Agricultural engineering education for agricultural transformation in Nigeria

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Abstract: Agricultural engineering education in Nigerian universities was appraised; focusing on changes in teaching curriculum, institutional capacity for training and human resources development, succession plan and post graduate training in relation to trending changes around the world. This is with the view to re-directing agricultural engineering education towards the Nigerian agricultural transformation agenda. A survey of 27 Nigerian universities wherein there is a department of agricultural engineering was conducted using secondary data, visits and oral interview. The results showed that one (3.7%) was established in the 60 s, five (18.5%) in the 70 s, six (22.2%) in the 80 s, four (14.8%) in the 90 s and eleven (40.7%) in the new millennium. Fifteen (55.6%), ten (37%) and two (7.4%) of the universities were owned by Federal Government, State Government Private Investors. The two privately owned institutions were based in the South West and were only established recently, between 2012 and 2013. Three of the universities were situated in the North East (11.1%), two (7.4%) in North West and four (14.8%) in the North Central. South Western zone housed seven (25.9%) universities, the South East, five (18.5%) and South South, four (14.8%). Approximately 31.6%, 28.7%, 11.8% and 27.9% of academic staff were in the area of farm power and machinery, crop processing and storage, farm structures and environment, soil and water conservation engineering, respectively. About 66% of academic staff in agricultural engineering departments are in the status of senior lecturer and above. Given Nigeria's vast agricultural resources and her place as Africa's most populous nation, this work provides valuable information on the path of agricultural engineering education has taken in Nigeria, how it impacts the development of the agricultural sector, regional needs in terms of food production and how it influences the type/skill of manpower available for addressing local problems. This may guide policy formulation in the establishment or approval of new programs in relation to specific regional and national needs, and other developing nations can learn from this scenario.

Keywords: agricultural engineering, education, curriculum, agricultural transformation, Nigeria

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1 Introduction

Food deficits, high population growth, increasing per capita, rising food demands and environmental challenges have pushed agriculture and food production up the international, political, policy and research agenda globally. Overt projection estimates that the world's population may reach 9 billion by 2050, with major increase emanating from Asia, Latin America and sub-Sahara Africa (FAO Statistics, 2016). One of the greatest challenges of the millennium is that at least 60% increase in food production will be required to meet the demand of this stupendous population (Blackmore, 2012; Wilson, 2013). Olagbende et al. (2016) remarked that the effect of climate change and population growth on agriculture and the world's environment in the years ahead would be more intense, constituting serious threat to food security. It is also most disturbing that the most food insecure people of the world live where there exits the greatest potentials to produce food that can largely meet the world's food demand (Tilman et al., 2011). Important to note is the fact that, at every stage of the world's development, agriculture had always been at the center of most economies, driven by engineering interventions; involving complex interaction between

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man, plants, animals (including microorganisms) and mechanical elements. The early man lived in existing caves, killing animals and picking ripe fruits in the wild for food. As communities began to expand with population increase, man had to develop simple tools from stones and his ability became more adroit. With time, he began to build mechanical devices with mobile parts, powered by man and domesticated animals (Adekoya, 2014). This grew in stages to the sophisticated technologies we have today for planting, harvesting, handling and processing of crops., The need for professionals with fundamental engineering knowledge to solve problems requiring engineering intervention arose between the 18^{th} and 19^{th} century. The educational system that produced the today's agricultural engineer (AE) is founded by the first generation of engineers with agricultural background (Heldman and Moraru, 2010).

Agricultural engineering underpins all the activities that enable the production and processing of food, feed, fiber and fuel resources, with marked reduction in drudgery, improved machine/process efficiencies and conservation of natural resources. It draws fundamental knowledge from agriculture, mechanical, civil, electrical and chemical engineering. Hoes cutlasses, horse/oxen driven agricultural implements have transformed to large diesel tractors and combined harvesters in the Western parts of the world. Electric power has been brought to farms to reduce drudgery and make the preservation of food products possible (Ogunlowo et al., 2005). Precision farming, integrated pest management and global positioning system receivers and electronic monitoring devices are now used for cultivation. The use of internet and wireless communication has helped farmers enjoy all that ICT has to offer and remain on the farm. In developed economies, this has limited rural-urban migration to a large extent; giving every farmer competitive power in their location and make each member of the global city have equal food rights (Sigrimis et al., 2005). Given the link between economic and institutional development, educational institutions must promote agricultural research, extension and vocational agriculture to evolve a knowledge-based agricultural economy that is capable of addressing the challenges of food and clean energy production from locally available resources (Oliver, 1970).

Onwualu (2005) documented 'agricultural engineering practice in Nigeria' for the Nigerian Institution for Agricultural Engineers. Mijinyawa (2005) highlighted entry requirements, training and regulations and professional affiliations for agricultural engineering education in Nigeria, calling on stake holders to give AEs relevance in national development. Adewumi (2008) advocated the inclusion of agricultural technology transfer and agricultural engineering extension in the teaching curriculum of agricultural engineering. In addition, Adekoya (2013) listed some career options, but information about agricultural engineering education viz-a-viz the Nigerian agricultural transformation agenda was rarely found in literatures. In this paper, authors focused on the trending curriculum change in agricultural engineering education in Nigerian universities in relation to local agricultural problems requiring engineering intervention. It appraised the primary choice of agricultural engineering as a course of study by young school leavers, institutional capacity for manpower development and training, gender parity, succession plans and postgraduate training with a view to the direct agricultural engineering education towards the Nigerian agricultural transformation agenda.

2 The Nigerian agricultural transformation agenda

The Nigerian agricultural transformation agenda seeks to achieve a hunger-free economy through an agricultural sector that generates employment, drives income growth, food and nutrition security. The agenda envisions moving the subsistence farmers from their high poverty level into a commercialized system that would facilitate trade and competitiveness. Several agencies have been put in place to institutionalize policy support for agricultural transformation agenda with emphasis on agricultural resources wherein each of the Nigerian geopolitical zones has comparative advantage, namely: rice, cassava, sorghum, cocoa cotton, maize, dairy, beef, leather, poultry, oil palm and fisheries (FMARD, 2011). This is to be achieved through the value chains of each commodity as well as to recognize the roles of actors/stakeholders, input for achieving production targets,

the expected output and associated constraints. Some of these agencies include: Nigerian Incentive-based Risk Sharing for Agricultural Lending, Growth Enhancement Support, Agricultural Transformation Implementation Council, Agricultural Investment Transformation Implementation Group and Agricultural Value Chain Transformation Implementation Group. However, achieving all that the Nigerian agricultural transformation agenda seeks to achieve was illusive over the years as Nigerians continue vicious struggle with poverty and hunger.

With a population of over 180 million (30% of which are youth), the Nigerian agricultural workforce is largely populated by women, children and aged peasants who cultivate few acres with crude implements in poverty-stricken rural areas. The arduous task and drudgery that tillage involves limits a farmer to barely one hectare, thereby the productivity is at a very low level. Akinyetun (2018) reported that about 90% of Nigeria's food was produced by these category of small-scale farmers, almost depending on rainfall alone, limited social services, poor infrastructures and incentives. As a result, the agricultural industry has witnessed serious decline for decades. As at 1961, Nigeria had the highest per capita agricultural growth with 42%, 27% and 18% of the world's groundnuts, palm oil and cocoa production figures, respectively (FMARD, 2011). With food imports increasing at the rate of 11% per annum, Nigeria's agricultural production per capita has declined rapidly over the last few decades. This has caused food shortage and made Nigeria a net importer of wheat, rice, sugar and fish; despite abundant resources to produce all these for local consumption and export. Nigeria loses about USD10 billion worth of annual export opportunities from groundnut, palm oil, cocoa and cotton (FMARD, 2011). Over 50% of harvested food crops including fruits, vegetables, roots and tubers and about 30% of grains are lost as a result of poor value addition along the food supply chain, inappropriate technologies for processing, storage and preservation, poor market infrastructures, high importation of agricultural machineries with low technical support and poor farmers-industry-academia linkage (Taiwo, 2010). Given the fact that an AE is the engineer with the requisite knowledge of the solutions to many of these problems, harnessing his/her education towards total agro-industrial development requires a critical appraisal.

3 Overview of agricultural engineering education in Nigeria and around the world

The first use of crude tools to till the earth may be taken as the beginning of agricultural engineering. The activities of a pre-historic farmer thatman was and his entire livelihoods, including food, clothing and shelter center on fundamental engineering disciplines. With man's relentless search for ways of improving various processes associated with tillage and food production (Makanjuola 1977, 3-4), agricultural engineering may arguably be said to have been in existence since prehistoric times. It was first listed as a profession in University of Nebraska, USA in 1896 with Mechanical, Electrical, Civil or Chemical Engineers as the earliest group of Engineers-in-Agriculture and foundation staff (Stewart, 1979). These Engineers-in-Agriculture came together to form the American Society of Agricultural Engineers (Odigboh 1985, 3) which later metamorphosed into American Society of Agricultural and Biological Engineers in 2010 (Adekoya, 2013). In 1905, Professor J. B. Davidson of Iowa State University developed a curriculum which focused on farm mechanization to evolve a global system for managing the production, processing, storage and handling of food and fiber (Stewart, 1979; Adekoya, 2013). The professionalism of agricultural engineering may be construed as a response to the industrial revolution, knowledge explosion and rapid growth of the American agriculture in the early part of the 20th century.

In Nigeria, early responsibilities of AEs were undertaken by agronomists, civil, clectrical and/or mechanical engineers (Mijinyawa, 2005) until 1959 when some of these engineers were recruited for training in Britain to become the first set of AEs (Odigboh, 1985; Igbeka, 2002). In 1967, University of Nigeria, Nsukka awarded the first bachelor degree in agricultural engineering to Messrs U.P.C. Akudo and E. Nwalo. The number of universities with programs in agricultural engineering has grown from 1 in 1962 to 27 in 2017 (Table 1).

Table 1 Nigerian universities with accredited programs in agricultural engineering

S/N	Geo-political location	Name	*Year	Availability of post graduate program	Name of program
1	South	[b]Rivers State University of Science and Technology, Port Harcourt	1971	Yes	Agric. and Environmental Engineering
2		[a]Federal University of Technology, Owerri	1982	Yes	Agric. Engineering
3		[a]University of Uyo, Uyo	2001	Yes	Agric. and Food Engineering
4		[b]Niger Delta University, Wilberforce Island	2000	No	Agric. Engineering
5		[b]Evan Enwerem University, Owerri	2006	No	Agric. Engineering
6		[b]Akwa Ibom University of Technology, Nkpat Enin	2010	No	Agric. Engineering
7	South East	[a]University of Nigeria, Nsukka	1962	Yes	Agric. and Biosystems Engineering
8		[b]Enugu State University of Science and Technology, Enugu	1981	Yes	Agric. Engineering
9		[b]Nnamdi Azikiwe University, Awka	1991	No	Agric. and Bioresources Engineering
10		[a]Michael Okpara University of Agriculture, Umudike	2001	Yes	Agric. Engineering
11	South West	[a]University of Ibadan, Ibadan	1975	Yes	Agric. and Environmental Engineering
12		[a]ObafemiAwolowo University, Ile-Ife	1970	Yes	Agric. and Environmental Engineering
13		[a]Federal University of Technology, Akure	1981	Yes	Agric. and Environmental Engineering
14		[b]Olabisi Onabanjo University, Ago-Iwoye	2003	No	Agric. Engineering
15		[a]Federal University of Agriculture, Abeokuta	2002	Yes	Agric. and Environmental Engineering
16		[b]Ladoke Akintola University of Technology, Ogbomoso	1995	Yes	Agric. Engineering
17		[c]Landmark University, Omu- Aran	2011	No	Agric. Engineering
18		[a]Federal University of Technology, Oye Ekiti	2012	No	Agric. and Bioresources Engineering,
19		[c]Adeleke University, ede	2014	No	Agric. Engineering
20	North West	[a]Ahmadu Bello University, Zaria	1974	Yes	Agric. Engineering
21		[b]Bayero University, Kano	2001	No	Agric. Engineering
22	North Central	[a]University of llorin, llorin	1982	Yes	Agric. and Biosystems Engineering
23		[a]University of Agriculture, Makurdi	1988	Yes	Agric. Engineering
24		[a]Federal University of Technology, Minna	1986	Yes	Agric. and Bioresource Engineering
25		[a]Modibo Adama University of Technology, Yola	1990	No	Agric. Engineering
26	North East	[a]University of Maiduguri, Maiduguri	1977	Yes	Agric. and Environmental Resources Engineering
27		[a]Abubakar Tafawa Balewa University, Bauchi	1998	Yes	Agric. and Bioresource Engineering

Note: Subscripts a,b and c represents ownership. [a]Federal government; [b]State government; [a]Private *Year of establishment of the Department.

Mijinyawa (2005) documented the development of agricultural engineering education in Nigeria; highlighting entry requirements into universities, professional regulations and affiliations within the context of national development. Oliver (1970) established that an AE must firstly be proficient in advanced mathematics, physics, basic engineering and biological sciences like every other engineers. Although, specific subjects and areas of strength varied from one institution to the other, the curricula typically emphasize basic physical sciences and mathematics with general subjects in civil, mechanical and electrical engineering, computer science, general agriculture, technology management and economics. These provide background for the design and application of machines to the production, processing, and storage of food, feed, and fiber. Anyone completing such a program therefore qualifies for a wide range of positions as an AE. Adewumi (2008) advocated the need to educate leaders and policy makers about agricultural engineering as a way of getting AEs to gain a strong voice in national agricultural policies. This perhaps is the impetus for the modification of curricula that train engineers for agriculture in many institutions in many regions of the world.

4 Agricultural engineering curriculum

Agricultural engineering was previously misconstrued as mere tractorization because the earliest AEs focused solely on reducing the drudgery associated with tillage; hence early curricula were also built around “Farm Mechanization” (Mijinyawa, 2005). In many cases, the programs emphasize one aspect of agricultural engineering (e.g. irrigation, soil and water resource, crops processing or forestry/wood products engineering). In some other cases, the curriculum covers emerging areas including agricultural biotechnology, renewable energy, information and communication technology (ICT),

integrated pest management, precision agriculture, genetic engineering and a wide range of specialties (Brown, 1988). The philosophy of agricultural engineering education essentially aims at integrating engineering and agriculture into a unified curriculum; broadening the capacity of the AE as an "all-in-one Engineer", equipped to solve the engineering problems associated with food production, rural livelihoods, soil and water resources conservation and sustainable agro-industrial development. This "all-in-one Engineer" is expected to produce tools and/or machineries to reduce the drudgery associated with crop production and processing as well as work with other professionals to produce food, fibre and high quality agricultural products for the local and export markets. In many institutions, the general areas of interest include farm power/machinery, post-harvest engineering/crop processing, value addition, bio-processing and food engineering; soil and water conservation, farm structures and environmental control. The application of fundamental engineering knowledge to solve agricultural problems wherein engineering intervention required is what makes agricultural engineering curriculum diverse and robust in many institutions. It is also what makes AEs fit many job situations where other engineering disciplines may be found wanting and perhaps the reason why AEs are nicknamed "jack of all trades and master of all". Within this context, agricultural engineering in Nigeria has evolved names in response to different local/regional/global needs. Adekoya (2013) explained that recent changes in the scope of agricultural engineering education in Nigeria presented better opportunities and prospects for the 21st century graduates in accordance with global trends in the profession. Oliver (1970) remarked that the problems that AEs had to solve in any particular society must be with consciousness of climate change adaptation, rising food demand, cultural beliefs and value system.

The oil-driven economy that Nigeria operated since the early 70s (when agriculture was undergoing phenomenal changes in other parts of the world) stimulated many young people seeking admission into universities to choose chemical, petroleum, electrical and electronic engineering. Many universities nowadays focus more on these courses because they attract more applicants. Consequently, many Federal Universities with large capacities for training AEs characteristically suffer low intake. For example, in 2017, only 30 out of the 1,022 students who applied to study engineering in Obafemi Awolowo University, and scored a minimum of 200 marks in Universities and Tertiary Institutions Matriculation Examination chose agricultural engineering as first choice. Authors' personal interaction with the admission office of some universities in South Western Nigeria revealed that agricultural engineering was still among the least subscribed engineering courses. When students cannot secure admission to their engineering course of first choice, they accept agricultural engineering merely as an option to secure admission. Afterwards, such candidates (sometimes under parental influence) seek immediate change of course to other engineering disciplines that are considered to be more competitive, such as chemical, electrical, computer and mechatronics engineering (which also attract more female students). It suffices that seminar on career opportunities in agricultural engineering is intensified for secondary school leavers to break this jinx. On the other hand, the crude and arduous use of the hand-hoe in African farming is the bane that repels youth and attracting them into agriculture may remain a dream for a very long time. The challenges of our world today have taken engineering in agriculture beyond tillage and traditional farm mechanization to new areas where youth in agriculture can retain and exhibit their fundamental interests while functioning as AEs. A change from "Agricultural Engineering" to "Biosystems Engineering" suggests that AEs integrate engineering with applied biology in the management and utilization of bio-resources for energy generation, development of systems that can promote sustainability and assure food security. Some highlights of new agricultural engineering curricula include:

a) Design of agricultural machinery equipment, processes and systems; selection, optimization, operation, maintenance and repairs.

b) Storage and postharvest handling, value addition and processing of food and fiber while at the same time protecting the environment;

c) Application of information n and communication

technology for precision agriculture and automation including artificial intelligence, mechatronics and robotics to drive food production, preservation, reduce post-harvest losses and extend the season of availability of food products;

d) Environmental management and agricultural waste conversion for soil improvement and energy generation;

e) Design planning and execution of rural infrastructural projects (including, livestock housing, roads, water supply and sanitation, buildings and electricity) for improved rural livelihoods; and

f) Soil/water conservation (including tillage, erosion control, irrigation and drainage systems);

These inclusions have opened up new frontiers for young people with core interests in computer, artificial intelligence, mechatronics, biotechnology, environmental engineering, energy and climate change adaptation while they function as AEs. It is advocated that the education of an AE should awake an attitude of responsibility, leadership, professionalism and relevance to his or her immediate environment. Some agricultural engineering programs with changed names and curricula in selected universities around the world are listed below (Table 2):

a) Biosystems engineering

For Biosystems and food engineering at UCD, candidates are taken after a first cycle honours Bachelor degree in engineering, engineering science or mathematical science background. The curriculum at this level cuts across production, manufacture and processing of biological materials food related materials (such as biosensors, enzymes, food products and packaging, precision, production and harvesting systems), agricultural mechanization, management techniques for improving air, soil and water quality. At postgraduate level, they are trained to be provide practical solutions to problems and exposed to a wide variety of opportunities in the processing of food and other biological materials, environmental protection, waste recycling, sustainable energy and green technologies. In Auburn University, the focus of the Department of biosystems engineering is on the development of sustainable and resilient solutions to global challenges and life's essentials: food, water, energy, environment and health. Bachelors' students are trained to function exceptionally well on the multidisciplinary teams in today's workforce, however they select to focus on any of the four pathways: biosystems engineering, bioprocess engineering, ecological engineering or forest engineering. In University of Manitoba, Canada, biosystem engineering program provides students the diverse opportunities of pursuing a career in environmental, bioprocess, biomedical or agricultural and natural resources engineering. The curriculum focuses on stored grains ecosystems, biological treatment of wastes, phytoremediation of polluted soils, management of environmental odours, bio-processing, hyperspectral imaging techniques, alternative building systems, animals and plant production environment. Under the same name in Wageningen University, Netherlands, Students who want to enrol for MSc programme of biosystems engineering at Wageningen University & Research must have a BSc degree or equivalent of a technical programme or an agricultural education programme with sufficient engineering background. The biosystems engineering programme focuses on the development of technology for the production, processing and storage of food and agricultural non-food, rural management, renewable resources and agro-industrial production chains. There is emphasis on modelling of biobased production systems, quantitative analysis of innovative biosystems, biosystems design

b) Bioresource engineering

McGill University, Montreal, Canada runs bioresource engineering as an interdisciplinary program that integrates engineering, design and biological sciences. The curriculum is built to teach the application of engineering principles to enhance and sustain the world's natural resources. The specializations include environmental engineering, soil and water engineering, ecological engineering (including ecosystem modeling, design, management and remediation). Embedded therein also are food, bioprocess and agricultural engineering with annexure in artificial intelligence, mechatronics and robotics.

c) Biological and agricultural engineering

University of California, Davis, USA was built with the view to integrate engineering principles with biological systems for research and education in the production, distribution and processing of biological

products. The program is a complex mix of agricultural, aquacultural, bioenvironmental, bioinstrumentation, biomedical, energy systems, food, forest, and postharvest engineering based on the leading position that California occupies in agricultural production and diversity of the United States. Students are therefore taken through rigorous courses in fundamentals of engineering, pure and natural sciences including concepts in their first two years. Afterwards, they choose to specialize in either of agricultural engineering, acquacultural engineering, biotechnical engineering, ecological systems engineering, food engineering, forest engineering or medical/bio-medical engineering. Similarly, in University of Saskatchewan, Canada the program covers a broad range of traditional agricultural engineering subjects (agriculture machinery design, tillage mechanics, postharvest and food engineering, agricultural building environments, soil and water management). It includes newer topics such as sensors and instrumentation for agriculture and biological systems, cold-regions hydrology and value-addition.

d) Agricultural machinery

Ankara University, Turkey runs a program in agricultural machinery focusing on the use of energy to meet the requirements of the modern agricultural and industrial community with emphasis on rural electrification, wind and solar energy technologies. The curriculum is built around farm mechanization, farm power and machinery. At the Central Agricultural University, Sikkim-Manipur, India, the College of Agricultural Engineering and Post Harvest Technology runs programs leading to the award of three separate degrees in process and food engineering, farm machinery and power or soil and water conservation engineering. Other top rated departments of agricultural engineering as we have in Iowa State, Penn State, Texas A&M, University of Wisconsin, Madison, University of Illinois, USA and University of Queensland, Australia, have their curriculas based on the state of agricultural development in that region.

Based on the foregoing, it may be posited that the new name and curriculum of agricultural engineering programs in any particular region focuses more on the aspects of agriculture where modern knowledge is required and how the production of food and fiber around that region affects local and international food demand. The common names adopted for programs training AEs under new curricula in most Nigerian universities include Agricultural and Environmental Engineering, Agricultural and Biosystems Engineering and Agricultural and Bioresource Engineering (Table 1). In universities where the name has not been changed, specific aspects of the curriculum have been broadened to conform to emerging trends. The general emphasis is on the complex interaction between technology, plants, animals and the environment in the conservation and management of the world's resources; showcasing the varied and multifaceted profession that agricultural engineering stands out to be. This places the education of AEs in Nigeria in the right perspective relative to modern trends around the world. Table 1 shows a total of 27 universities in Nigeria running programs leading to the award of bachelor degrees in Agricultural Engineering disciplines. Fifteen (55.6%), ten (37%) and two (7.4%) of the universities were owned by Federal Government, State Governments Private Investors. The two privately owned institutions were based in the South West and were only established recently, between 2012 and 2013. In a country with over 180 universities, less than 20% were found to be offering agricultural engineering. Considering growing awareness that Nigeria should return to an agriculture-led economy, authors' opinion is that more universities should start programs in agricultural engineering in the near future. The spread of these universities in Nigeria shows a cluster in the South-West and South-South geo-political zones on the Nigerian map (Figure 1). Three of the universities were situated in the North-East (11.1%), two (7.4%) in North-West and four (14.8%) in the North-Central. South-Western zone houses seven (25.9%), the South-Eastern, five (18.5%) and South-South, four (14.8%). These data show that about 63% of the universities with programs in agricultural engineering are based in the South. Although the North East, North West and North Central occupy about 70% of Nigerian land mass with diverse weather and crops, only a few universities are available to meet their needs for agricultural engineering as a course of study. There was

only one Department of Agricultural Engineering in the 60 s (i.e. 3.7%), while there were five (18.5%) in the 70 s, six (22.2%) in the 80 s, four (14.8%) in the 90 s and eleven (40.7%) in the new millennium. Although, given the Nigerian socio-political situation over the time period within which these departments came up, it may be remarked that the establishment of these programs was politically motivated. Given the national consciousness occasioned by the agricultural transformation agenda, it may also be said to be need-driven. Going by the rate at which new programs sprang up in the new millennium, more agricultural engineering programs are likely to spring up in the years to come. This should stimulate a wide variety of agricultural activities and diverse agricultural investments and attract/inspire more enrolment in agricultural engineering. Analogous to this, is the characteristic location of maritime/marine engineering programs in universities in the South-South geopolitical zone (near the sea coast and thus attracting larger intakes to such departments from that region).

Table 2 The different names of agricultural engineering around the world

S/N	Country	Institution	Name of program
1	USA	Iowa State University North Dakota State University South Dakota State University University of Arizona	Agric. and Biosystems Engineering
		University of Wisconsin	Biological Systems Engineering
		Cornell University	Biological and Environmental Engineering
		North Carolina University Texas A&M University University of Arkansas University of California, Davis University of Georgia	Biological and Agricultural Engineering
		North Carolina University	Chemical, Biological and Bioengineering
		Oregon State University	Biological and Ecological Engineering
		Purdue University University of Florida University of Illinois	Agric. and Biological Engineering
		Auburn University	Biosystems Engineering
		University of Georgia	Agric. Engineering
		Utah State University	Biological Engineering
		University of Minnesota	Bioproducts and Biosystems Engineering
2	Canada	University of Manitoba	Biosystems Engineering
		University of Saskatchewan	Biosystems Engineering and Soil Science
		McGill University	Bioresource Engineering
3	UK	Cranfield Institute of Technology	Agric. and Environmental Engineering
		Harper Adams University University of Reading	Agric. Engineering
4	Ireland	University College Dublin	Biosystems Engineering
5	Italy	University of Bologna	Agric. Engineering and Mechanics
6	Hungary	University of Debrecen	Agric. Engineering
7	Belgium	University of Liege	Gembloux Agro-Biotechnology
8	Germany	Leibniz University Hannover	Water Resources and Environmental Management
9	Austria	University of Natural Resources and Life Sciences	Sustainable Agricultural Systems Engineering
10	Turkey	Atatürk University	Agricultural Machinery and Technologies Engineering
		Ankara University	Agricultural Machinery and Technology Engineering
		Akdeniz University	Agricultural Machinery and Technology Engineering
11	Brazil	University of Sao Paulo	Biosystems Engineering
		University of Campinas	Agric. Engineering
12	China	China Agricultural University	Agric. and Biosystems Engineering
		Zhejiang University	Biosystems Engineering and Food Science
		Northwest Agriculture and Forestry University	Agricultural Soil and Water Engineering
13	India	Central Agricultural University	Agric. Engineering and Post Harvest Technology
14	Indonesia	Universitas Gadjah Mada	Agricultural and Biosystems Engineering
15	Malaysia	Universiti Putra Malaysia	Biological and Agricultural Engineering
16	Bangladesh	Bangladesh Agricultural University	Agric. Engineering and Food Engineering

Note: Source: http://en.wikipedia.org/wiki/Agricultural_engineering.

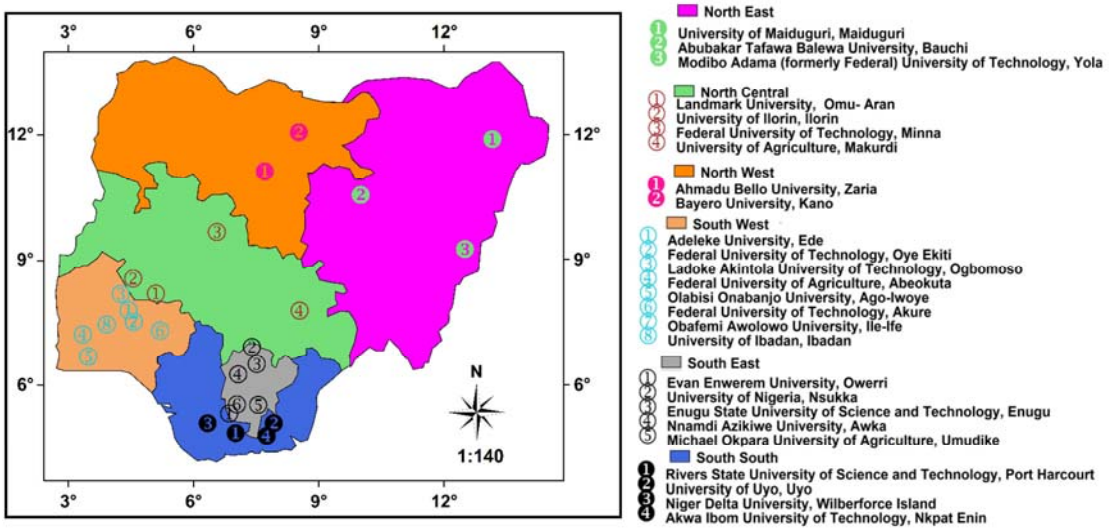

Figure 1 Agricultural engineering departments in Nigerian universities with respect to geopolitical zoning

5 Academic staffing for agricultural engineering education in Nigerian universities

Table 3 presents information on the number of academic staff in the different areas of specialization in agricultural engineering education in ten selected Nigerian universities. The results showed that 31.6% engaged in research in farm power machinery/ mechanization, 28.7% worked in the area of crop processing/post-harvest technology and 27.9% focused on soil and water conservation engineering/environment. Farm structures/environment attracted just about 11.8% of the staff. This may be partly due to the fact that lecturers in the area of farm structures are drawn from civil engineering background in some universities. With the recent inclusion of the environmental component by some universities, it is expected that more AEs will be attracted into this area of specialization in future. Although the highest proportion of academic staff (31.6%) engages in farm machinery, the impact on the society has been little felt. In most universities, farm power and machinery cover machines for soil tillage, livestock production, postharvest operations/crop processing and renewable energy. A lot of machines and implements have been designed for these purposes over the years but much of these have not been taken up by the industries or commercialized even though many of them are tailored towards meeting local indigenous needs. This raises the issue of low industrial uptake of research output but this is not the focus in this paper. Table 4 shows staff mix ratio across specialties in agricultural engineering programs including the number of female staff engaged. Professors constituted 39.6% of the faculty, senior lecturers are 26.4% while lecturer I and below constituted 33.9%. This contradicts the Nigerian Universities Commission (NUC) guidelines that professors, senior lecturer and others in any department should be in the ratio 20%, 35%, 45% (Tella and Daniel, 2013). This implies that many agricultural engineering departments in Nigerian universities are top heavy, especially, the first generation universities (notably, University of Ibadan, Ahmadu Bello University, University of Nigeria, University of Maiduguri, Obafemi Awolowo University and Federal University of Technology, Akure). This may partly be due to the fact that these universities are older and were among the first generation universities in Nigeria with more senior faculty who have not attain retirement age. In addition, it should be noted that not all the 27 universities have postgraduate programs in agricultural engineering. The top heavy institutions engage more in postgraduate programs. Although, this should encourage more graduate students, promote linkage/exchange/collaboration and fund sourcing for research and development, there is the need to rectify/redistribute staff mix to ensure adequate succession plan in all universities and equip the next generation of academics with requisite knowledge that will promote national development. A touring visit to the departments of agricultural engineering in Akwa Ibom State University, Adeleke University and Landmark

University showed that many professors were employed as visiting or adjunct staff. The implication is that many of the new universities depend on the older ones to train up their young academic staff. With the current increase in the establishment of agricultural engineering in some private universities in Nigeria, more openings are being created for the uptake of young AEs.

Table 3 Academic staff in agricultural engineering and their areas of specialization in ten selected Nigerian universities

S/N	Area of specialization	Farm power, machinery/echanization	Crop processing/post harvest technology	Farm structures/ Environment	Soil and water conservation engineering/Environment	Total
1	University of Ibadan.	2	3	2	4	11
2	Obafemi Awolowo University, Ile-Ife.	7	3	3	4	17
3	Federal University of Technology, Akure.	4	3	1	2	10
4	Federal University of Agriculture, Abeokuta.	5	5	0	5	15
5	University of Ilorin	4	4	2	2	12
6	Ahmadu Bello University, Zaria.	3	3	0	3	09
7	University of Maiduguri	4	3	3	6	16
8	University of Nigeria Nsukka.	5	5	4	6	20
9	River State University of Science and Technology, Portharcourt.	4	4	1	2	11
10	Ladoke Akintola University of Science and Technology, Ogbomoso.	5	6	0	4	15
	Total	43	39	16	38	136
	% in each specialty	31.6	28.7	11.8	27.9	100%

Table 4 Staffing of agricultural engineering department in ten selected Nigerian universities

S/N	Status	Professors/ readers	Senior lecturers	Lecturer I & lecturer II	Trainees (assistant lecturer & graduate assistant)	Total	Number of females lecturers
1	University of Ibadan.	7	2	2	0	11	1
2	Obafemi Awolowo University, Ile Ife.	9	5	3	0	17	1
3	Federal University of Technology, Akure.	5	2	1	2	10	2
4	Federal University of Agriculture, Abeokuta.	5	5	0	5	15	0
5	University of Ilorin.	3	6	1	2	12	0
6	Ahmadu Bello University, Zaria.	5	0	3	1	09	0
7	University of Maiduguri.	5	6	4	1	16	0
8	University of Nigeria, Nsukka.	5	3	6	6	20	4
9	River State University of Science and Technology, Portharcourt.	4	3	3	1	11	1
10	Ladoke Akintola University of Science and Technology, Ogbomoso.	2	2	8	3	15	2
	Total	50	34	31	21	136	10
	% of each status on total	39.6	26.4	19.0	14.9	100%	7.3%

It is noteworthy that manpower and human resource development are vital for growth in any economy. In 2006, when there were 91 universities, 95 research institutes, 58 polytechnics and 82 colleges of education in Nigeria (Taiwo, 2010), 22 universities were offering degree programs in Agricultural Engineering. With five additional departments of agricultural engineering in the last 12 years, the ability of most universities to impart knowledge should be improved with adequate funding and staffing. In a personal interview, 70% of M.Sc. students in three universities (Obafemi Awolowo University, University of Ibadan and Ladoke Akintola University of Technology) admitted that they returned for a Masters/Ph.D. degree after futile efforts to get jobs in the last 1-3 years. The higher number of intakes for postgraduate studies owing to unemployment in Nigeria should be a capacity booster for research and development if positively harnessed.

6 Some emerging issues in agricultural engineering education: the Nigerian case

With the trending curriculum changes in agricultural engineering in most institutions across the world, it is expected that more AEs will continue to emerge to deal with problems related to production of food, fiber and renewable energy. The integration of ICT into agrarian

life has brought about tremendous agricultural transformation in most developed economies in the western world. In the 21st century, increased ICT consciousness will be more crucial to livelihoods and food production from land clearing to the consumers' table.

With about 100 tertiary institutions and research institutes engaged in agricultural engineering training and research in Nigeria, the provision of adequate facilities for teaching and research, improved coordination of the students' industrial work scheme and good funding are issues requiring urgent attention to enhance training (Ogunlowo et al., 2005, Obiora and Emodi, 2013). The accreditation, visitation and resource verification exercises of the NUC and Council for the Regulation of Engineering in Nigeria must be harnessed to influence policy decisions and drive engineering education in the right direction. Like some countries where research and development in engineering is mostly driven and funded by the industry (Oliver, 1970), there is the need for tripartite academia/government/industry relationship in Nigeria to boost the quality of engineering education and make it address local problems. This requires knowledge and outcome based cooperation, synergistic and workable imperatives for learning/teaching, engineering training, practice and research. Although Nigeria has not fully recovered from the negative impact of brain-drain, many innovative technologies that were developed in universities, institutes and research centers have been largely neglected and unexplored. Many of these, if taken up by the investors can stimulate industrial development. In authors' opinion, a compendium of technological innovations and research outputs in agricultural engineering or establishment of technology parks, innovation banks or centers of excellence may be an important step to synergize research efforts in addressing regional problems.

In addition, lack of gender parity in applied science and engineering education has generally attracted serious global concerns in recent times (Woodcock et al., 2012). Although, national averages of women in the agricultural labor force varied from one region to the other, about 90% of women in most farming communities in sub-Saharan Africa are involved in postharvest operations (Boyle, 1988). A number of studies have shown that women's employment is concentrated in a few occupations typically as home/farm helpers, nurses, lower-school teachers, secretaries among others. Mohammed and Abdulquadri (2012) reported a ratio of 40/60 for women/men involvement in agricultural production and advocated for equitable participation of both women and men for increased productivity especially in reducing postharvest losses. Low enrolment of female students over the years has placed great limitations on the presence of females in agricultural engi neering. A typical scenario in this study is that of Obafemi Awolowo University where an average of 5 female students' enrolled for agricultural engineering per session in the last 10 years, constituting about 16% of the class. Although the number rose to 12 female students in 2016/17, the percentage (15%) was still in the same range. About 20-30 years ago, female students were rarely found in Agricultural Engineering except few cases when there may be 1 or 2. An oral interview with colleagues at the Universities of Ibadan and Ilorin revealed an average of 4 female students per session in the last 10 years constituting less than 10% of the class. In a previous study Aderemi et al. (2009) found that female enrolment in engineering/technology still fell below 30% in most Nigerian institutions. Mainstreaming gender balance into agricultural engineering as a profession is therefore increasingly becoming a matter of concern. The imperatives of gender balance in modern society occasioned by the United Nations Millennium Development Goals necessitates that conscious efforts should be geared towards increasing female enrolment into engineering education of the 21st century (Kimani, 2000; IFPRI, 2000). The society needs to help girls be more confident about their abilities about mathematics and the sciences.

On female participation in the teaching of AE programs, Table 4 showed that many departments rarely had female lecturers while the percentage was less than 8% in few cases where there are. University of Ibadan, Obafemi Awolowo University, and Rivers State University of Science and Technology had one female lecturer each; while, Federal University of Technology, Akure and Ladoke Akintola University of Technology,

Ogbomoso have two and University of Nigeria, Nsukka has four. Personal communication with colleagues in University of Uyo, Akwa Ibom State University and Federal University of Technology, Minna revealed that they had four, one and two female lecturers, respectively. The presence of more female lecturers will serve as role models to fresh undergraduates, most of whom have the wrong perspective that engineering is a male dominated field. Lack of women's presence in agricultural engineering teaching, research, development and application of new technologies may bring about inappropriateness of the new technologies and create new problems. Sometimes the views of women are different from that of men and bring new perspectives and diversity into research issues. Cases wherein the introduction of new technologies has increased women's workload instead of reducing it have been reported (Ashby, 2002). Men takeover the operations of some machines meant to ease drudgery for women and charge them exorbitant fees. This may be connected to the low presence of women in the development of such technologies. Given the principal roles that women play in agribusiness, food processing and consumer-related activity globally (Henn, 1984), their influence in agricultural research and development should not be undermined. In addition, discussions on brain drain have led to increased awareness of untapped human resources for science and technology (S&T) among women. Bound up with changing trends in the employment market are employers' changing attitudes to gender parity in human resource management. As part of the move towards total quality management and in pursuit of quality standards such as investments in people, top business leaders now recognize the difference that a highly skilled workforce can make in the organizational effectiveness and competitiveness. As a result, the recruitment, retention and development of the most talented people (including women) in organizational workforce are attracting global interests across spheres. However, when there is mass exclusion of a group of people with a different set of perspectives and worldviews, the profession unavoidably gets poorer. This may be intentional or coincidental. In recent years, another compelling reason for employers to pay greater attention to the female workforce is the awareness that women are increasingly becoming better skilled and educated, and account for almost half of university graduates in some regions of the world (Aderemi et al., 2009). Therefore, engineers of the 21st century must acknowledge that design considerations that are vital to the female gender are better captured by women-in-engineering. With more females in engineering education and research, gender related ideas will be adequately considered and agricultural engineering for agricultural transformation can be all embracing.

7 Career opportunities in agricultural engineering

The earliest AEs in Nigeria were employed by the State and Federal Ministries of Agriculture, while a few took up teaching and research appointments in schools of agriculture and research institutes where they taught and undertook research in farm mechanization, post harvest technology, irrigation and drainage. Employment opportunities improved between mid 70s and early 80s when the early generations of agricultural engineering departments were established in the universities. When institutes and agencies with agricultural engineering interests began to emerge (e.g. National Centre for Agricultural Mechanization, Ilorin, National Strategic Grain Reserves; Institutes of Agricultural Research and Training, Directorate of Food, Roads and Rural Infrastructure, National Agricultural Land Development Authority, Agricultural Development Projects and the River Basin Development Authorities), uptake of AEs increased. Agric Engineers rarely encounter difficulties in getting employed in those times because there were none to even fill the existing vacancies in those institutions. The order was transited from the classroom to well paid jobs in the civil service, government institutions or teaching and research. As the profession became more popular, the number of graduates increased and the river basins development authorities, agricultural development projects, Nigerian Tobacco Company, ministries, teaching and research institutions could not absorb all the graduates. Alternative employers were the private mechanized farms and produce companies (e.g. Amo Sanders, Asamu farms, Bagudu farms, Chi farms, Ajanla farms, Shonga farms, Olam and Zartech etc), equipment

manufacturers and service-based multinational companies (such as Steyr, Massey Fergusson, Dizzengoff etc). Many locally owned engineering firms had limited recruiting capacity or did not invest in manufacturing of agricultural tools and equipments.

Given the trending change of name and curricula rebranding, AEs now have diverse opportunities to explore and are emerging as the one of the most versatile engineering professionals in the world. With growing concerns about the attitude of young people towards agriculture and the vast uncultivated agricultural land in Nigeria, it is important that AEs should be fully integrated in policy formulation at all levels for effective agricultural transformation. Adekoya (2013) elicited some job opportunities wherein AEs had performed competently. They included: equipment design and fabrication, water/irrigation, sales, production and maintenance engineers; farm management, farm inputs marketing, research and development. In addition, Onwualu (2005) similarly elicited some areas in which AEs were notably relevant at graduation as follows:

a) Federal, State and District/Local Government Ministries/Departments of Agriculture, Works Fisheries, Environment, Energy, Mines, Natural Resources (Land and Water), Rural Development, Science and Technology.

b) Food processing, fisheries, biotechnology firms, greenhouses, renewable energy industries; manufacturing of goods for pollution control, waste handling and environmental safety.

c) Engineering companies involved in the design of agricultural and food processing machinery, borehole drilling, dam construction, irrigation and drainage systems. Storage and postharvest handling, value addition and processing of food and fiber (including breweries).

d) Teaching and research in universities, polytechnics, colleges of science/technology/ agriculture, research and training institutes.

e) Livestock farming and feed milling, aquaculture and forest resource conservation.

f) Financial institutions such as banks and agricultural credit institutions.

g) Renewable energy systems for sustainable agriculture, technologies for communication, environmental management and agricultural waste conversion systems.

h) Planning and execution of rural infrastructural projects (including, livestock housing, roads, buildings and electricity) for improved rural livelihoods;

The revised curricula in most institutions equipped the graduates with capacities to function in any of the sectors above.

8 Conclusions

The role of the AE in realizing the agricultural transformation agenda in Nigeria and the capabilities of Nigerian universities to provide manpower to drive it has been documented. Agricultural engineering education in Nigerian universities is responsive to national needs and is in tandem with global trends. However, the geographical spread of the institutions has implication on the nature and depth of research undertaken in specific subject areas in different regions. The poor staff strength in the area of soil and water conservation engineering has implications on diversity of research studies on the river basin authorities in Nigeria. The high proportion of academic staff in senior cadre in some Nigerian universities calls for improved succession plan. Considering the vast agricultural resources that Nigeria has and the strategic position she occupies as Africa’s most populous nation, harnessing the education of an AE towards total agro-industrial development deserves critical attention. While this publication does not aim at addressing all the problems associated with agricultural engineering education in Nigeria, it seeks to stimulate debates and trigger action on the inclusion of AEs in all tiers of governance and levels of policy formulation to drive the agricultural transformation agenda in Nigeria.

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References

Adekoya, L. O. 2013. Agricultural and Environmental Engineering Education and Career Options. Ile Ife, Nigeria: A Special Lecture in Honour of Prof Fola Lasisi by the Agricultural and Environmental Engineering Students Society, Obafemi Awolowo University.

Adekoya, L. O. 2014. Man Minus Machine Equals a Labourer. Ile Ife, Nigeria: 267th Inaugural Lecture Delivered in the Department of Mechanical Engineering, Faculty of Technology, Obafemi Awolowo University.

Aderemi, H. O., O. M. Hassan, W. O. Siyanbola, and K. Taiwo. 2009. Managing science and technology occupations of women in Nigeria. *Journal of Technology Management and Innovations*, 4(3): 34–45.

Adewumi, B. A. 2008. Engineering education for agricultural and rural development in Africa. *European Journal of Engineering Education*, 33(3): 321–330.

Akinyetun, T. S. 2018. Towards achieving food security in Nigeria: The economic strains and strategies for way forward. *Global Journal of Economics and Finance*, 2(1): 7–23.

Ashby, J. 2002. Mainstreaming Gender Sensitive Participatory Research. Participatory Research and Gender Analysis Program. Centro Internacional de Agricultura Tropical, Cali, Colombia. Available at: http://www.prgaprogram.org/prga/download/stakeholder_meeting/mainstreaming_ashby.pdf. Accessed 22 August 2002.

Blackmore, S. 2012. Precision Farming – Agricultural Engineering in the 21st Century. Available at: https://cdn.harper-adams.ac.uk/document/page/121207-Precision-Farming-and-Agricultural-Engineering-for 952937.pdf. Accessed 20 October 2017.

Boyle, P. 1988. The Socio-Economic Effects of Structural Adjustment on Women. Washington D.C., USA: USAID Office of Women in Development.

Brown, R. H. 1988. *Handbook of Engineering in Agriculture*. Boca Raton, Florida, USA: CRC Press.

Federal Ministry of Agriculture and Rural Development (FMARD). 2011. Agricultural Transformation Agenda: Federal Ministry of Agriculture and Rural Development Abuja, Nigeria. Draft for Discussion, Executive summary. Available at: https://www.unaab.edu.ng/attachments/Agricultural%20Transformation%20Blue%20Print.pdf. Accessed 20 November 2016.

FAO Statistics. 2016. FAO Statistics. Available at: http://www.fao.org/statistics/en/. Accessed 20 November 2016.

Heldman, D. R., and C. I. Moraru, 2010. *Encyclopedia of Agricultural, Food, and Biological Engineering*. 2nd ed. Taylor and Francis, UK: CRC Press.

Henn, J. K. 1984. Women in the rural economy: past, present, and future. In *African Women South of the Sahara*, ed. M. J. Hay, and S. Stichter, ch. 1, 1-18. New York, USA: Longman Group Limited.

Igbeka, J. C. 2002. A brief write-up on Agricultural Engineering Department, University of Ibadan. In *Agricultural Engineering in Nigeria: 30 years of University of Ibadan Experience*, ed. E. A. Ajav, A. O. Raji and T. A. Ewemoje. Ibadan, Nigeria: Aluelemhegbe Publishers.

International Food Policy Research Institute (IFPRI). 2000. Women: The Key to Food Security. Washington D.C., USA. Available at: http://www.ifpri.org/pubs/ib/ib3.pdf. Accessed 22 August 2017.

Kimani, L. 2000. Institutionalizing Gender in the Kenyan Agricultural Research Institute. Available at: http://www.isnar.cgiar.org/gender/index.htm. Accessed 7 November 2017.

Makanjuola, G. A. 1977. Farm Mechanisation in Nigeria: Constraints and Prospects. Unife Inaugural Lecture Series. Department of Agricultural Engineering, University of Ife, Nigeria. pp 2–3.

Mijinyawa, Y. 2005. Agricultural engineering education in Nigeria. *Agricultural Engineering International: The CIGR Ejournal*, Vol. VII, Invited Overview Paper No. 10.

Mohammed, B. T., and A. F. Abdulquadri. 2012. Comparative analysis of gender involvement in agricultural production in Nigeria. *Journal of Development and Agricultural Economics*, 4(8): 24 –244.

Obiora, C. J., and A. I. Emodi. 2013. Restructuring the agricultural extension service for effective agricultural transformation agenda in Nigeria. *Greener Journal of Agricultural Science*, 3(6): 511–517.

Odigboh, E. U. 1985. Mechanization of Cassava Production and Processing: A Decade of Design and Development. An Inaugural Lecture Delivered in the Department of Agricultural Engineering, Faculty of Engineering, University of Nigeria. pp 3.

Ogunlowo, A. S., L. A. S. Agbetoye, B. A. Adewumi, and A. A. Adesina. 2005. The contributions of the universities of technology to the technology of food Storage and processing. *FUTA Journal of Engineering and Engineering Technology*, (4): 77–85.

Olagbende, H. O., E. F. Aransiola, B. S. Ogunsina, O. Sanda, and D. Shonibare. 2016. Modification of a fixed bed reactor system for pyrolytic conversion of royal poinciana pods into alternative fuels. *International Journal of Renewable Energy Research*, 6(4): 1350–1360.

Oliver, E. F. 1970. Agricultural Engineering Education in Developing Countries. Office of International Programs and

Studies, University of Illinois, Urbana-Champaign. Available at: http://pdf.usaid.gov/pdf_docs/PNABJ265.pdf. Accessed 6 November 2017.

Onwualu, A. P. 2005. Agricultural Engineering Practice in Nigeria (NIAE Book of achievements). Nigerian Institution of Agricultural Engineers, National Centre for Agricultural Mechanization, Ilorin, Nigeria, pp 5.

Sigrimis, N., A. Munack, Y. Hashimoto, and J. De-Baerdemaeker, 2005. Prospects in agricultural engineering in the information age: technological developments for the producer and the consumer. *Agricultural Engineering International, The CIGR Ejournal*, Invited Paper, 1–20.

Stewart, R. E. 1979. *Seven Decades that Changed America: A History of the American Society of Agricultural Engineers: 1907-1977*. St. Joseph, Michigan, USA: American Society Agricultural Engineers.

Taiwo, K. A. 2010. The role of food technology in the actualization of vision 2020. In *3rd International Conference and Exhibition of the School of Science and Computer Studies*. Ado Ekiti, Ekiti State, Nigeria, 15-18 August.

Tella, Y., and S. Daniel. 2013. Mathematical model for Nigerian university academic staff mix by rank. *International Journal of Educational Planning and Administration*, 3(2): 145–150.

Tilman, D., C. Balzer, J. Hill and B. L. Befort. 2011. Global food demand and sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108(50): 20260–20264.

Wilson, C. L. 2013. Establishment of a World Food Preservation Center: concept, need and opportunity. *Journal of Postharvest Technology*, 1(1): 1–7.

Woodcock, A., W. G. Graziano, S. E. Branch, I. Ngambeki and D. Evangelou. 2012. Engineering students' beliefs about research: sex differences, personality and career plans. *Journal of Engineering Education*, 101(3): 495–511.