is a clear reason why it is difficult to provide information on critical economic indices and in particular secure empirical answers to the following questions by even from those who are expected to know, I inclusive:

i. What per cent of the Nigerian population are fully or partially involved in agriculture?
ii. What is the average farm holdings/size of large-scale, medium-scale and small-scale farmers at farm-level, district, local, zone, state and national levels in Nigeria?
iii. What is the livestock population in Nigeria?

iv. What is the farm income of large-scale, medium-scale and small-scale farmers at farm-level, district, local, zone, state and national levels in Nigeria?
v. What is the poverty rate at farm-level, district, local, zone, state and national levels for the various strata of the Nigerian population?

Etc.

In all the previous agricultural development policies, projects and programmes, no attention has ever being paid to the issue of data management system that will enhance sustainable agricultural development in Nigeria. Sustainable development starts from establishing numbers and targets based on population growth and welfare status and then tasking physical and other social scientists to develop products that meet the numbers and targets. Those numbers and targets cannot be established without proper analysis and proper analysis is not possible without credible data (Ajulor, 2013; Umoh, Jacob, & Chuku, 2012).

In my own view, the issue of data generation is a revenue-generating venture and expected to provide gainful employment to as many Nigerian graduates that is willing to key into my proposed data gathering pyramid as show in Fig. 4. In this pyramid, data collection only takes place at the lowest level and if we propose that one graduate should be put in-charge of each village area, while an officer each is in charge at the district, local government, zone, state, regional and national levels, then quite a number of our unemployed youths will be gainfully employed.

The good thing about this proposal is that each person can earn his or her salary from the sales of these data. The cost of collecting and managing the data can be further reduced if the collection at the village level is integrated with the one year national service i.e. NYSC and the issue of continuity and transition from one group to another will not jeopardise the structure. On the other hand, individuals can go into data collection as a vocation and earn a living out of it. The management of the data does not require elaborate infrastructural facilities; the data would be stored virtually especially

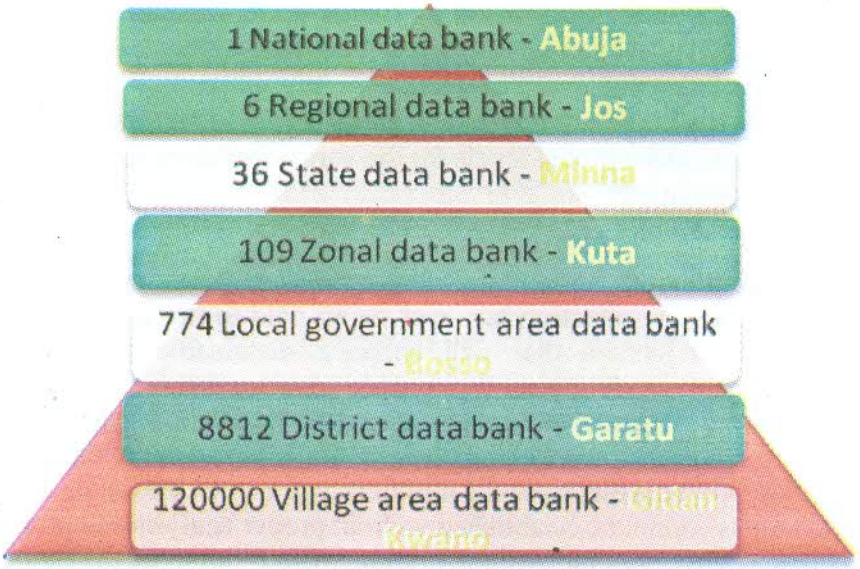


Fig. 4 Proposed data management structure for Nigeria

with recent technology of cloud storage. The storage infrastructure can be created by the universities in each state and probably coordinated at the national level by the National Bureau of Statistics. However, there is need to put in place the laws, level-playing ground and the enabling environment for private data collection and distribution to ensure that the data so distributed is 'clean', standardised and follows certain laid down procedures; and so as not to discourage any individual or groups interested in this type of business.

The above data management system will ensure that credible data is available and as much as possible every available data should be collected so that research themes would not have to be modified for lack of data and our research system will become more robust and effective in bringing about sustainable development. It will also facilitate the transition from modelling of isolated factors or farmers or enterprises to the state-wide or nationwide modelling i.e. CGE. If this system becomes operational, then our final year degree students, as well as masters and doctoral students will not have to generate their

own data except where the research is experimental.

Contributions to econometric modelling

Statistical and econometric software

Before the advent of Windows Operating System (WOS), software for analysis was not as available as they are now. So with the use of Disk Operating System (DOS) after obtaining a Diploma in Data Processing and Computer Programming, I developed a number of BASIC programs that were helpful for my future econometric analysis. The software include

i. Regression analysis (Nmadu & Okolobah, 1998)
ii. Linear programming (Nmadu, 2000a)
iii. Farm planning (asset depreciation and valuation) (Nmadu, 1999)
iv. Whole farm enterprise analysis and evaluation (Nmadu, Amos, Alade, & Fesojaiye, 2002)
v. Basic statistics (Nmadu, Alade, & Fesojaiye, 2003; Nmadu, Fesojaiye, & Alade, 2003)
vi. Project appraisal analysis and net worth (Nmadu, 1997a, 1997b)

This group of software became 'extinct' with the advent of Visual BASIC and all efforts I made to upgrade myself to the new platform proved very difficult. Of course today, there are varieties of software as enumerated earlier. The output from the software is comparable to any commercial one.

Jobian coefficient for estimating farmers forecast errors

The major challenge facing farmers annually is the ability to properly predict produce prices at harvest time while investing in production at planting time often leading to the so-called *cobweb* problem (Nmadu, Ajiyelitsoya, & Sallawu, 2013; Nmadu & Amos, 2011). The key characteristics of agricultural production and marketing processes are:

i. The duration between time of planting and time of harvesting is very long which makes prediction of prices difficult,
ii. There is always abundance at harvest forcing prices downward while scarcity persist while investment is on,

iii. Marketing of agricultural produce is beset with low technology like low storage capacity and technology, inadequate transportation infrastructure, low processing capability and technology leading to substantial losses after harvest.

(Ayinde, Adewumi, Nmadu, Olatunji, & Egbugo, 2014; Nmadu *et al.*, 2013).

In view of the above, there has been a search for an appropriate way of capturing the amount error associated with farmer's attempt to predict how much they will sell their produce at harvest which will guide their investment decisions and number of acreage put to production. The lead for this came through what is generally known as Nerlove's reformation through what is popularly known as adaptive expectation and partial adjustment models (Nerlove, 1956, 1958a, 1958b). Since the reformation, a body of literature have developed around the concept including Just (2003, 1974) and a very comprehensive survey by Lim, (1975).

The major setbacks of the reform are that some of the estimates were static over the estimation period e.g. (Phillip & Abalu, 1987) and that the reform is a two-model equation indicating that the forecast error was exogeneously determined (Nmadu, 2002, Nmadu & Amos, 2003)

My major contributions to this reformation are in four respects:

i. The reformation was extended to a three-model equations (eq. 3-8) and successfully estimated (e.g. Fig. 5) with results comparable to all previous models (Nmadu, 2002, 2010; Nmadu, Olukosi, Musa, & Agada, 2013; Nmadu & Amos, 2003; Nmadu, 2004).

Adaptive expectation

$$A_t = \alpha_o + \alpha_1 P_t^e + \alpha_2 R_t + \alpha_3 F_t + \alpha_4 \overline{PF_{t-1}} + \overline{U_t} \qquad (3)$$

$$P_t^e = P^e_{t-1} + \beta_t (P_{t-1} - P^e_{t-1}) \qquad (4)$$

$$0 < \beta_t \leq 1$$

$$\beta_t = a + b_1 R_t + b_2 F_t + b_3 PF_{t-1} \qquad (5)$$

Partial adjustment:

$$A^*_t = \alpha_o + \alpha_1 P_{t-1} + \alpha_2 Y_t + \alpha_3 W_{t-1} + \alpha_4 O_t + U_t \quad (6)$$

$$A_t = A_{t-1} + (1-\lambda_t)(A^*_t - A_{t-1}) \quad (7)$$

$$0 \leq \lambda_t < 1$$

$$\lambda_t = a + b_1 Y_t + b_2 W_{t-1} + b_3 O_t \quad (8)$$

ii. All the associated coefficients (expectation and adjustment, price elasticities) were dynamically determined (e.g. Table 4) in contrast to the static estimates obtained by Nerlove (Nmadu, 2002, 2010, 2014; Nmadu *et al.*, 2013; Nmadu & Amos, 2003).

iii. A breakthrough for directly estimating farmers' error instead of modelling the system each time to do so. The breakthrough is called *jobian* coefficient for farmers'

error i.e. $P_t^e = \frac{\beta_t}{[1-(1-\beta_t)L]} P_{t-1} = \frac{\beta_t}{\beta_{t-1}} P_{t-1}.$

(Nmadu *et al.*, 2013; Nmadu & Amos, 2003; Nmadu, 2004)

iv. The adaptive-partial adjustment complex (eq. 9-13) was successfully modelled and estimated (Fig. 6a, 6b) for the first time (Nmadu, 2000b; Nmadu & Amos, 2003).

$$A^*_t = a + bP^e_t \quad (9)$$

$$A_t = A_{t-1} + (1-\lambda_t)(A^*_t - A_{t-1}) + U_t \quad (10)$$

$$P^e_t = P^e_{t-1} + \beta_t(P_{t-1} - P^e_{t-1}) \quad (11)$$

$$\lambda_t = a_1 + b_1 Y_t + b_2 W_{t-1} + b_3 O_t \quad (12)$$

$$\beta_t = a_2 + b_4 R_t + b_5 F_t + b_6 PF_{t-1} \quad (13)$$

$$0 \leq \lambda_t < 1; \; 0 < \beta_t \leq 1$$

Table 4 Estimates of the varying price elasticities of sorghum supply from adaptive models

Year	Linear Short	Long	Semilog Short	Long	Expo 1 Short	Long
1962	-0.001	-0.001	-0.016	-0.321	6.66E-16	0.0005
1963	-0.002	-0.002	-0.022	-0.303	8.87E-16	0.0007
1964	-9.00E-04	-0.001	0.0037	-0.324	4.76E-15	0.0005
1965	-7.00E-04	-9.00E-04	-0.008	-0.339	8.48E-15	0.0004
1966	-8.00E-04	-0.001	-0.023	-0.331	4.34E-15	0.0005
1967	-0.002	-0.002	-0.025	-0.281	2.31E-14	0.001
1968	-0.002	-0.002	-0.054	-0.304	3.25E-15	0.0007
1969	-9.00E-04	-8.00E-04	-0.081	-0.347	1.16E-15	0.0004
1970	-4.00E-04	-7.00E-04	-0.04	-0.36	9.88E-15	0.0003
1971	-5.00E-04	-7.00E-04	-0.058	-0.359	4.21E-15	0.0003
1972	-5.00E-04	-8.00E-04	-0.045	-0.347	1.04E-14	0.0004
1973	-5.00E-04	-1.00E-03	-0.025	-0.338	1.72E-14	0.0004
1974	-8.00E-04	-0.001	-0.073	-0.334	5.15E-15	0.0005
1975	-0.001	-0.001	-0.065	-0.309	4.69E-15	0.0007
1976	-0.001	-0.002	-0.063	-0.296	8.97E-15	0.0008
1977	-6.00E-04	-0.002	-0.013	-0.288	1.45E-13	0.0009
1978	-0.003	-0.003	-0.071	-0.254	2.72E-15	0.0015
1979	-0.002	-0.003	-0.058	-0.268	9.14E-15	0.0012
1980	-0.006	-0.007	-0.043	-0.202	1.62E-14	0.0033
1981	-0.004	-0.007	-0.037	-0.207	6.52E-14	0.003
1982	-0.006	-0.01	-0.032	-0.179	2.73E-13	0.0046
1983	-0.004	-0.012	-0.035	-0.17	9.08E-13	0.0053
1984	-0.009	-0.015	-0.045	-0.156	2.53E-13	0.0064
1985	-0.015	-0.02	-0.088	-0.135	1.23E-13	0.0088
1986	-0.014	-0.021	-0.104	-0.132	2.98E-13	0.0093
1987	0.0012	-0.02	-0.074	-0.135	1.80E-11	0.0088
1988	-0.021	-0.029	-0.087	-0.11	1.43E-13	0.0128
1989	-0.043	-0.057	-0.052	-0.065	3.12E-13	0.0252
1990	-0.049	-0.072	-0.047	-0.049	7.82E-13	0.0319

Year	Linear Short	Long	Semilog Short	Long	Expo 1 Short	Long
1991	-0.037	-0.04	-0.101	-0.089	8.26E-14	0.0175
1992	-0.048	-0.137	-0.006	-0.006	1.72E-11	0.0606
1993	0.0833	-0.176	0.0089	0.0105	9.65E-10	0.0777
1994	0.0489	-0.175	0.0151	0.0101	1.06E-09	0.0773
1995	0.1403	-0.179	0.0142	0.0117	1.79E-08	0.0791
1996	0.0333	-0.497	0.1288	0.0798	1.27E-09	0.2191
1997	-0.684	-0.42	0.1657	0.0687	4.11E-09	0.1855
Mean	-0.018	-0.053	-0.032	-0.199	7.05E-10	0.0235
St.Dev	0.1189	0.1129	0.0542	0.1374	3.05E-09	0.0498
Z test	-0.916	-2.836	-3.546	-8.682	1.38917	2.8362

(Nmadu, 2002)

Spline or grafted functions

Most regression models estimate a straight line to the data used irrespective of whether the data exhibit non-linear patterns. In 1969, W. A. Fuller proposed a technology by which data having linear and non-linear sections can be 'grafted' to form a continuous model. This technology was applied to Nigerian data and was estimated successfully. The estimated model (1961-1997) was used to forecast sorghum production from 1998 to 2010. A very important finding was the fact sorghum production started decline since 1969 (Fig. 7) in contrast to the popular notion that the major setback to agricultural production was caused by the oil boom; suggesting that the civil war could actually be the culprit. Another finding is that choice of joint points (Fig. 8) does not affect the model's forecasting power (Nmadu, 2002; Nmadu *et al.*, 2004; Nmadu *et al.*, 2009; Nmadu & Phillip, 2001; Nmadu, Ojo, & Ibrahim, 2012).

Cointegration and error correction modelling (ECM)

These are models utilising time series data and have the capacity to engender long-range planning. The major finding is that sorghum acreage dollar exchange rate and fertilizer consumption did not exhibit any error correction model only short time dynamics exists (Nmadu & Amos, 2009; Nmadu, 2009).

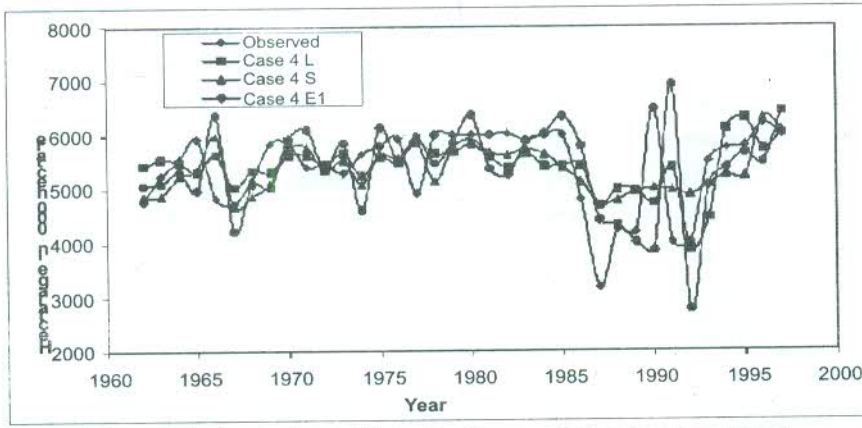


Fig. 5 Historical simulation of the adaptive models (Nmadu, 2002)

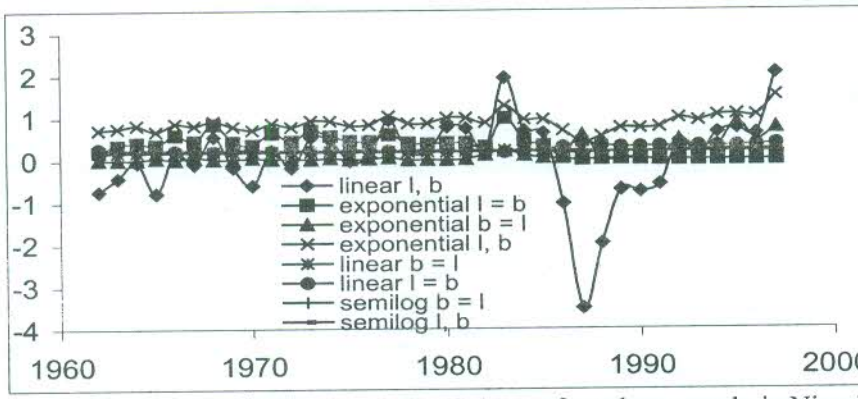


Fig. 6a Varying partial adjustment coefficients of sorghum supply in Nigeria

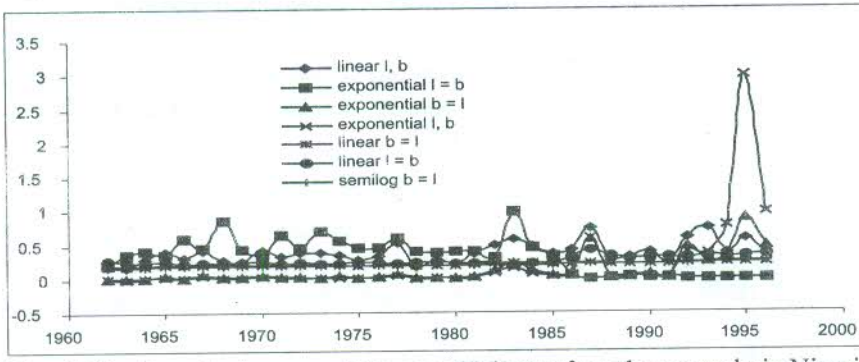


Fig. 6b Varying adaptive expectation coefficients of sorghum supply in Nigeria

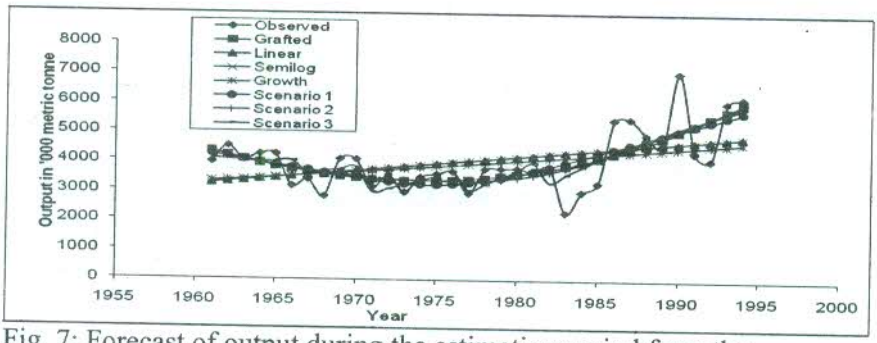


Fig. 7: Forecast of output during the estimation period from the alternative models (Nmadu, 2002)

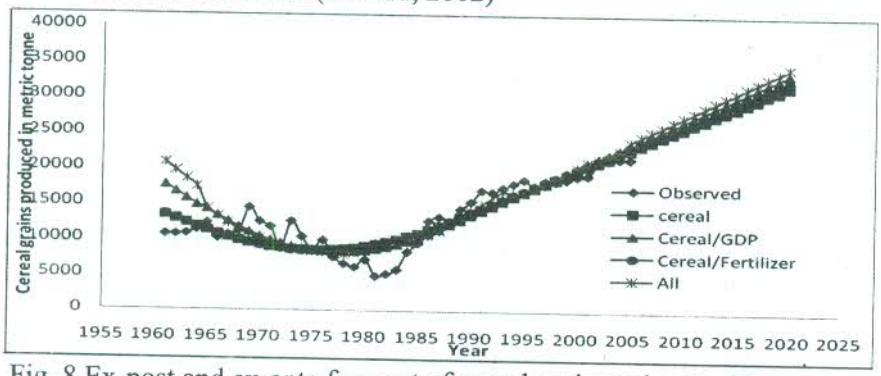


Fig. 8 Ex-post and ex-ante forecast of cereal grains using the Linear-Quadratic-Linear model (Nmadu et al, 2009)

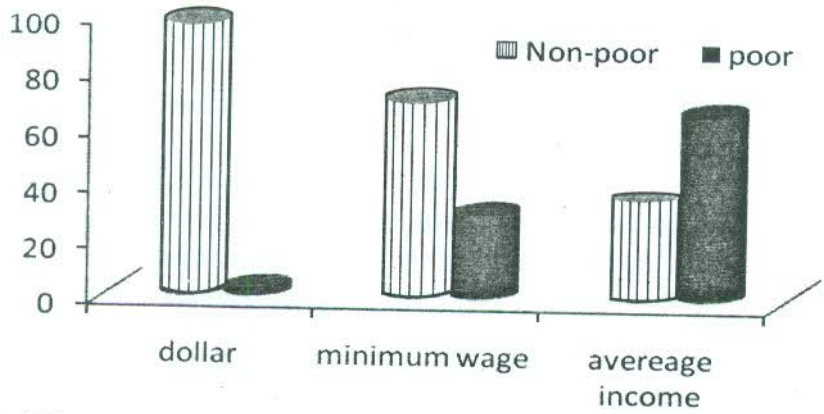


Fig. 9 Poverty status of small scale farmers in Niger and Kogi States (Nmadu *et. al*, 2015)

Poverty, risk and related studies

These studies indicated that Nigerian farmers are low risk takers and the level of poverty seems to have risen above the international level of USD1.25 (Fig. 9). Farmers in Mariga local government area of Niger State seem to be the richest in a study involving local government areas in Niger and Kogi States (Nmadu, Eze, & Jirgi, 2012; Nmadu, Yisa, Simpa, & Sallawu, 2015; Nmadu & Adeyemi, 2012; Nmadu & Dankyang, 2015; Jirgi, Grové, Jordaan, Viljoen, & Nmadu, 2015).

Production economics and farm management

By far, the most popular area in which most of the agricultural economics research is conducted. A number of models for various conditions or problems have been estimated. Some of the major contributions to knowledge in this area include:

i. Most Nigerian farmers operate on a small to medium scale with farm size less than 3ha
ii. The age distribution of the farmers divides them into two main groups i.e. those who are very old (above 50years) and their percentage is reducing fast. The farmers in this group had little or no formal education. The second group are those in the middle age group (below 40years) and majority of them only acquired secondary education. This second group are the hope of Nigerian agriculture but low education is a major setback.
iii. Most Nigerian farmers use out-dated technology leading to low productivity.
iv. Finance is a major setback for capital build-up of Nigerian farmers, so the net worth of most farms is very low making loans and other forms of credit difficult for them.
v. Nigerian farmers carry out farm operations manually and tend to utilise more of family labour thereby making the farm family-based and not operated commercially.

(Nmadu & Simpa, 2014; Nmadu, 1998; Nmadu & Akinola, 2015; Ajah & Nmadu, 2012a, 2012b; Nmadu, Inalegwu, & Sallawu, 2014;

Nmadu et al., 2015; Nmadu & Nwawulu, 2015; Nmadu & Garba, 2013; Nmadu & Garba, 2013; Nmadu, Bako, & Baba, 2013; Amos, Chikwendu, & Nmadu, 2004; Jirgi, Grové, Jordaan, Viljoen, & Nmadu, 2014; Jirgi, Jordaan, Grové, Viljoen, & Nmadu, 2015; Nmadu, Iwuajoku, & Jiya, 2012; Ojo, Nmadu, Tanko, & Olaleye, 2013a, 2013b).

Land markets and management, HIV/AIDS, agricultural financing etc.

i. Land markets in Nigeria are not well established which tends to allow sharp practices and that has affected land acquisition for agricultural purposes. Method of land acquisition is still by inheritance and no pricing mechanism is available. In view of this, there is a very strong need for reformation of the land laws to allow easier acquisition for agriculture.
ii. Agricultural financing was boosted with the introduction of Peoples Bank of Nigeria and the Community Banking platform. However, the issue of capacity to utilise loans granted to small scale farmers was not addressed. In addition, financial institutions' reluctance to lend to agriculture is still a major constraint.
iii. Although HIV/AIDS infection has been confirmed among small scale farmers, there is no major concern about any negative impact on agricultural production and productivity.

(Amos & Nmadu, 2004; Nmadu, 1999b; Nmadu *et al.*, 2014; Nmadu & Nwawulu, 2015; Nmadu et al., 2013; Nmadu & Nwawulu, 2015; Nmadu *et al.*, 2015).

International collaborations

I have collaborated with Scientist from other countries:

Prof. Mark Harris, School of Economics and Finance, Curtin Business School, Curtin University, Australia.

Dr. Jochem Wilhelm, Department of Medicine, Justus Lieberg University, Germany.

Dr. H. Jordaan, Dr. B. Grové, Dr. M. F. Viljoen, Department of Agricultural Economics, University of the Free State, South Africa.

Manpower development
For this short period, I have developed 11 PhD, 35 MTech, 2 MBA, 1 MPA, 2 PGD, 47 BTech and 7 HND graduates.

Top rated Journals
Kasetsart Journal - Social Sciences
Eastern Africa journal of rural development
African journal of agricultural research
Trends in Agricultural Economics

Textbooks published
Three books have been published and two of them are on sale on eBay. They are:

Nmadu J. N. *Computer appreciation and operation.* Published by Yekabo Educational Publishers, Bida in conjunction with Akan Communications, Bida ISBN 978-32573-7-4, 1st edition 1998 printed 1999, 2nd edition 2001 printed 2002.

Nmadu, J. (2010). *Sorghum Production in Nigeria: Analysis of trend and estimation of its supply functions (ISBN: 978-3-639-23806-8).* Published by VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrücken, Germany. Also Printed in USA and UK.

Nmadu, J. and T. T. Amos (2011). An Introduction to Agricultural Economics for First Timers (978-3-639-37589-3). Published by VDM Verlag Dr. Müller Aktiengesellschaft & Co. KG, Dudweiler Landstr. 99, 66123 Saarbrücken, Germany. Also Printed in USA and UK.

Concluding remarks
The purpose of this paper is to show that with credible data and up to date statistical and econometric analysis training, it is possible to develop models that can engender, maintain and sustain agricultural growth and development in Nigeria. However, certain constraints and set backs have been highlighted. In order to resolve those constraints, the following actions have been advocated i.e.

i. A strategic plan for econometric analysis retraining program so as to bring to level all agricultural economics to the same page world over, in particular, there is need to urgently train

all agricultural economists on computable general equilibrium (CGE) and emerging econometric software like GAMS and R.

ii. The establishment of a credible data structure as typified by the data pyramid in this paper.

iii. A non-formal training system for the middle level farmers so as to raise their capacity to imbibe new and improved production technologies.

iv. There is need for awareness of the farmers on the need to imbibe the culture of risk-taking so as to be able to access enough capital through loans and credits to raise productivity and alleviate poverty.

v. There is need to institutionalise agriculture so that minimum standards for operating a farm can be set and thereby forestall low productivity and high rate of farm failures.

vi. Technology development and improvement can increase farm size considerably and make the farm enterprise more commercially-oriented.

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Profile of the Inaugural Lecturer

Job Nda (*kotsu-gbangba*) Nmadu, the first professor of Agricultural Economics (Econometrics) from Niger State, was born on the 4th of October, 1963 to the family of Mr Zacheaus Baba and Mrs Elizabeth Kashi in Patishabakolo (aka Zion Hills) in Doko Division of Lavun Local Government Area of Niger State, Nigeria. He started his educational pursuit at St. John's Primary School, Bida in January 1972 and completed the primary education at South Primary School also in Bida in 1977. He then proceeded to Government Secondary School, Izom for his secondary education in January 1978 but was transferred to Government Secondary School Suleja in 1980 and successfully completed the secondary education in 1982. He immediately proceeded to School of Basic Studies, Ahmadu Bello University Zaria and obtained IJMB in 1983 upon which he was admitted to the Faculty of Agriculture, Ahmadu Bello University Zaria the same year. He obtained BSc (Agriculture) in 1987. He returned to the same institution in 1994 and 1998 and obtained MSc (Agricultural Economics) and PhD (Agricultural Economics) in 1998 and 2002 respectively. He also obtained *Diploma* in *Data Processing and Computer Programming* (1995) from Soft Design Computer Institute, Zaria. He attended Advanced Leadership Course at Haggai Institute, Singapore in 2006 and obtained Competence as Trainer in 2011 at Olusegun Obasanjo Centre for Organic Research and Development (OOCORD) in conjunction with Nigerian Organic Agriculture Network (NOAN) facilitated by Agro Eco Louis Bolk Institute, Netherlands. He also attended the EcoMod Modelling School in Washington DC in 2016. Professor Nmadu has also attended a number of trainings and seminars as listed below:

- *Web 2.0 Learning Opportunity organised* by CTA Netherlands in collaboration with Bowen University, Iwo, Nigeria
- *Introductory Seminar on Organic Agriculture in Nigeria.* Organised by Olusegun Obasanjo Centre for Organic Research and Development (OOCORD) and Nigerian Organic Agriculture Network (NOAN)

- *Train the Trainer Workshop on Writing Convincing Research Proposal.* An ARCN–IFPRI Collaborative Programme Workshop
- *Revitalizing Agricultural Research in Nigeria.* An ARCN–IFPRI Collaborative Programme Inception
- *Zonal Stakeholders Sensitization Workshop preparatory to Baseline survey of Nigeria's National Science, Technology and Innovation System* organized by the Nigeria/UNESCO Project for the reform and revitalization of Nigeria's Science, Technology and Innovation System
- NBTE 13th National Seminar on *"Managing Resources for effective Technological manpower training in Agriculture": 'Expanding the scope of technician training in agriculture in the new decade"*
- Church of Nigeria (Anglican Communion) Information Technology skill improvement and Computer Training – Windows, MS-Word, MS-Powerpoint, MS-Outlook, Internet Explorer
- NBTE 6th National Seminar on *"Managing Resources for effective Technological manpower training in Agriculture": 'Laboratory Management for maximum utilization'*

After his National Service as the National President National Christian Corpers' Fellowship (NCCF) and the President of Plateau State Christian Corpers' Fellowship (PCCF) between 1987 and 1988, Prof. Nmadu commenced his career as Education Officer at Federal Government College Enugu in December, 1988 and was transferred to Federal Government College Kwali in February 1989. In August of 1989, Professor Nmadu resigned his appointment with Federal Ministry of Education and moved to National Directorate of Employment as Agricultural Development Officer, a position he held until January 1992 when he took a faculty position in the Department of Agricultural Engineering of the Federal Polytechnic, Bida as Lecturer III. He rose through the ranks (five ranks) and became a Chief Lecturer in July, 2006. He joined the services of the Federal University of Technology, Minna in the Department of Agricultural

Economics and Extension Technology as a Senior Lecturer i October, 2006 and then rose through the ranks again to become Professor in October, 2013.

A distinguished and astute academic, Professor Nmadu has publishe more than 100 papers in Journals (30 international and 22 national conferences (9 international and 25 national), technical reports an textbooks involving more than 50 collaborators within the Universit and around the world; which earned him h-index of 4, g-index of and hc-index of 4.

Professor Nmadu married Hannah Teni on the 11th of Novembe 1989 and together they have three biological children: Yeka (medical doctor), Yebo (mathematician in training) and Yami (hopin to become.....).

Professor Nmadu has served in various capacities in Bida and Minna some of which include:

- Departmental Librarian, Department of Agricultura Engineering, Federal Polytechnic, Bida, 2001-2006
- Acting Head of Department, Department of Agricultura Engineering, Federal Polytechnic, Bida,2001, 2002, 2003
- Departmental SIWES Co-ordinator, Department o Agricultural Engineering, Federal Polytechnic, Bida 2000/2001
- Officer in Charge, The Polytechnic commercial farm 1992/94
- Officer in Charge, The Polytechnic poultry project, 1992
- Staff Adviser to the National Association of Agricultura Economics and Extension Technology Students (NAAEES) 2007-2008
- Admission Officer, School of Agriculture and Agricultura Technology, 2006-2009
- Head of Department, Department of Agricultural Economic and Extension Technology, Federal University o Technology, Minna, February 2008 - October, 2012

He also served in a number of Committees as listed below:

- Member, Committee to investigate Allegations from Centre for Preliminary and Extramural Studies, 2015
- Chairman, Committee on "AGRIC TALK SHOW" with AFOMA, 2015
- Member, Committee to look into the operation of Academic Staff taking up Visiting Appointment in other Institutions, 2015
- Member, Budget Monitoring Committee, Federal University of Technology, Minna, 2012
- Member, Accreditation Committee, Federal University of Technology, Minna, 2012
- Member. Committee on Co-Operative policy in Federal University of Technology, Minna, 2012
- Chairman, Technical Sub-Committee, Local Organising Committee, 35th Scientific Conference of the Soil Science Society of Nigeria held at the School of Agriculture and Agricultural Technology, Federal University of Technology between 7th and 11th March, 2011
- Member, Student Union Independent Electoral Committee, Federal University of Technology, Minna, Nigeria, 2011-2012, 2010/2011 and 2011/2012
- Member, Senate Estimate and Budget Committee, Federal University of Technology, Minna, 2011-2013
- Member, Students Disciplinary Committee, Federal University of Technology, Minna, 2010 - 2012
- Co-Chairman, Human Capacity Syndicate Research Group, University Board of Research, Federal University of Technology, Minna, 2010-2012
- Member, Campus/Community Communication Forum, Federal University of Technology, Minna, 2009-2011
- Member, Honourary Degrees Committee, Federal University of Technology, 2009 – 2011
- Member, Committee on Microfinance Programme of the Central Bank of Nigeria, 2008

- Member, Committee on the Establishment of Commercial Farm in School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, 2008
- Member, Committee on the Establishment of Co-operative Extension Centre, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, 2008
- Member, School Action Committee on MOU between FUT Minna and Niger State Government, 2008
- Chairman, Research, Conference and Publications Committee, School of Engineering, Federal Polytechnic, Bida, Nigeria, 1998-2004
- Chairman, SenStaf Multipurpose Co-operative Society Ltd., The Federal Polytechnic, Bida, Nigeria, 1998-2006
- Member, The Production Committee, The Federal Polytechnic, Bida, Nigeria, 1992/94

Outside the University, Professor Nmadu has served in more than 50 Committees and capacities, some of which are:

- **Editor-in-Chief,** Australasian Journal of Social Science, 2016
- Chairman, World Bank/CSDP Electrification project of Patishabakolo Community, 2012-2016
- Secretary, Supra-Diocesan Development Committee, Diocese of Bida (Anglican Communion), 2010-2016
- Secretary, Diocesan Development Committee, Diocese of Doko (Anglican Communion), 2010-2016
- Chairman, Board of Agriculture and Rural Development, Diocese of Doko (Anglican Communion), 2009 -2016
- Peoples Warden/Treasurer, All Saints Anglican Church, Gidan Kwanu, Diocese of Minna, 2009-2016
- Member, EIA Panel Review Meeting of some development projects between 2009 and 2016, organised by the Federal Ministry of Environment, Abuja
- Secretary, Task Force on the Inauguration of Diocese of Doko (Anglican Communion) and Enthronement of the Bishop, 2009

- Secretary, Primate's Advisory Committee on the election of a Bishop for the Diocese of Doko, Church of Nigeria (Anglican Communion), 2009
- Chairman, Building Committee, Fellowship of Christian Students, Niger State, 2008-2016

Professor Nmadu is a member of several professional associations and organisations as listed below:

- Agricultural Society of Nigeria
- Nigerian Association of Teachers of Technology
- Nigerian Society for Plant Protection
- Nigerian Association of Agricultural Economists
- Farm Management Association of Nigeria
- Life Member, Bible Society of Nigeria
- Asia-Pacific Chemical, Biological & Environmental Engineering Society
- International Economics Development Research Center, Hong Kong
- Australian Agricultural and Resource Economics Society
- Agricultural and Applied Economics Association (AAEA, *formerly American Association of Agricultural Economics*)
- International Association of Agricultural Economists (IAAE)
- World Economics Association

He is presently the second Vice President of the Nigerian Association of Agricultural Economists.