UNIVERSITY OF ILORIN

THE ONE HUNDRED AND EIGHTY-SEVENTH (187TH) INAUGURAL LECTURE

GATHERING THE FRAGMENTS … THAT NOTHING IS WASTED: ADVANCING AGRICULTURAL MECHANIZATION, ENERGY AND FOOD SOVEREIGNTY CATENA

By

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Distinguished Invited Guests,
Members of My Nuclear and Extended Families,
Members of the University of Ilorin Alumni Association; particularly, Unilorin Agricultural and Biosystems Engineering Alumni,
Distinguished Students of Agricultural and Biosystems Engineering,
Gentlemen of the Print and Electronic Media,
Great Unilorites!
Distinguished Ladies and Gentlemen

Preamble

I give thanks to the Lord of all lords: for He is good and His mercy endures forever (Psalm 136:3). I equally thank the Vice-Chancellor, Prof. Sulyman Age Abdulkareem for approving my presentation of the 187th Inaugural Lecture of the University of Ilorin. Also, with grateful heart I stand to present the 4th Inaugural Lecture from the Department of Agricultural Engineering. The first one was delivered on 26th March 1987 by Professor E. U. Nwa, the pioneer Head of Department, with the title “Irrigation and Nigeria”; the second was on 26th May 2011, by Professor K. C. Oni, a former Head of Department and former Dean of Engineering and Technology with the title “Man, Machine and Food Insecurity” and the third one was delivered by Professor A. O. Ogunlela, a former Head of Department on 17th November, 2011 with the title “Towards God’s Own Watershed”. The second Inaugural lecture that was given in the Department was from the Farm Power and Machinery option of Agricultural and Biosystems Engineering. Today, the second lecture is coming from the same area and 8 years after the last lecture from the Department.

My lecture is titled **“Gathering the Fragments … that Nothing is Wasted: Advancing Agricultural Mechanization, Energy and Food Sovereignty Catena”.**

2. Introduction

When God created man and installed him in his first estate He provided all the needed resources for his upkeep and sustenance. The main preoccupation of man was to till and take care of the Garden (Gen. 2:15). The Disciples of Christ were taught and trained to take caution on the management of resources without subjecting same to waste (John. 6:12-13). As at today in Nigeria, can we say we satisfied with the status and level of utilization of our natural resources? Is the nation truly optimizing its endowed agricultural and human resources in meeting the food needs of her citizens? Why is the World Hunger on the rise? Why is it on record that an estimated one third of all food produced globally is lost or goes to waste?

Sweet is the love which nature brings. Our meddling intellect misshapes the beauteous form of things, we murder to dissect. Different regions of the world are sufficiently endowed in measures commensurable to their ability to harness the available resources for their wellbeing and comfort. The activities of man on the surface of the earth have proved that man has lost his ability and lacks wisdom to live in harmony with nature. These are responsible for all the harmful effects on the environment. In the real sense of it, in our world, man is the only enemy of mankind and his environment. This brings about colossal wastes. No bird spoils its own nest. The unconscionable disposal of wastes by man into the compound of his neighbour is unwittingly endangering the environment and tilting the ecological balance. This subsequently threatens the very survival of mankind.

The amount of garbage produced by a person in his life time is approximately 700 times his adult weight. Man exploited the land for cultivation that became barren today without heeding to the warning of Plato that over-cropping and over-grazing will lead to soil erosion that may make deserts of fertile lands [1]. That is the experience that we are currently facing. When a knowledgeable person commits a mistake, it is always brutal. Animals obey the law of nature unknowingly or by instinct, but man is the only one of the 20 million animal species who understands well the laws of nature, yet disobeys with carefree abandon.

Mr. Vice-Chancellor Sir, the issue of wastage of resources requires holistic approach to be able to put it to a halt. The gathering of the fragments of the constituents of our natural endowment for productive agricultural activities and in the protection of our environment is a joint responsibility of every citizen. These I have elected to combat in the course of my research efforts so far.

2.1 Understanding Agricultural and Biosystems Engineering

Agricultural and Biosystems Engineering is the application of engineering and technology at the interface of physical and biological sciences to solve agricultural production problems. It requires the application of knowledge from other branches of engineering to the extent that such knowledge may be used in solving engineering problems of agriculture in all ramifications and in rural living. Agricultural and Biosystems Engineering is divided into six major sections: Farm Power and

Machinery; Aquacultural Engineering; Crop Processing and Storage; Farm Structures and Environment; Food and Bioprocess Engineering; Soil and Water Engineering; and Renewable Engineering. My area of specialization is Farm Power and Machinery Engineering, which involves the application of mechanical, physical, biological and electronic principles to the solution of real-life problems or issues in crop/ fruit/ vegetable/fibre production and processing. Its major divisions are machine design and development, tillage systems, instrumentations and control, renewable energy, automation of livestock farming and power systems. Agricultural and Biosytems Engineering is one of the key disciplines that can bring about food sovereignty.

2.2 My Journey into Agricultural and Biosystems Engineering

Late Pa Deacon Paul Salami Olaoye, a worker under the then Public Works Department (PWD), Ilorin province was so passionate about his work but he would spend his leisure on two other fields - his agricultural field and mission field. Working on the farm (agricultural field) always took the latter part of my father's day after closing from work and on Saturdays while Sundays are devoted for the work on the second leisure field of mission. As a middle-born child in the family, my younger siblings and I could only go to the farm on Saturdays to help out with farm work due to school commitments during the week. But, from my early interactions with my father on the farm and my personal involvement, I experienced how laborious farm work was. This aroused my desire to find a less tedious way to carry out farming activities with machines. At the end of each planting season, Late Deacon and Mama Paul Salami Olaoye, after harvesting their crops and as a family tradition, all households, and those houses within the vicinity of our compound must be given part of the harvest, while the remaining would be stored in the warehouse to feed the Olaoye family all through the following year, when another planting season would kick off.

Having being a part of the family farming activities and watching my father aging fast due to the rigours of manual farming, I was dissatisfied with the status quo, which therefore influenced my unquenchable desire to help find a mechanical alternative to manual farm work. This was the beginning of my interest in mechanical agriculture. At that time, I knew next to nothing about mechanical or agricultural engineering but fate was leading me in that direction though unknown to my father. The first step I took towards finding a mechanical solution was to help my father to get a tractor to plough, harrow and ridge the farmland. Further discussions with my father on issues of mechanization of his farming activities increased my interest in mechanization of farming. Though it was highly limited in scope at that time but the seed had been sown and it began to grow in me. Little wonder that my first agricultural machine design and fabrication project was a mechanical planter. I was able to get all the required materials, information and support to make this a reality, arising from my interactions and discussions on farming subjects with Late Deacon Paul Salami Olaoye. It is no surprise that fate made me study Agricultural Engineering eventually.

During my early stages in life, my eldest brother, Dr. Sunday Paul Olaoye and the first born of the Olaoye family was very academically endowed and all other siblings were looking up unto him having learnt a lot from our parents while growing up in the family. The case with Late Deacon and Mama Paul Salami Olaoye could be synonymous to the remark that was made concerning Abraham in Gen. 18: 19. Dr. Olaoye was a role model to all of us – his younger siblings. I loved to stay with him and we the younger ones loved to spend our holidays around him. He had a bosom friend – Late Dr. Davis Olu Ajayi who was better described as a soul mate to my elder brother. They were both very studious and led us by showing good examples. I spent a lot of time around them. As I grew, I noticed that “Boda Olu” as I fondly called him was always calling me – Professor. I wondered why, so I asked him. He told me the story of having asked me then as a young boy, what I wanted to become in life and my response was – a Professor. The meaning of which I didn't know at that time. So, he started calling me Prof. from childhood. He consciously monitored my progress very closely as I veered into academics and as I grow older. Unfortunately, death took Dr. Davis Olu Ajayi away when I had just become a Reader. It was a very painful loss and experience to me that he did not wait to witness the fulfillment of what he had prophesied for so long. I cannot but recognize him on a day like this. Today, as an Agricultural Engineer, I am more than you think. This is a slogan we adopted at the 2019 Nigerian Institution of Agricultural Engineers (NIAE) conference and it is apt.

My Research Background: Research is an investigative study to obtain information or new facts. "Basic research" is conducted to establish new concepts while "applied research" is a "directed research", conducted to solve a problem in the society [2]. I was admitted in 1985 to study Agricultural Engineering. I have never heard about Agricultural Engineering, even during the career counselling throughout my secondary education. The only engineering course I had initially known that would enable me to venture into agricultural mechanization was Mechanical Engineering which I applied to study.

Prof. K. C. Oni admitted me to study Agricultural Engineering in 1985. This I believed was not by coincidence when in my final year again I was assigned to him to supervise my undergraduate project entitled "Design and Construction of a Row Crop Grain Planter". This project exposed me to contemporary problems in Agricultural Engineering and further aroused my consciousness for immediate further studies in Agricultural Engineering. Late Prof. O. O. Babatunde supervised my Master's of Engineering thesis, and in his unique and characteristic approach, he re-enacted my interest in the characterization of biological materials and postharvest engineering. He left a lasting impression on me that made me to further view issues diversely beyond a stereotype perception.

Prof. K. C. Oni kept a close watch on my academic progression as I was fortunate to be recalled from the Federal Polytechnic, Bida to join the services of the University of Ilorin in 1998. I had the opportunity to work closely with Prof. K. C. Oni who further mentored me in my area of specialization with focus on the development of Agricultural Machinery.

3. Gathering the Fragments: Agricultural Mechanization, Energy and Food Sovereignty Catena

3.1 Agricultural Mechanization

The mechanization of agriculture requires energy and this comes from farm power sources. In large scale agriculture the predominant farm power source is the diesel engine installed in tractors, combines, other self-propelled machines and stationary units where electric motors also play an important role. In the developing world, engine power is generally on the increase as low-cost tractors and other engine-powered technologies become increasingly available, especially from India and China [2].

Mechanization covers all levels of farming and processing technologies, from simple and basic hand tools to more sophisticated and motorized equipment [4]. It eases and reduces hard labour, relieves labour shortages, improves productivity and timeliness of agricultural operations, improves the efficient use of resources, enhances market access and contributes to mitigating climate related hazards. Sustainable mechanization considers technological, economic, social, environmental and cultural aspects when contributing to the sustainable development of the food and agricultural sector.

There is a pressing need to increase global food production to feed the growing, and increasingly urban, global population [5]. The world is facing a crisis originated by a three-pronged attack which threatens the well-being of vast numbers of the planet's people. The crisis which has its origins in the convergence of population growth, natural resource degradation and the impacts of climate change. The population of the world currently stands at 7.5 billion and is set to rise to around 10 billion by 2050; after that it will continue to rise and may exceed 12 billion by the end of the century [6]. These global figures mask regional variations and it seems that Asia (especially south Asia) and Africa will be home to the vast majority of the global population as their rates of growth are highest (Figure 1). Buffet [7] estimates that the population of Africa is projected to increase from 1.1 billion today to at least 2.4 billion by 2050; while the Asian population will rise from the present 4.5 billion to 5.3 billion over the same time period [8].

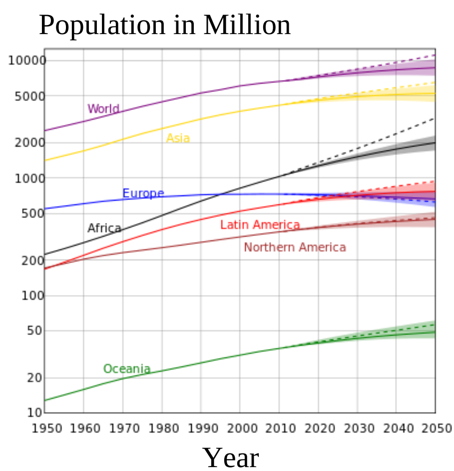


Figure 1: Projected World Population [12]

In most developing countries, there is little room for the expansion of arable land. Virtually no spare land is available in South Asia and the Near East/North Africa. Where land is available, in sub-Saharan Africa and Latin America, more than 70 percent suffers from soil and terrain constraints. Between 2015 and 2030, therefore, an estimated 80 percent of the required food production increases will have to come from intensification in the form of yield increases and higher cropping intensities [9]. However, the rates of growth in the yield of the major food crops such as rice, wheat and maize are all declining. Annual growth in wheat yields slipped from about 5 percent a year in 1980 to 2 percent in 2005; yield growth in rice and maize fell from more than 3 percent to around 1 percent in the same period [10]. Achieving food security in an environmentally sustainable way is one of our greatest challenges [11].

To overcome the burgeoning future challenges to our food supply and to the environment, sustainable intensification of agricultural production is therefore desired. Sustainable intensification has been defined as producing more from the same area of land while reducing negative environmental impacts and increasing contributions to natural capital and the flow of environmental services [12].

Mechanization is useful and important as it takes place in almost every facet of human endeavour to meet required target and to boost efficiency. It speeds up the rate at which jobs are accomplished and are carried out in the nation's economy such as in banking, agriculture, building, construction, and education, among others.

Agricultural mechanization is the process whereby equipment, machineries and implements are utilized to boost agricultural and food production. It is the application of machineries, equipment and implements in the day to day farm activities to increase marginal output in food production and poverty eradication. Agricultural mechanization reduces drudgery, which hitherto makes it difficult for large scale food production and which has also been making it difficult for Nigeria to meet her food requirement for her teeming population.

Mechanization is a crucial input for agricultural crop production and one that historically has been neglected in the context of developing countries. Factors that reduce the availability of farm power compromise the ability to cultivate sufficient land and have long been recognized as a source of poverty, especially in sub-Saharan Africa. Increasing the power supply to agriculture means that more tasks can be completed at the right time and greater areas can be farmed to produce greater quantities of crops while conserving natural resources. Applying new technologies that are environmentally friendly enables farmers to produce crops more efficiently by using less power.

Increasing levels of mechanization does not necessarily mean big investments in tractors and other machinery. Farmers need to choose the most appropriate power source for any operation depending on the work to be done, who is performing it and how their needs are met effectively and efficiently. The level of mechanization is predicated on the ratio of workforce to overall population and available power units (Table 1) [13]. Women play an important role in many farming based communities, and in some countries, up to 80 percent of the total farm labour comes from women [14]. This implies that power sources (human, animal or motor-based) need to be adapted to such necessities from an ergonomic, social, cultural and economic point of view. The reduction of drudgery is a key element of sustainable mechanization and contributes to reducing women's hard workload by taking into consideration technologies apt to their needs and improving their access to appropriate forms of farm power.

Table 1: Selected indicators of agricultural mechanization

	Africa	**Latin America**	**Europe**	**World**
Total population 2000 (million)	643	294	509	5,295
2000 agricultural workforce (million)	211	40	30	1481
Cropland (million ha)	181	115	138	1,441
Tractors	544,000	1,125,000	10,384,000	26,411,000
Agricultural workers/tractor	387	36	3	56
Hectares/tractor	333	102	13	55
Harvesters	70,000	117,000	831,000	3,956,000
Agricultural workers/harvester	3,019	340	36	374
Hectares/harvester	2,599	980	166	364

Source: World Odometer [13]

Sustainable mechanization is a means to an end. Farmers who have access to improved agricultural tools and powered technologies can shift from subsistence farming to more market-oriented farming, making the agricultural sector more attractive to rural youths. Sustainable mechanization supports the development of food supply chains through improved agricultural practices for increased production and enhanced food security [15].

Sustainable mechanization is applied to agricultural land preparation, supports timely seeding and planting, weed control, integrated pest management, precise fertilizer application, harvesting, preparation for storage, and value addition operations along the food supply chain in terms of on-farm processing, transport and marketing. Sustainable agricultural mechanization covers all levels of farming and processing technologies, from simple and basic hand tools to more sophisticated and motorized equipment.

Today, the debate on development of agricultural mechanization turns into the debate on improving agricultural techniques as well as helping them improve the sustainability of the entire agricultural system [16]. Evidence suggests that mechanization has a major impact on demand and supply of farm labor, agricultural profitability, and a change in rural landscape [17]. Therefore, agricultural mechanization can be defined as an economic application of engineering technology to increase the labour efficiency of farming and agricultural productivity. The United Nations Food and Agriculture Organization (FAO) and the United Nations Industrial Development Organization (UNIDO) concluded that the goals of agricultural mechanization are to reduce labor, increasing productivity by updating executive operations in order to gain more power, increasing the level of cultivated land, moving toward industrialization and strengthening the market for rural economic growth and ultimately improving the livelihood of farmers. [18, 19].

3.2 Energy Issues

The way energy is produced influences the way food is grown, processed, packaged and sold. Industrial food production in particular relies heavily on fossil fuels. From the production of agrochemicals to fuel for mechanization and long distance transportation, this kind of production is responsible for one third of global greenhouse gas emissions [20]. Fossil fuel based production and the resulting acceleration of climate change is not gender neutral. Since women in many part of the world on average earn less than men, they are at a disadvantage when faced with increasing costs of adaptation yet they tend to be less present in decision-making about climate policy. Care work is furthermore performed more often by women, who will bear a disproportionate share of the burden of growing health problems or natural disasters caused by climate change. Building food sovereignty means dismantling an ecologically destructive fossil fuel based system. To democratize the decisions about energy, and begin this transformation, many groups and movements are calling for energy sovereignty. In other words, “Energy sovereignty has appeared as a concept from which to stand, act and think about an energy transition” [21].

Three entry levels of energy needs for agriculture and the requirements for rural energy services in developing countries are based on the "energy ladder" approach. These include: basic human work for tilling, harvesting and processing, together with rain-fed irrigation, none of which involve an input from an external fuel source; then the use of animal work to provide various energy inputs; and finally, the application of renewable energy technologies such as wind pumps, solar dryers and water wheels, together with modern renewable and fossil fuel based technologies for tractive and stationary power applications, and for processing agricultural products [22].

It can be seen that wood-fuel still plays an important role for households even at higher income levels. In agriculture and industry, diesel engines and electricity replace human and animal work; where rural electrification is not available or too costly, diesel generators may be used instead. Wind pumping for water extraction from wells, together with mini-hydro and, more recently, PV systems for small-scale electricity supplies for homes, farms and community buildings are possible renewable energy options [23].

Energy is needed for activities such as mechanization, water pumping, irrigation, fertilizer production, transport and food processing and storage. The role of agriculture as a major energy supply sector is rarely recognized or put into practice. Awareness of the potential for bioenergy as an economic driver for rural development, together with growing attention to global climate change have highlighted this new approach to the energy function of agriculture.

The production and use of biomass as energy sources are linked to many issues, including agriculture and food sovereignty or security, land use and rural development, sustainable forest management and biodiversity conservation, and mitigation of climate change. Bioenergy must also be seen in relation to poverty, population development and health. The fact that women and children in many rural areas spend a good portion of their working day in search for wood-fuel reflects the need to look at bioenergy in the context of gender roles and survival strategies for the poorest of the poor.

Agricultural practices in many developing countries continue to be based to a large extent on animal and human energy. Insufficient mechanical and electrical energy is available for agriculture hence the potential gains in agricultural productivity through the deployment of modern energy services are not being realized. Agricultural energy demand can be divided into direct and indirect energy needs. The direct energy needs include energy required for land preparation, cultivation, irrigation, harvesting, post-harvest processing, food production, storage and the transport of agricultural inputs and outputs. Indirect energy needs are in the form of sequestered energy in fertilizers, herbicides, pesticides, and insecticides [23].

Mankind has adapted a variety of resources to provide for energy in agriculture. Animal draught power obtained through domestication of cattle, horses and other animals has existed for over 8,000 years, the water wheel is over 2,000 years old, and windmills were introduced over 1,000 years ago. Direct sun energy for drying and biomass fuels for heating have also been prominent as agricultural energy inputs for centuries [24].

The bulk of direct energy inputs in developing countries, particularly in the subsistence agriculture sector, is in the form of human and animal work. Human work has a limited output, but humans are versatile, dexterous and can make judgments as they work. This gives humans an advantage in skilled operations such as transplanting, weeding, harvesting of fruits and vegetables and working with fibres.

There are three major factors in assessing the future role of biomass in rural energy supply [25]:

i) the supply of biomass as feedstock can improve the efficiency with which agricultural and forestry land is used in developing countries. In industrialized countries, biomass could provide non-food feedstock from marginal or surplus agricultural land;
ii) modern biomass production and exploitation offers the opportunity to address multiple environmental concerns such as land degradation, biodiversity, air pollution and health problems;
iii) biomass as a raw material for high value electricity generation is becoming cost-competitive with fossil fuel energy systems.

Agriculture can deliver a wide range of non-food goods and services. This can include its use as a viable, sustainable source of energy, as set out in the FAO perspective [26] on the "Multifunctional Character of Agriculture and Land (MFCAL)". The perspective recognizes that agricultural activity and related land-use contribute directly to other non-agricultural functions comprising social, environmental, economic and cultural goods and services. These can result in significant benefits or costs. Evidence suggests that, in addition to food security, agriculture makes a major contribution to achieving sustainability in rural development, energy and the environment at local, national and global levels. The effective operation of the market stimulates the identification and enhancement of these multiple functions and the emergence of new techniques and technologies.

Food Sovereignty

Food Sovereignty is the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems.

According to FAO [27] World Hunger is on the rise; in 2011, FAO presented the estimate that around one third of the world's food was lost or wasted every year. Since then, much has changed in the global perception of the problem. We all have a part to play in reducing food loss and waste, not only for the sake of the food but for the resources that go into it.

Food loss and waste has indeed become an issue of great public concern. The 2030 Agenda for Sustainable Development reflects the increased global awareness of the problem. Target 12.3 of the Sustainable Development Goals calls for halving per capita global food waste at retail and consumer levels by 2030, as well as reducing food losses along the production and supply chains.

The Food Loss Index is calculated by FAO [27] and provides new estimates for part of the supply chain, from post-harvest up to (but not including) retail. The Food Waste Index measures food waste at retail and consumption levels. The Food Loss Index and the Food Waste Index are two indices which allow us to measure more precisely how much food is lost in production or in the supply chain, or is wasted by consumers or retailers.

Food loss is the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain, excluding retailers, food service providers and consumers. Empirically, it refers to any food that is discarded, incinerated or otherwise disposed of, along the food supply chain from harvest/slaughter/catch up to, but excluding, the retail level, and does not re-enter in any other productive utilization, such as feed or seed.

Food loss, as reported by FAO [27] occurs from post-harvest up to, but not including, the retail level. Food waste refers to the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers. Food is wasted in many ways:

i) Fresh produce that deviates from what is considered optimal, for example in terms of shape, size and color, is often removed from the supply chain during sorting operations.
ii) Postharvest losses and waste account for high percentage of food loss in Nigeria. Grains, vegetables, fruits such as mangoes, tomatoes, pineapples and all manner of produce perished after three days of harvest.
iii) Initial estimates made by FAO [27] for the Food Loss Index tells us that around 14% of the world's food is lost from post-harvest up to (but not including) the retail level.
iv) The fertile nature of agricultural lands in Nigeria support growth of crops such as shea nuts, locust bean, castor nuts, among so many other cash crops in the wild but unattended to. Unfortunately, these fragments account for crops over 13.5 metric tons per hectare of crop loss per annum.
v) The percentage of food loss and waste in Nigeria is more than estimated 30 % of world food loss yet there exists feasible hunger in the land.
vi) Livestock development is an important component of Nigeria agriculture with abundant social and economic potentials. Domestic production of livestock products is

far below the national demand, resulting in large imports of livestock and livestock products.

The demand for Food Security reaffirmed the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger. Less food loss and waste would lead to more efficient land use and better water resource management with positive impacts on climate change and livelihoods. Reducing food loss and waste is critical to creating a Zero Hunger world and reaching the world's Sustainable Development Goals (SDGs), especially SDG 2 to end hunger and SDG 12 that will ensure sustainable consumption and production patterns [28].

To combat the problem of food loses in Nigeria, the agricultural sector requires systemic deployment of agricultural mechanization and agro-industrial development policies that will bring about encompassing irrigation development, mechanically assisted crop production and processing with appropriate adoption of research findings and technologies. Energy as one of the prime inputs to agriculture plays a decisive role in attaining food security. Energy drives mechanization. Attempts to alleviate hunger and to promote rural development and food security must be accompanied by efforts to promote the key role of energy. Low quality and the meagre amounts of energy available for the food production and supply chain are to be seen as the main issue of food security and sovereignty challenges.

3. MY CONTRIBUTIONS TO RESEARCH IN FARM POWER AND MACHINERY ENGINEERING

3.1 Contributions to Research in Farm Power and Machinery Engineering

My contribution to knowledge can be broadly classified into five categories:

i) Characterization of Biological Materials, Optimization of Tillage Operations and Crop Processing Parameters.

ii) Design and Development of Farm Machinery and Equipment for reduction of Energy Input and for Increased Agricultural Productivity.

iii) Process and Product Development of Agricultural and Biological Materials.

iv) Renewable Energy Studies.

v) Application of Computer Modelling and Simulation in Agricultural and Biological Systems.

3.1.1 Characterization of Biological Materials, Optimization of Tillage Operations and Crop Processing Parameters.

My interest to conduct research in characterization of biological materials was initiated by my desire to mitigate waste that might occur during tillage and post-harvest operations. Material waste is related directly to improper selection of crop and machine variables during crop processing [29, 30, 31]. Understanding tractor tractive performance during ploughing operation and generation of requisite models for future prediction is key to efficient tractor-implement combination. Many researchers over the years have seen this as a major challenge. Improved performance of a tractor-implement combination can correspondingly lead to reduction in energy requirement and power losses at the soil-wheel interface and subsequently enhance efficient commitment to operating within the requisite working conditions.

Olaoye [32] conducted studies on the effects of five tillage treatments: No tillage (NT), Disc harrowing (DH), Mould board ploughing followed by disc harrowing (MPH), Disc ploughing followed by disc harrowing (DPH), and Disc ploughing followed by two passes of disc harrowing (DPHH) on crop residue cover, soil properties and some yield parameters of cowpea were investigated for a Derived Savannah Ectone soil. The residue left on the soil surface for NT, DH, and MPH is not significantly different from DPH and DPHH. The NT 32.1 % and 44.3 % left more residue on the soil surface than the DPH and DPHH treatments, respectively. The NT treatment had least average value of soil bulk density of 1.01 g/cm^3. The mean soil bulk densities for the DH, MPH and DPH and DPHH vary between 1.20 to 1.35 g/cm^3. The soil moisture content decreased with increasing soil depth. At the soil depth of 10 to 30 cm, the cone penetration resistance at NT was 1.18 MPa compared with 0.92 MPa for the DH treatment, although these were not significant (p0.05). The tillage treatments had a significant effect on grain yield, leaves and stems, root length density, and number of pod per plant of cowpea except on the germination count. DH and NT treatments gave different grain yield and number of pods per plant but these values were not statistically different and represent the highest grain yield and number of pods per plant among the other treatments considered. The root zone exploration revealed highest root density at shallow depths with the DH and MPH treatments.

The agronomic performance of the cowpea was significantly influenced by the tillage methods. DH treatment gave the highest grain yield and number of pods per plant followed by the NT treatment. The effects of the MPH, DPH, and DH treatments revealed an increase in the growth of the vegetative part of cowpea, shown by increased root length density, leaves and stems of the plant without increasing the grain output.

Olaoye [33] investigated some physical properties of castor nut relevant to the design of processing equipment. Some of the physical properties of castor nut were studied, namely: shape, surface area, angle of repose, static coefficient of friction and the behaviour of the nut under compressive loading. Representative samples of plant materials were collected from three varieties. The results of the investigation show that the frequency distribution of the size, shape and contact area for the nuts of each variety follow a normal distribution curve. The angle of repose of the nut ranges between 25 and 29^O. Castor nut Evahura had the highest value of angle of repose. The hardness values for the nuts were 23.6, 25.6 and 70.9 kN/m^2 for castor nut

Ojji, Evahura, and Asbowu varieties, respectively. The coefficient of sliding friction for each variety of nuts showed varying values on different structural surfaces.

Olaoye [33] noted that the mean difference between the energy requirement when the nut is loaded along different axes of orientation gave an indication that half of the energy required along the major axis is needed when the nut is loaded along the minor axis for the three varieties that were examined Table 2.

Olaoye and Oloruntoyin [34] investigated the vegetation characteristic of Ecological Zones of Kwara State, Nigeria, in response to different land clearing options. Figure 2 shows the vegetative cover of Kwara State. It was deduced that cost, time or period of operation, number of labour and machine employed and farm size are significant in the land clearing option selection. 500 m^2 was cleared in an average time of 31.92 hrs at an average cost of ₦ 9, 116.69 using manual land clearing plus burning while using manual land clearing cum winching and sawing 500 m^2 was cleared in 26.40 hrs at an average cost of ₦11,297.43 and similarly, using mechanical land clearing same area of land was cleared in 0.33 hr at an average cost of ₦ 128, 067.97.

Table 2: Compressive energy at bio-yield and rupture points for Ojji, Evahura and Asbowu varieties

Variety	Axis of loading	Energy at different points, J	
		Bio-yield	Rupture
Ojji	Major	0.040	0.041
	Intermediate	0.037	0.039
	Minor	0.020	0.021
Evahura	Major	0.058	0.065
	Intermediate	0.045	0.048
	Minor	0.028	0.029
Asbowu	Major	0.090	0.092
	Intermediate	0.075	0.081
	Minor	0.045	0.047

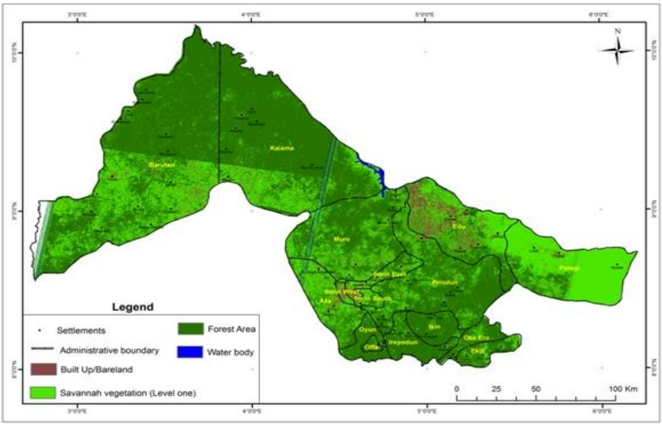


Figure 2: Vegetation Characteristic Map of Kwara

In another work Busari and Olaoye [35] achieved optimization of the oil expression process by applying Central Composite Rotatable Design of Response Surface Methodology. The optimal conditions for oil yield within the experimental range of the studied variables were 7%, 110°C and 20 min; moisture content, roasting temperature and roasting duration respectively. These values of the optimum process conditions were used to predict optimum value of oil yield to be 25.77%. A second-order model was obtained to predict oil yield as a function of moisture content, heating temperature and duration. This research becomes significant in the biofuel studies as an alternative energy that could be produced using plant material without any conflict with food security.

3.1.2 Design and Development of Farm Machinery and Equipment for reduction of Energy Input and for Increased Agricultural Productivity.

Further steps were taken in my research endeavours towards designing and developing machines to reduce drudgery during farm operations, enhance value addition to crops and improve agricultural productivity.

My research work on mechanization of crop production was directed towards mechanizing shea nut, locust bean, castor nut, and sugarcane production among others. Shea nut and locust bean are crops that grow in the wild. My interest is to achieve development of machines for the primary processing of the crops.

Mechanization of Locust Bean Production

Locust bean tree occurs naturally in savannah forests. The locust bean seeds are the raw material for the popular *iru* condiment and the pulp surrounding the seeds in the fruit pods has been the source of local brews and sweeteners since the prehistoric times.

The primary crop processing of locust bean fruit is identified to include decorticating, depulpping, dehulling and crop drying. These processing activities are aimed at improving the quality of crop materials, transform the nature of this perishable crop to a stable commodity that one can recall and use for further processing or consumption. The chains of processing activities have potentials to spring up cottage industry that can provide additional employment and prevent crop product from being attacked by insects and rodents (Figure 3). The general goal of primary processing is to add value to the crop products.

There exists a distinct difference in the primary crop processing and secondary food processing of locust bean. The main food processing activity of locust bean that I have also worked on was the fermentation of the locust bean seed to produce the 'iru' condiment and the development of a locust bean cubing machine.

Mr. Vice-Chancellor Sir, the design and construction of major machinery for the primary crop processing activities of locust bean were carried out as part of my research activities and these include: decorticating machine (Figure 4), depulpping machine (Figure 5), dehulling machine (Figure 6), locust bean cabinet dryer (Figure 7) and locust bean parboiler (Figure 8)

(Morakinyo and Olaoye [36], Olaoye [37], Olaoye and Olotu [38] and Adamade and Olaoye [39]).

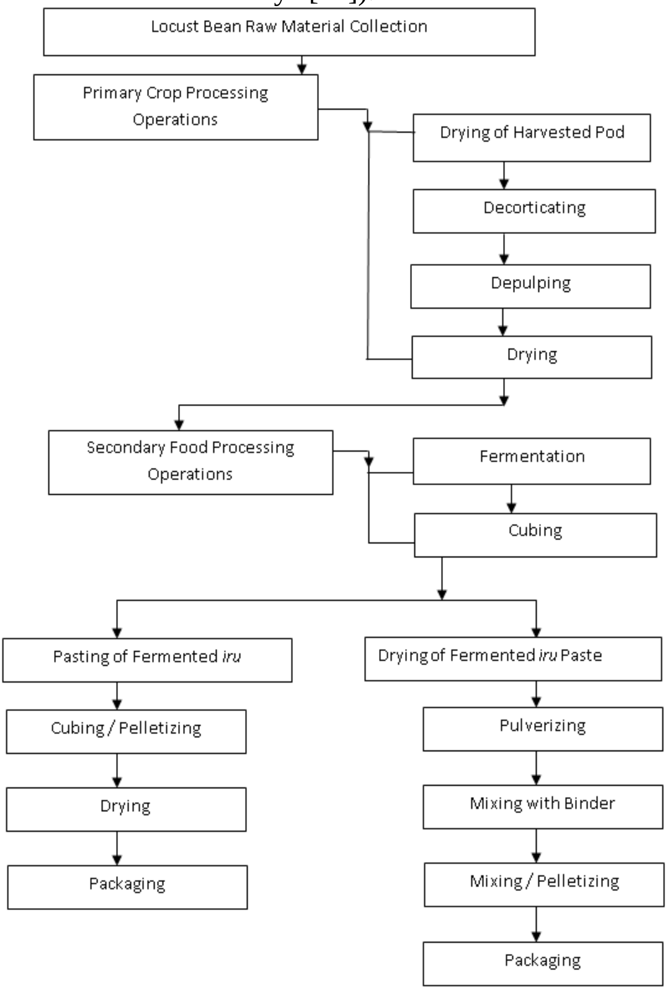


Figure 3. Different Unit Operations in Mechanizing Locust Bean Crop

Figure 4. Photographic View of a Locust Bean Decorticating Machine

Figure 5. Photographic View of a Locust Bean Depulpping Machine

Figure 6. Photographic View of a Locust Bean Dehulling Machine

Figure 7. Photographic View of a Locust Bean Cabinet Dryer

Figure 8. Photographic View of a Locust Bean Parboiler

Mechanization of Shea Nut Production

My research activity on Mechanization of shea nut production was situated on the reminiscence of activity of my

Grandmother who we fondly referred to as “Iya Loko” (Mother in the Farm) a grain and nut merchant. Mama dedicated a whole room in our family house for the storage of shea nut. These stored products are either procured by shea nut processors from within our community or nut merchants from the cities that would usually procure the nuts in tons of jute bag for export to Europe and other countries. Shea nuts are raw materials for various products which vary from Shea oil to assorted cosmetics and other pharmaceutical products.

The energy expended by the local shea nut processor during the conversion process of the raw shea nut to finished shea oil was my initial concern. So much raw materials are needed in return for little oil that are usually produced as the final products. High level of material wastage could be noticed. Hence, mechanizing shea nut production remained an issue of concern to me until I received a challenge to work on “Development of a modified clarification protocol for shea nut”.

Mr. Vice-Chancellor Sir, the first request I received for the use of the research outcome came from Dr. Camille George, University of St Thomas, USA. This is instructive to me since the crop is not grown in her environment but her insistence and desire to have the whole volume of the report was a source of encouragement to me for further studies on the crop.

Olaoye and Babatunde [40] developed a manually powered beater type mixer. The mixer was constructed to effectively mix milled shea nut with little effort and at minimal initial capital (Figure 9a). The mixer has a conical shape located inside a hemispherical mixing bowl. A close clearance was provided between the sides and bottom of the mixing bowl and the beater during operation. The operation of the beater was to generate both rotary and translatory motion for effective mixing of the milled shea nut. A planetary gear assembly was used to generate a planetary motion of the beater from the effort applied to the handle. The whole arrangement was mounted on a wooden support. The mixer has an output capacity of 120 kg/h and the capacity of the mixing bowl at full load is 20 kg.

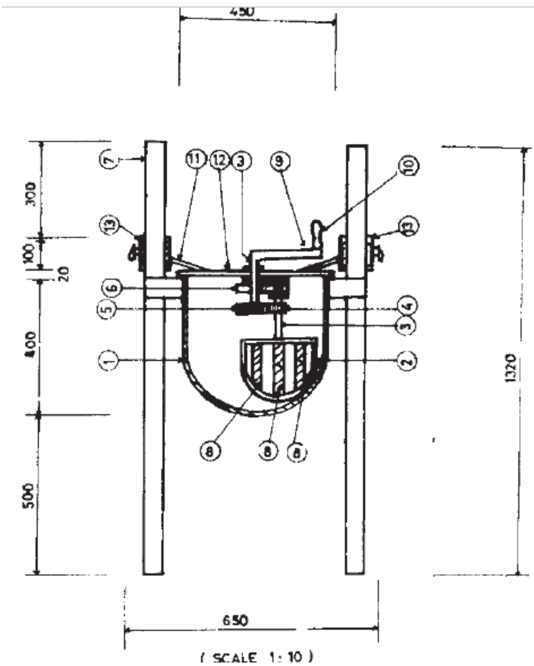


Figure 9a: Sectional view of the Milled Shea Nut Mixer
1. Mixing bowl 2. beater 3. shaft 4. planet gear 5. sun gear
6. Arm 7. main frame 8. paddle 9. crank 10. handle
11. beater holder 12. corner plate 13. sliding guide

A modified version of this mixer with contribution from Camila George team (Figure 9b) is currently made available to shea nut farmers and processors in Mali, West Africa.

Figure 9b: Modified Version of the Milled Shea Nut Mixer with Camille George Team

Other Research Efforts on Mechanization of Crop:

Further steps taken to design and develop machines towards mechanizing crop production included the following: Olaoye and Bolufawi [41] designed and fabricated a multipurpose row crop planting machine (Figure 10). Olaoye [42] developed a treadle operated abrasive-cylinder for threshing cowpea (Figure 11). The choice of abrasive-cylinder was informed in reference to the low energy requirement to split the cowpea pod and to conserve energy as this would be required in operation of tooth peg or spikes as available in other threshing mechanism.

In another work, Ogunlowo and Olaoye [43] developed a guided horizontal conveyor rice harvester (Figure 12). Olaoye and Aturu [44] designed and fabricated a mechanised centrifugal melon shelling and cleaning machine (Figure 13). Olaoye and Oyelade [45] developed a slider crank squeezing action sugarcane juice extractor (Figure 14) among other efforts in mechanizing agricultural production.

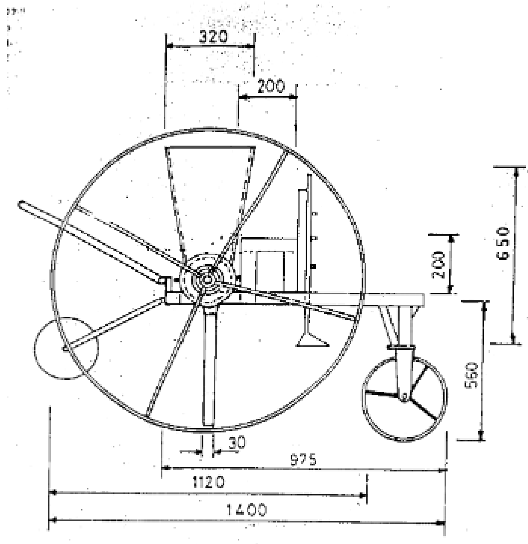
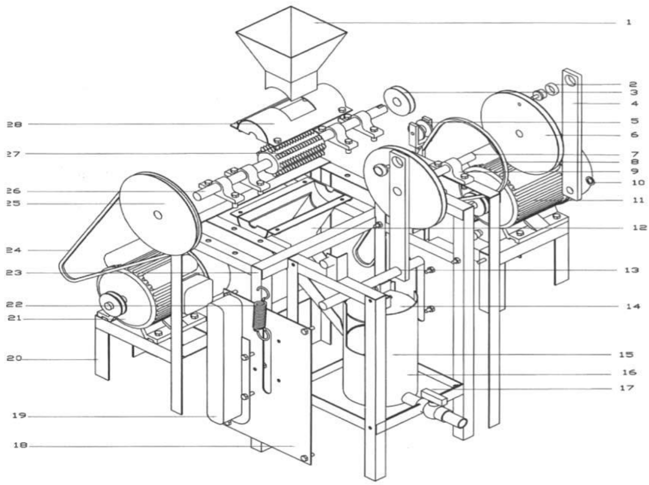


Figure 10: End view of the Multipurpose Row Crop Planting Machine

Figure 11: Display of the Treadle Operated Abrasive-Cylinder for Threshing of Cowpea

Figure 12: View of a Guided Horizontal Conveyor Rice Harvester showing the Slider-crank and other Transmission Parts

Figure 13: Pictorial View of the Fabricated Melon Shelling and Cleaning Machine



Legend

S/No	Description
1.	Hopper
2.	Ball Bearing
3.	Idler Pulley of Main Shaft
4.	Connecting Link or Rod
5.	Idler Pulley for Slider Crank Mechanism
6.	Slider Crank Driven Pulley
7.	Mild Steel Shaft
8.	V - Belt
9.	Pillow Bearing
10.	Nut
11.	Speed Reduction Gear Electric Motor
12.	Discharge Chute
13.	Press Rod
14.	Press Head
15.	Sieve
16.	Extraction Chamber
17.	Basement Plate
18.	Guide Plate
19.	Spring Guard
20.	Prime Mover Seat
21.	Electric Motor
22.	Spring
23.	Main Frame
24.	V – Belt
25.	Main Driven Pulley
26.	Stainless Steel Shaft

Figure 14. Exploded view of the Slider Crank Squeezing Action Sugarcane Juice Extractor

3.1.3. Process and Product Development of Agricultural and Biological Materials

My interest in the area of process and product development of biological materials such as castor nut, shea nuts and locust bean seeds predicated on two major profound reasons. First, these crops predominantly grow indiscriminately in the wild but have great potentials as economic crops. The crops in the wild struggle unattended for survival within their habitat against numerous adverse environmental conditions and other related hazards. More often than none, crop processors pay attention only to the output from the crops without showing any interest to the welfare of the crops. The crops are over exploited for their fruits and other derivatives. The second fundamental issue has to do with observed high level of wastes and losses associated with handling and processing of the biological materials (Olaoye [46] and Olaoye and Oni [47]).

Olaoye [48] worked on the Enhancement of Oil Extraction of Shea Butter Using an Optimised Dillution / Clarification Protocol as an alternative process for mixing operation during local shea oil production. The local method of extraction of shea butter oil was critically examined. Material handling during processing procedure was identified as the major cause of poor oil quality; while poor oil recovery is due to poor clarification techniques. Experimentation was carried out on the effects of dilution rate and settling time on oil recovery in a two to power two factorial experiment. Results indicated an optimum dilution rate of 3:1 (3 parts water to 1 part oil meal) for best oil recovery. Figure 15 shows the proposed clarification protocol. The oil recovery for the new clarification dilution protocol showed a significant increase of 25% in oil recovery when compared with the traditional procedure.

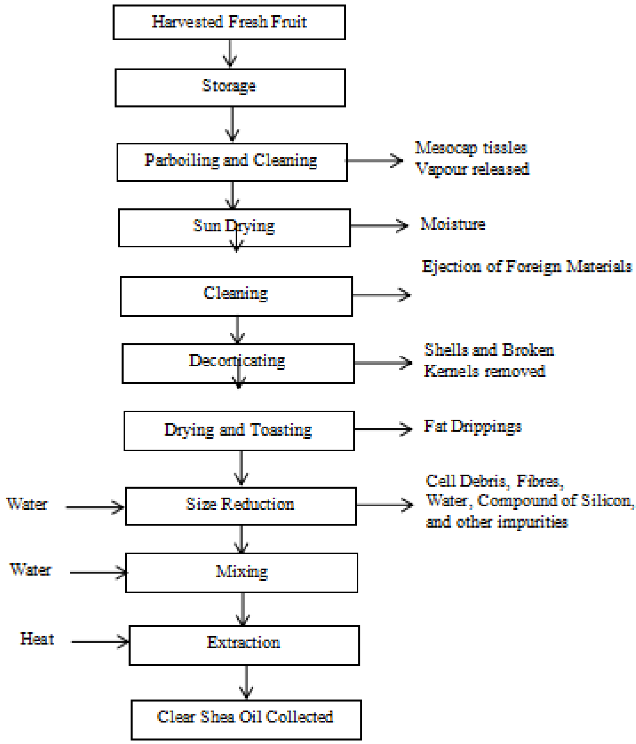


Figure 15. Illustration of Modified Path for Optimised Dillution / Clarification Protocol for Shea Oil Extraction

In another study, Olaoye and Adekanye [49] investigated the motion of the weeding disc along the trajectory of motion on the surface of a rotary tiller travels. Parametric equations were used to describe the motion of the path followed by the weeding tines (Figure 16). The effective performance of soil working tool was related to the kinematic parameters of the weeding disc, the forward travel distance and speed of the rotary tines and working action of components of weeding tool with reference to the common weeds within the ecological zone. The design parameters for appropriate soil working tools and implements were established.

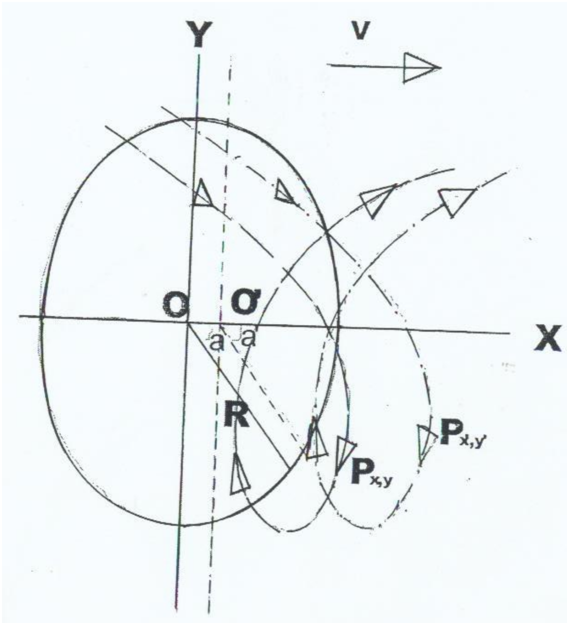


Figure 16. The Trajectory of Weeding disc Described by Forward Travel of a Rotary Tiller

The velocity at the point of interest, P_{xy} on the rotor carrying the weeding disc and its direction are determined by Equations 1 and 2, respectively. Similarly, acceleration of P_{xy} in the direction of point of interest and the direction are indicated by Equations 3 and 4, respectively.

$$\dot{V} = \left(x^2 + y^2\right)^{1/2} \qquad 1$$

$$\tan \psi = \frac{\dot{y}}{\dot{x}} \qquad 2$$

where:

ψ = angle between the x-axis and velocity vector V.

$$a = \left(\ddot{x}^2 + \ddot{y}^2\right)^{1/2} = Rw^2 \qquad 3$$

$$\tan \psi = \frac{\ddot{y}}{\ddot{x}} \qquad 4$$

The analysis of the result indicated that the forward speeds of 0.4 m/s to 0.5 m/s and engine speeds of 1804 rpm to 2261 rpm resulted in weeding efficiency of 74.98% to 79.05% respectively. The iron rod tine performed better than the wooden twine and cable tines with reference to weed removal efficiency. This result is significant in rotary weeder design.

To ensure value addition on some common staple crops, process conditions were developed along the production chains of yam, cowpea, sugarcane and tomato for the conversion of these products into intermediate state (Olaoye and Kudabo [50], Olaoye and Oyewole [51], Oyelade and Olaoye [52], Olotu and Olaoye [53]).

Olaoye and Kudabo [50] noted that management of biomass waste is one of the problems faced in the rural-urban areas of developing countries. These materials exist in abundance and in the natural form as waste since they cannot be used directly as sources of energy. These materials must first be converted to a more suitable and stable form. An optimum stable condition for various agricultural wastes is essential and must be established. The fuel-related characteristics of biomass (rice husk, castor and sorghum stovers) at ordinary temperature acts as a flame retarding material (Olaoye [54]).

Olaoye and Kudabo [50] established the constitutive conditions of the densification of Sorghum stover. Selected physical and chemical properties of Sorghum stover were determined and the effects of constitutive conditions (particle size, moisture content, and pre heating temperature) on such parameters as stress at peak, strain at peak and energy at peak of Sorghum stover were studied. Relationship between process variables for densification process for the stover was established. A fabricated densification rig was used (Figure 17). The rig consisted of a compression cylinder 32 mm diameter and110 mm height, and piston of 32 mm diameter and 250 mm length, was instrumented on a 300 kN UTM (Testometric SF-300-2041) combined with a temperature heating chamber (SIEMENS TLK-96). The pulverized Sorghum stover and compressed sorghum stover as biomass briquette are shown in Figure 18.

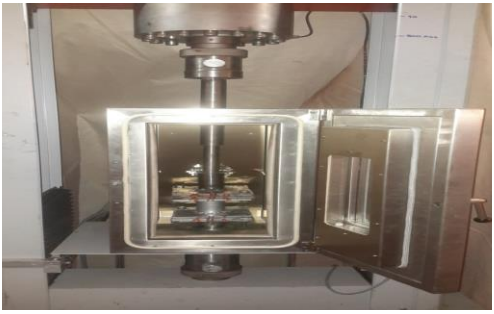


Figure 17: Display of Biomass Densification Rig inside the Heating Apparatus on the Universal Testing Machine

(a) (b)

Figure 18: Forms of Sorghum Stover: a) Pulverized Sorghum Stover and b) compressed Sorghum Stover as Biomass Briquette

The bulk density of Sorghum stover formed ranged from 170.000 to 170.267 kg/m^3 and crude protein was estimated to be 5.03 %. The fabricated densification rig is recommended for the determination of relevant parameters for other biomass materials.

Olotu and Olaoye [53] determined the optimum operating speed of the dehuller and the soaking time of cowpea seeds for dehulling four-variety of cowpea seeds. Four-variety of cowpea seeds were used to evaluate and optimize the performance of the dehuller. The optimization of performance of the dehuller also showed the optimal values of cleaning efficiency, feed rate and output capacity occurred at operating speed of 350 rpm and at about 10 mins soaking time for all the varieties of cowpea seeds used, except for IAR60/62 that is at 150 rpm operating speed.

Olaoye *et al.* [55] investigated the effects of processing techniques and packaging materials on the quality of "Suya" meat. Processing techniques and packaging materials were found to have effects on the quality of processed and stored "Suya" meat. In order to have a high quality Suya meat, roasting technique should be used for processing and the products are to be handled and stored in Glass jars.

Olaoye and Obajemi [56] deployed foam-mat drying technique to produce tomato with good quality and investigated some process parameters (foaming agent and foam stabilizer concentration) that can influence drying rate and the quality of the dried powder. Foaming agent concentration is an important parameter that influences the quality attributes of foam-mat dried tomato.

Obajemihi, Olaoye *et al.* [57] determined the effect of osmotic pre-drying treatment on the vitamin C content of Hausa variety of tomato. Optimized process conditions for producing the best quality of tomato product were considered to be advantageous as they were more economical, especially in terms of time and energy saving.

Mr. Vice-Chancellor Sir, at these new intermediate or storage states of the biological materials, the products are more secure with improved shelf life, stability and storability. These intermediate products curtail the pressure off the crop producers at selling their products at give-away prices during the glut season. The anticipated crop waste is addressed and attainment of food sovereignty guaranteed.

3.1.4 Renewable Energy Studies

Biomass is considered to be one of the key renewable resources of the future at both small- and large-scale levels. It already supplies 14 % of the world's primary energy consumption. Furthermore, biomass used to produce ethanol could reduce oil imports by up to 50%. These biomass residues included primarily forest materials, near existing biomass power plants, agricultural residue, and urban waste processed in many small facilities (Olaoye [58]).

Bioethanol has been used as a motor fuel additive since the 1930's. Bioethanol sourced from the fermentation of sugar cane has been manufactured in large volumes and blended with gasoline for use as fuel in conventional (internal combustion) engines for cars in Brazil for over 30 years.

Mr. Vice-Chancellor Sir, my research effort in the renewable energy is focused on the development of appropriate hardware for the production of biofuel using sugar fraction of plant materials as the feedstock.

Four basic machine components (Grating cylinder, Slider Crack arrangement for the automation extraction process, Power transmission mechanism and Selection of Various Transmission Elements) were developed for pre-treatment operation of the feedstock (Sugarcane). A juice extractor that is capable of producing 17.5 – 20 tons of cane per day was also developed. Figure 19 shows the view and the arrangement of the sugarcane juice extractor. The extracted juice constitutes the feedstock to be processed as biofuel. Various machine components were developed for the fermenter and biofuel Distillation unit. Figure 20 shows the views of the machine assembly. The machines components include the fermentation and distillation units for bioethanol distillation. The developed machine is a composite mini plant for the generation of ethanol from sugarcane at operating capacity of 200 litres of substrate per unit batch operation Olaoye [59] and Olaoye *et al*. [60].

Figure 19: The views and the arrangement of the sugarcane juice extractor.

Figure 20: The views of the Fermenter Machine and Biofuel-Reflux Column Distillation Assembly.

My further research efforts in the area of renewable energy studies include Optimization process using Response Surface Methodology for biodiesel production from Castor Bean seed (Busari and Olaoye [61]). Estimation of wood residues generation from sawmilling activities and energy potentials in Kwara State (Alhassan, Olaoye *et al*. [62]) and the development of cross flow turbine for small hydropower generation (Oyebode and Olaoye [63]).

Olaoye, Adegite and Salami [64] developed a laboratory scale reactor (Figure 21). The biodiesel reactor is needed to enable researchers perform their experiments with very cheap equipment. Local farmers who want to produce biodiesel on their farms also need one. This was to save cost and have a reactor with separation and other units in a composite arrangement.

Figure 21: The Biodiesel Reactor

3.1.5. Application of Computer Modelling and Simulation of Agricultural and Biological Systems

Modelling is an essential and inseparable part of many scientific disciplines. A scientific model seeks to represent empirical objects, phenomena, and physical processes in a logical and objective way. In the course of my research effort, I also employed Computer modelling and simulation by means of extensive computational modelling which involves coding and application of software.

Mr. Vice Chancellor Sir, I developed modelling equations to describe the threshing processes. The output of the computer simulation using the modelling equations showed high level of correlations with the observed results of the thresher performance when an International Institute for Tropical Agriculture, Ibadan, Nigeria (IITA) multi - crop thresher was used for validation of the simulated results. The results generally revealed that the regression coefficients obtained from the regression lines of the various models were between 0.90 and 0.99 at 0.05 level of significance. The results gave the R^2 values for the computed against predicted threshing efficiency for sorghum and rice as 0.985 and 0.998, respectively.

Peg tooth, rasp bar, wire loop, and rubber strips threshing mechanisms were simulated and the peg tooth was tested. The performance modeling equations and the modeled thresher were used dynamically to observe machine performance by following changes in the machine parameters and crop characteristics (Olaoye and Oni [65]).

In a related study that was conducted on the simulation of Cassava Grating Systems for cottage industries, Olaoye [66] deployed a computer programme written in a basic language to compute the appropriate size of grater for a given processing cottage capacity and the source of power required at various cost associated with grating operation; fixed cost, variable costs and timeliness cost; system's hour requirement; cost of the system and the least cost grating system. The model thus developed was tested on some selected *gari* processing cottage industries with varying processing cottage capacities. The cost requirement and the associated components of grating system for grating cassava at varying cottage processing capacity up to about 10 ha of crop service area was evaluated in Bida, Nigeria. The least cost involved for different system was determined.

The programme developed can be used to select an optimum grating system for a given cottage processing unit and the crop area it serves and the size of the power source it uses. It can aid in selecting the least cost grating system among many available grating systems in the farm. The programme developed can be used as an important tool for research and extension purposes in establishing the profitability and appropriateness of the adoption of a specific form of grating system.

Olaoye and Sunmonu [67] also applied computer modelling to develop a management tool to computerize a mechanized aquacultural farm operations to achieve improved productivity of farm workers and to curtail operational losses.

4. FUTURE RESEARCH ENDEAVOURS

Mr. Vice-Chancellor Sir, this inaugural lecture has attempted to amplify the synergy that exists between agricultural mechanization, energy and food sovereignty. The sources of losses and wastes of the existing fragments of our natural resources ought to be redressed, protected and gathered. I look forward to expanding my attention into the following other areas in the years ahead:

i) My attention will be directed to exploring other possible products that could be derived from the identified economic crops to maximize the potentials of the crops that nothing be wasted.

ii) Further research activities will be focused on other alternative renewable energy sources such as small hydropower turbine for electricity generation in a low flowing river.

iii) Investment on development of laboratory equipment, facility and instrument using locally available materials to ensure effective hands on practical at different levels of my engagements.

iv) My interest will be to explore and engage in new developments in technology to farming, Agro-based industries and rural development as may be available in different parts of the world.

v) Curriculum development: My desire is to initiate innovative and adaptive training, teaching and research in Agricultural Mechanization that will expose students to Agro-preneurship in Agricultural and Biosystems Engineering practice.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary and Conclusions

Mr. Vice-Chancellor Sir, this Inaugural Lecture has highlighted the link that exists between agricultural mechanization, energy and food sovereignty. I have attempted to show that if we gather the fragments of our abundant natural resources for effective utilization, agricultural losses and waste will be curtailed. To attain food sovereignty, appropriate action must be taken to till the land. In tilling the land, appropriate energy source will be required to drive agricultural mechanization. If this is sustained a continuous loop will emerge as food will subsequently lead to energy supply.

For the beauty of the earth
For the beauty of the skies
For the love which from our birth
Over and around us lies
Lord of all to thee we raise
This our sacrifice of praise

For the beauty of the hour
Of the day and of the night
Hill and vale, and tree and flower

Sun and moon and stars of light
Lord of all to thee we raise
This our sacrifice of praise

For the joy of ear and eye,
For the heart and mind's delight,
For the mystic harmony
Linking sense to sound and sight;
Lord of all to thee we raise
This our sacrifice of praise

For the joy of human love,
Brother, sister, parent, child
Friends on earth and friends above
For all gentle thoughts and mild;
Lord of all to thee we raise
This our sacrifice of praise

For each perfect gift of Thine
To our race so freely given
Graces human and divine,
Flowers of earth and birds of heaven;
Lord of all to thee we raise
This our sacrifice of praise

5.2 Recommendations

Agricultural mechanization is an essential input for agricultural crop production. Neglect of mechanization will lead to inability to cultivate sufficient land to meet the food need of the citizenry. Increasing the power supply to agriculture means that more tasks can be completed at the right time and greater areas can be farmed to produce greater quantities of crops while conserving natural resources. Therefore, the following recommendations are made:

1. Industrialization and urbanization are related to high level of energy self-sufficiency, it is recommended that

concerted efforts should be geared towards the identification and development of a specific feedstock for renewable energy generation.

2. Domestication of crops with high economic potential that grow naturally in the wild such as shea nut and locust bean crops require dedicated attention. These crops must be adequately protected.
3. These fragments of existing natural resources peculiar to Nigeria ecology must be gathered to ensure that nothing is wasted. There is the need to enact endless loop of energy supply, adequate investment in agricultural mechanization to bring about food sovereignty.
4. Synergy between the research institutes, universities and industries must be strengthened to achieve technological and national growth in the area of agricultural mechanization and agro-industrial development.
5. The federal government is enjoined to deploy all necessary political will and commitment to implement already documented food security programmes to the letter.
6. There abound sufficient natural resources that can meet the dire food sovereignty of our nation, the concern therefore is to identify, appreciate, develop and apply them gainfully to attain surplus energy supply and food security. No known ‘spirit’ will come down to develop same for our use except to recolonize us!
7. The teaching and training of agricultural engineering in all our polytechnics and universities must be restructured to result oriented approach and providing solutions to meet the needs of the farmers. Departments of agricultural engineering are to be assigned to clusters of farmers within given ecological zones as solution providers to their Agricultural Mechanization problems. The Bank of Industries (BOI) are to be empowered to support industries and other stake holders emanating from the researchers and farmers’ engagements.

8. Government regulations must be enforced especially as regards deforestation, mining, construction and other activities which distort the natural ecosystem and sustainable environment. Indiscriminate bush burning and dumping of refuse (especially in river courses) should be discouraged.
9. Nigeria needs National Agricultural Mechanization and Agro-Industrial Development Policy and not Mechanization Strategies as currently available. As a matter of urgency, Agricultural Engineering Department should be established at all levels of government- federal, state and local. This is to ensure the aggregation of various programmes of mechanization technology under one functional unit.
10. Incentives should be provided for students of agriculture- either basic or applied, and especially postgraduate students should be encouraged to show interest in agricultural mechanization and renewable energy studies.

Acknowledgements

All good gifts around us are sent from heaven above, I give my thanks to you O Lord for all Your love. I give glory, honour and adoration to the Almighty God, for making today a reality. His name must be praised. The list of those who have made positive impacts on my life is too numerous to enumerate, but permit me, Sir, to mention these people:

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