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AGRICULTURAL MECHANISATION IN NIGERIA: THE PROSPECTS AND PROMISES

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AGRICULTURAL MECHANISATION IN NIGERIA:

THE PROSPECTS AND PROMISES

by

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INTRODUCTION

The application of technological innovations to the solution of problems is perhaps the single most important factor responsible for human progress. The pre-historic man first lived as a normad, hunting wild beasts and gathering or picking fruits of the natural vegetation on his way. At this stage, population was sparse and widely scattered. Man lived in small groups with only one activity of hunting or fishing depending on the place where he lived. Man's advancement started only when he developed the art of technological innovations; when he fashioned his first hunting tools and weapons consisting of blunt instruments made from chipped stones and used simply to kill wild animals which he cornered in places from which there was no easy escape. Later he developed cutting and throwing weapons (still from stones), with which to hit wild beasts in their tracks instead of engaging in exhausting pursuits. Even at this stage, he still devoted all his energy to feeding himself and each time he needed food he had to make a new kill as there was no way of preserving any previous kill. Fire was unknown then. Man made significant technological steps when he learnt to produce and control fire, when he began to fashion his tools from metals, when he developed the techniques of applying handles to his tools and when he invented and applied the wheel for transportation.

Agriculture is perhaps the greatest single invention that made it possible for man to live in settled communities which grew gradually in complexity from families through villages and cities to modern nations. The development of agriculture itself to its high level of efficiency today took a very long time but each step forward was associated with some definite technological innovation resulting in better ways of carrying out farming operations.

The use of tools in agriculture began with the application of digging sticks, hoes, spades, harvesting knives and some form of man-drawn ploughs. Perhaps at about the same period that man started developing tools for agriculture, he also evolved the techniques of the domestication of certain animal species, first to help as hunting aids and later to constitute reserves of meat on the hoof. The development of the art of keeping domestic animals made possible another significant technological step resulting in the invention of the first set of animal drawn farming implements and the first transport vehicles pulled behind the animals. With the advent of easier transportation came the possibility of growing crops away from settlements and transporting the products to the settlements for storage. The latest stages of innovations in agriculture took place during the last two hundred years. These resulted in the development of high yielding crop varieties, better breeds of livestock, more effective herbicides, pesticides and fertilizers. The development of modern tractor with its complete range of equipment used for the various cultural operations, the self-propelled harvesting machines, irrigation pumps and sprinkler heads and the different types of processing machines and storage facilities took place during these stages. In most cases, the benefit of technological innovations in other areas of agriculture are fully realised only when some degree of mechanisation is involved.

In this inaugural address, I like to focus attention on the following:

(a) The importance and role of agricultural mechanisation as a vehicle for agricultural production.

(b) The problems faced by Agricultural Engineering as a profession.

(c) The present state of mechanisation in Nigerian agriculture highlighting the main problems and difficulties.

(d) The type and level of mechanisation appropriate to our farming system.

(e) The contribution of the University of Ife to agricultural mechanisation in Nigeria.

(f) The challenges of ensuring that our future mechanisation programmes are meaningful and fruitful.

THE PROSPECTS AND PROMISES

Agricultural mechanisation includes all forms of mechanical assistance and processes used at any level of sophistication in agricultural production to reduce human drudgery, improve timeliness and the effectiveness of various farm operations, add more crops per year, increase yields, improve and preserve the quality of agricultural products, provide better rural living and markedly advance overall efficiency.

Mechanisation extends man's activities. His activities widen in scope and his services become more valuable. Mechanisation transforms the farmer from a power source or power unit to a manager of mechanical power many times bigger than his muscle power. He is, therefore, able to plan his work better. This planning allows him to develop appropriate division of labour in his operations. He is also able to employ skilled labour for different categories of work. Skilled workers use their abilities of decision making and dexterity to advantage when faced with adverse or difficult conditions and thereby help to improve the quality of agricultural production. Mechanisation of many crops usually results in a more uniform labour requirement and often at a higher year-round level than before, thereby encouraging the development of a more stable and skilled work force.

By their very nature, some jobs are better done by machines. Examples of such are pumping and distributing water for irrigation, applying chemicals in the form of sprays to control diseases, insects and weeds, working on skin irritating materials like removing the back of kenaf, and so on.

In fact, some farming operations must be mechanised. If such operations are not mechanised, we would only succeed in perpetuating menial, arduos, hazardous and low level productivity jobs usually carried out by unskilled labour. If workers are unskilled they perform the work making only the simplest or no decisions. They behave like machines and can, therefore, be replaced by machines which when controlled by skilled operators will make important decisions and carry out the work faster, better and more effectively.

Mechanisation contributes to increased production of raw materials used in other industries, provides opportunities for decreasing interpersonal and inter-regional differences in income. Agricultural mechanisation, therefore contributes to achievement of increased industrialisation, not only by providing the raw materials for some industries, but also by promoting the growth of a population which has a well defined domestic market for intermediate goods. This makes possible a systematic development of industrial complexity in response to the growing needs of the nation.

THE PROBLEMS

Agricultural mechanisation holds out a lot of hope and benefits to any nation, no matter the nation's stage of development. Even in a developing country like Nigeria with a high level of unemployment and under-employment, the real issue is not whether mechanisation should be introduced into the agricultural processes or not. The real issue involves the taking of important decisions that would promote mechanisation. For instance, it is important to know what operations should be mechanised, and to what particular crops, areas and production bottlenecks must mechanisation be applied, what level of priority should be placed on hand tools and animal drawn equipment in comparison with motorized equipment and what is the best way to promote the desired mechanisation. In discussing some of these issues, it is perhaps useful to examine the problems of agricultural engineering as as a profession, review the extent of mechanisation of agriculture practised in the country as of now, and highlight some of the difficulties involved.

The Agricultural Engineering Profession

Engineering is the application of knowledge of the physical and mathematical sciences gained through study and practice, applied with judgment in the utilization of the materials and forces of nature for the benefit of mankind. Engineering is, in other words, the bridge between new knowledge—the product of research in the sciences—and the fulfilment of the needs of society by putting this knowledge to work.

Agricultural engineering is that field of engineering in which the physical and biological sciences are utilised to find and apply better ways of exploiting natural resources for the production, handling, processing and storing of food and fodder. It is also concerned with finding better ways for carrying out such allied activities as rural housing and living. Agricultural engineering consequently involves the design, development, testing, manufacturing, marketing, operation, maintenance, and repair of all agricultural tools, implements, machines and equipment which are used in mechanising agricultural operations with the objective of raising the productivity of human labour and land in the face of prevailing economical, human and social realities of the time and place of concern.

Struggle for Recognition

Agricultural engineering is a younger profession than such other traditional engineering disciplines as civil, mechanical and electrical. As a result, many or most of the people in charge of public agencies including even some agricultural institutes have not become accustomed to the existence of the Agricultural Engineering profession as a distinct discipline of engineering practice which has come of age over the last half century. It is neither new nor uncommon for the older, more established disciplines of the engineering profession to discriminate against the newer, not-so-well known ones. Thus, the discipline of Chemical Engineering which is product of this century achieved full professional status in the United Kingdom with the granting of a Royal Charter only in 1922. For nearly half a century before this time, the Institution of Mechanical Engineers saw the skills of the chemical engineer as only one incidental specialization of the wider functions of the Mechanical Engineering discipline. Mechanical Engineering evolved from Civil as Electrical Engineering grew out of Mechanical. Each new discipline evolves through a grey period in its history during which it receives only token acceptance and even sometimes must confront outright opposition from the more established ones. This historical process, on the one hand, symbolizes a challenge for an evolving discipline to justify its professional uniqueness. On the other hand, it can be seen as one rational expression, on the part of the institutionalized disciplines, of an instinct for professional pride as well as self-preservation.

It is against this background that one must examine some of the contemporary problems of the agricultural engineering profession. Even in the United States of America where the largest collection of the World's most creative and productive agricultural engineers may be found, the problem of professional recognition are still present. In an article published in Agricultural Engineering of September 1972, Nissing and Poole cited experiences in the state of Louisiana as follows:

'In Louisiana the agricultural engineer is legally limited in the range and scope of his professional activities even though he is qualified by educational training and experience. The state laws that directly or indirectly regulate the practice of engineering have been enacted by the state legislature with the intent of protecting the public. Unfortunately, some of those laws are interpreted by various state agencies in such a manner that they protect the selected groups of professionals and prevent other qualified professional engineers from practicing in certain areas of engineering ...'

The Act 73 of the state of Louisiana defines the practice of engineering as 'responsible professional service which may include consultation, investigation, evaluation, planning, designing, or supervision of construction, in connection with any public or private utilities, structures, machine, equipment, processes works as projects wherein public welfare, or the safeguarding of life, health and property is concerned or involved, when such professional service requires the application of engineering principles and the interpretation of engineering data'. There cannot be any doubt that the practice of agricultural engineering falls within this broad definition. The same Act 73 further states that: 'the Board (that is the Louisiana State Engineers Registration Board) shall grant registration by these branches: Agricultural, Chemical, Civil, Electrical, Industrial, Mechanical, Metalurgical, Mining and Petroleum Engineering. The seal and the certificate of registration shall bear the branch in which the engineer is registered ...' In the same state of Louisiana a building permit will not, under any circumstances, be issued unless the plans are affixed by the seal of an architect or a civil engineer.

In 1969 a licenced, that is, professionally registered agricultural engineer, requested a permit to build an agricultural feed manufacturing complex in East Baton Rouge Parish. The project included facilities for handling and storing grain and a mill to process the grain into feed. In contrast to the spirit of Act 73, the written reply from the building official of East Baton Rouge Parish was concise and to the point: 'The law requires that the person who prepares the plans and supervises the construction must be a registered architect or a civil engineer licenced in the state of Louisiana.' The architects licensing law of 1950 makes it illegal for any engineer other than a civil engineer to design any facility costing more than $40,000. Thus the law makes it illegal for an agricultural engineer to design and supervise the construction of agricultural facilities costing over $40,000. Only an architect or a civil engineer can legally design agricultural barns, agricultural processing plants, agricultural marketing and storage structures, livestock production buildings, agricultural warehouses, farm equipment service and sales buildings and refrigerated food storage structures. The irony of it all is that in Louisiana all architects and all civil engineers are entitled under that law to design such facilities whether or not they are qualified by training and or experience.

Fortunately, the Council of Registered Engineers of Nigeria, a body created by the Nigeria Engineer (Registration) Decree of 1970, to regulate and control the practice of Engineering profession in Nigeria has accorded full recognition to the agricultural engineering profession. The list of works in which young engineers should practice to earn the experience required for registration include many aspects of agricultural engineering discipline. Unfortunately, the important fields of grain drying, farm products conditioning and storage and some on the farm feed processing and food processing are omitted from the list. The Council has also certified the quality of the B.Sc. programme in agricultural engineering at the University of Ife, along with other engineering curricula in the Faculty of Technology, as meeting the requirements for registration.

The Strengths of Agricultural Engineering Profession

Many problems in agricultural engineering overlap the basic concepts of other engineering disciplines. For example, agricultural engineers are trained to design structures for housing and storing grain. This would normally involve reinforced concrete foundations, concrete, steel or wood storage bins, as well as a structure for housing the facility. Electrical ring and electrical control systems, heating, ventilation and refrigeration may also be involved. Agricultural engineers are also trained to design machines and other mechanical equipment used in farming process. In the design of weeding and root crop harvesting machines for example, the agricultural engineer combines the knowledge of engineering design principles and procedure with that of the rooting patterns of surface and deep feeders as well as root characteristics in arriving at the shape and depth of operation of the functional parts. Agricultural engineers are also taught to design dams, water distribution systems for human and livestock consumption and for irrigation–– purposes. Many more examples can be cited in the areas of farm structures, soil and water conservation and utilisation, rural electrification, crop processing, farm power and farm machinery. In carrying out all these functions, agricultural engineers must work with fundamental principles that have, because of their historical development, been characterized as concepts taught in subjects in civil, mechanical and electrical engineering curricula.

The agricultural engineer, in addition to having a good and sound training in engineering, has extended knowledge of the biological character of agricultural materials. He learns through formal education and practice the soil-plant-moisture relationships, the effect of plant consumptive use of water, evaporation, evapotranspiration and the level of water table on the frequency of applying irrigation water and the problems of salinity in irrigated soils. He also has good knowledge of the physical properties of biomaterials, optimum environmental conditions for livestock including the physiological basis of design for temperature, humidity, light and space requirements in livestock production systems. Other distinguishing abilities of agricultural engineers include knowledge of rheology and fluid properties of biomaterials, light, temperature, oxygen and other environmental requirements for growing plants. Agricultural engineers also have working knowledge of microbial activity involved in waste disposal, fermentation in feed manufacture and spoilage of stored products. The agricultural engineer has full awareness of equilibrium moisture relationships of biomaterials and the importance of human factor considerations in machine design. This additional specialised knowledge of the biological character of agricultural materials constitutes an important aspect of agricultural engineering professional know-how.

One is not suggesting that only agricultural engineers have the solution to all problems in the agricultrual industry. I do not want to leave such false impression. I have gone at some length to distinguish between agricultural engineering and the other disciplines in the profession of engineering and tried to highlight the strengths of the agricultural engineer because I believe that engineers must understand and respect each other's strength and unique areas of competence. Agricultural engineers must be allowed to participate and play their rightful role, without any inhibition, in our national development effort along and in co-operation with other engineers, agronomists, soil scientists, nutrition experts, conservationists, architects, planners and economists. It is important that the potential contribution of the agricultural engineer should be limited not by legislations, discriminations or by covert restrictive practices in the engineering profession but only by the merits of his professional training and competence.

Present State of Mechanisation in Nigerian Agriculture

Three evolutionary stages of farm mechanisation corresponding to three different social and economic situations of a society can be identified:

(a) The stage of early development of agriculture as a dominant activity of the population with the use of simple hand tools.

(b) The stage of improved hand tools and simple animal drawn equipment mainly confined to the working of the soil and transportation.

(c) The stage of application of modern technology to agriculture in the form of better varieties of crops, improved breeds of livestock and the use of motorised machines for land preparation, crop sowing, fertilizer application, weed control, harvesting and post harvest processing and storage.

Mechanisation of Nigerian agriculture is moving away from the first and second stages of development towards the third stage. Specifically, the different equipments used in Nigerian agriculture can be classified as follows:

(i) Hand tools, mainly hoes, cutlasses and harvesting aids like sickle.

(ii) Animal drawn implements.

(iii) Motorised machines consisting of: (a) Two wheel or single axle tractor and the accompanying implements, (b) Four wheel tractor and the accompanying range of implements.

(iv) Motorised post-harvest handling and processing machines like threshers, corn dehuskers and shellers, seed cleaners, rice hullers and polishers, feed mills and other barn machinery.

(v) Crop storage equipment.

(vi) Manually operated and motorised pumps for rural water supply and irrigation purposes.

Hand Tools and Equipment

The important hand tools used in Nigerian agriculture are the hoe and cutlass for operations including bush clearing, land preparation, staking, weeding, harvesting, and some farming processing. There are other hand tools mainly used as harvesting aids and post harvest shelling and threshing devices.

The use of hand tools suffers many limitations but the most serious of these derives from the fact that the tools must be powered by human muscle. This is the source of the drudgery usually associated with the use of hand tools especially when carrying out energy sapping operations like land clearing, seed bed preparation and weeding. Man as a source of continuous power can work at a rate not greater than one-tenth of a kilowatt. This is usually not enough to cope with the more difficult farming operations. The future of hand tools, no matter how efficient is not promising for such heavy jobs.

It is a commonly quoted statistic that, at the present time, over 70 percent of Nigerian labour force is engaged in the production of food and cash crops at the farm level. This is, of course, high compared with what obtains in many of the advanced countries of the world. In the United Kingdom for example the figure is less than 4 percent. In the United States of America and France the proportions are 4 percent and 14 percent respectively. Mechanisation in these countries involves the use of high mechanical power equipment. In contrast, the total engine and mechanical power available to farmers in Equatorial Africa has been estimated at less than 0.04 kilowatt per hectare whereas farmers in Europe and United States expend more than 0.75 kilowatt per hectare. From a rigorous analysis of yields in various countries, it is estimated that a minimum power level of about 0.4 kilowatt per hectare is needed for an efficient agriculture anywhere in the world. This shows that an average farmer in Equatorial Africa has only one-tenth of the minimum energy requirement for efficient production. It is therefore not surprising that the farmer does not cultivate more than 1 to 3 hectares of land at any time. The effect of this low energy input on the level of machanisation and consequently on the land cultivated per person employed in agriculture is illustrated in Figures 1 and 2. In these diagrams, mechanisation index is the ratio of machine work to the sum of human work and machine work expended in agricultural production processes.

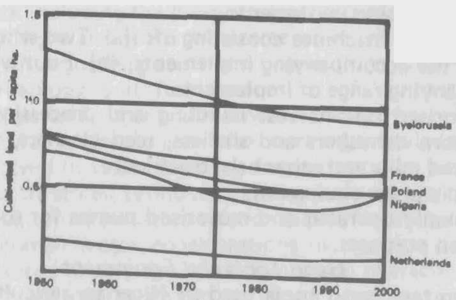

Fig. 1: Cultivated land per head of population in Nigeria and some selected countries

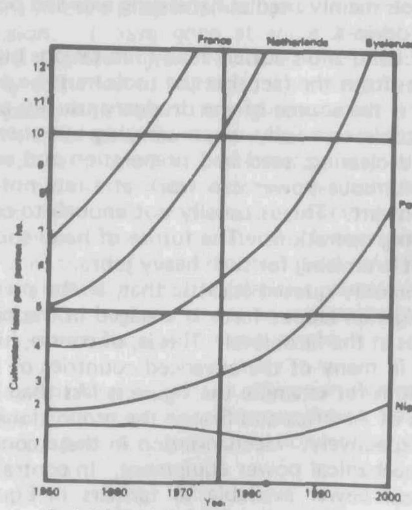

Fig. 2: Cultivated land per person employed in agriculture in Nigeria and some selected countries

In short, human muscle as a source of power in agriculture will not lead to any appreciable increase in the country's agricultural production. There are, however, some jobs that involve selective and delicate operations such as harvesting of some fruits and vegetables. For this category of jobs, the use of hand tools may continue to be effective and in some instances may prove to be the only enduring alternative.

Animal Power and Animal Drawn Equipment

The use of animal power in the form of a pair of work bulls is one of the alternative energy sources that can be used on the farm. The utilization of animal power is less tasking and perhaps more effective when compared with the use of human muscles. This power source is particularly applicable to the needs of the small farmers in the Northern States because of its suitability to meet the power requirements of their small sized farms, easy adaptability to the level of technical skills of farmers, the convenience of the low costs of acquisition of the work bulls and the accompanying equipment, and the fact that the farmers in that part of the country have a tradition of keeping large animals.

The use of animal power, however, has its limitations. The major ones can be summarised as follows:

(a) It is limited only to the tsetse-free northern states of the country.

(b) The cost of maintaining the work bull is becoming prohibitive. If the feeding of the work bull is properly done, the value of work output has been shown to be probably just barely enough to pay for the cost of feeding. This makes it somewhat irrational for the farmer to keep the work bull properly fed.

(c) The peak of the season's work with respect to the use of animal power comes at the end of the dry season. The dry season is usually a period of shortage of food, both for human and livestock consumption. The animals compete with human beings for the available food. This competition becomes worse now that fresh grass, fodder and similar livestock feed materials are being reduced as a result of putting more land into building and road construction and because of frequent drought. In practice, the animals are not usually well fed during the dry season and are, therefore weak and ill prepared for the heavy work which follows at the beginning of the rainy season. During the rainy season and harvest period when the animals get better food, there is very little work for them to do.

(d) There is a shortage of beef animals in the country and butchers have to compete with farmers for the available animals that can otherwise be trained for use as agricultural work-bulls.

(e) Animal-powered equipment for various harvesting and post harvest handling and processing operations are not easily available. There is, therefore, the need to use in addition, other power sources for these operations.

In the light of the problems discussed above, this source of power may soon become unsuitable and uneconomical to use. Consequently, one can only see animal power serving a transitory role as an introduction to the more suitable mechanical power which will put agriculture on the go in this country.

Two types of engine power units are available on the Nigerian market. These are the small single axle tractors or power tillers and the four wheel multi-purpose tractors equipped with a range of implements. Experience to date with respect to the use of the power tillers shows that they are not suitable for primary cultivation and at the best can be used only for final seed bed preparation after a medium power tractor has been used for primary tillage. All the tests carried out on the different models of single axle tractors have not yielded conclusive results to indicate the usefulness of these tractors for the conventional dry-land farming. In addition to the inability to handle primary cultivation, other difficulties experienced are, low rate of work, inability to work in fields not properly stumped, prices too high for individual farmers, lack of implements suitably adapted to Nigerian soils, crops and vegetation, lack of spare parts and inadequate after sales services.

The introduction of the first conventional agricultural tractor dates perhaps as far back as 1930 when it was first used on government plantations. Encouragement to use this power source for farm operations by private individuals did not become wide-spread until about 1964 when the then regional governments introduced a scheme for the hiring of tractors. This type of tractor is particularly useful because of its adaptability and suitability for the different cultural operations involved in modern agricultural system. The multi-purpose tractor and the range of matching implements can handle various operations including tillage, planting, weeding, harvesting and transportation. Two other approaches, in addition to government tractor hiring scheme, are currently being pursued to make the services of the medium-all-purpose tractor available to the farmer. These are through co-operative ownership and private tractor hiring scheme. The problems of co-operative ownership of equipment are both technical and human. The farmers, in many instances, do not have the required skills for both the operation and maintenance of the equipment before they are acquired. The close supervision and control necessary to ensure proper use and maintenance of the equipment are often interpreted by the farmers as interference. The order of rotation of the equipment among the farmers also presents problems as the farmers have a need for similar operations at the same time. These problems have frustrated what, otherwise, may have blossomed into promising associations.

Tractor hiring units have enjoyed some limited but encouraging success. In spite of this, they have their own share of problems. The farms they service are usually small and scattered over large areas and in some cases tractors have to travel long distances to plough areas as small as 2 hectares. Shortage of good tractor operators, irregular fuel supplies, difficulty of obtaining spare parts leading to high frequency and long period of equipment down-time, improperly stumped fields, lack of motorable roads and poor programming are among the major problems limiting the success of these units.

Criticisms of Engine Power Farming

With respect to the developing countries, agricultural mechanisation involving in particular engine power farming has always been under severe criticism. Some of the objections may be listed as follows:

(a) Factor composition of under-developed countries is unfavourable for mechanisation.

(b) Farm mechanisation displaces labour and destroys employment. It often encourages migration of labour from rural areas. Agriculture must be a reservoir to absorb the growing population thus mechanisation must not be introduced as it reduces the job opportunities in agriculture.

(c) Mechanisation accentuates inequalities of income and wealth.

(d) Mechanisation generates social problems rather than contributing to their solution.

(e) Mechanisation is not suitable for fragmented and inaccessible holdings. It is conducive for use only by big farmers.

(f) Mechanisation increases productivity of labour but not necessarily farm productivity per unit of land area.

(g) Mechanisation may be profitable for individual owners but not for society.

(h) Appropriate technology is not available for the developing countries to allow them take full benefits of mechanisation.

(i) Mechanisation may lead to erosion problems thus rendering opened land unproductive within a very short time.

It would be imprudent, and certainly frivolous, to brush these criticisms aside since they contain elements of truth in varying degrees. However, not many people would deny the fact that the development programmes in the agriculture of many developing countries of the world, consequent upon the absence of any significant degree of mechanisation, has hitherto been largely ineffective in terms of economic growth as well as social welfare of the peoples of these countries. Against the background of this dilemma, it would seem more fruitful to be concerned, not so much about whether mechanisation or the absence of it provides a more viable approach to agricultural development, but more relevantly, about how to achieve that type of mechanisation, the social and economic impact of which is both real and widespread.

There is perhaps, a number of important respects in which a substantial infusion of innovation has become an inescapable requirement for the development of Nigerian agriculture.

First, there exists a mixed bag of endemic problems which have become both characteristic of as well as perculiar to traditional agriculture in this country. They include:

(i) Small holdings scattered over large areas without adequate access roads.

(ii) Difficult land tenure system resulting in fragmentation of holdings into odd-shaped individual farms.

(iii) Poverty, low level of production, shortage of capital and insecurity of income.

(iv) High cost of machines usually far beyond the means of the average farmer.

(v) Poor level of education among farmers and a lack of technical skills or the know-how to cope with changes resulting from modern technology.

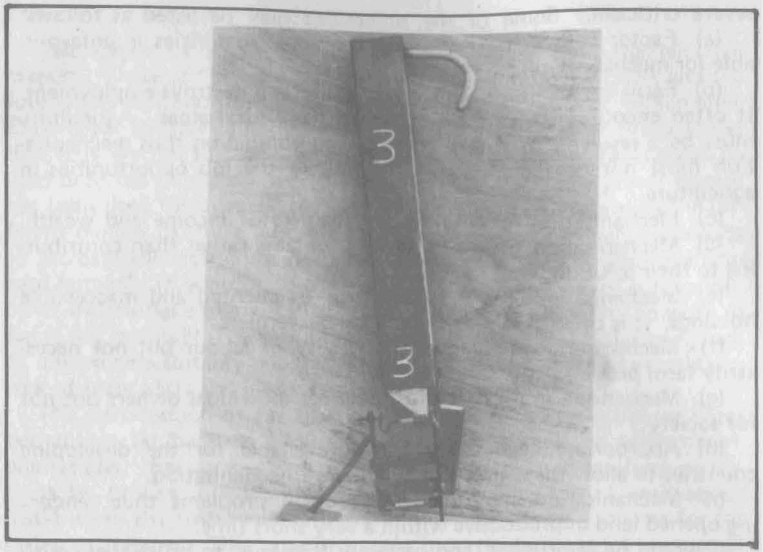

Plate 1: The Portable Planter for Grains

Plate 2: The metering Device of the Grain Planter

Plate 3: The Grain Planter undergoing Field Test

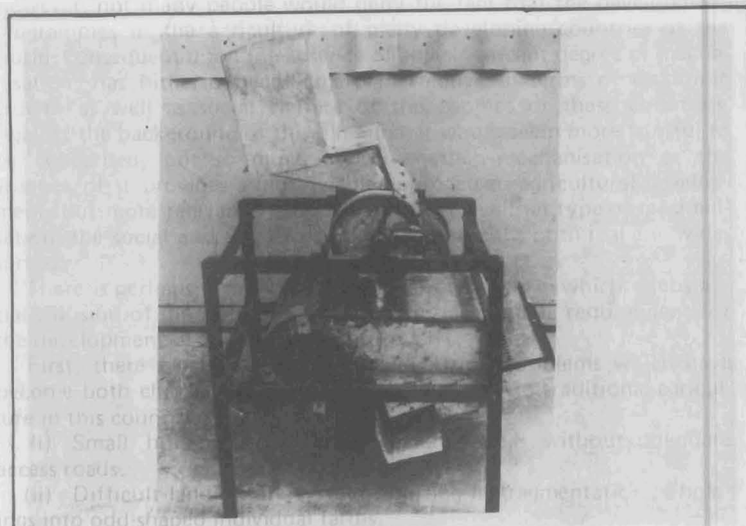

Plate 4: The cowpea sheller

Plate 5: The heap of cowpea straw as thrown away from the machine

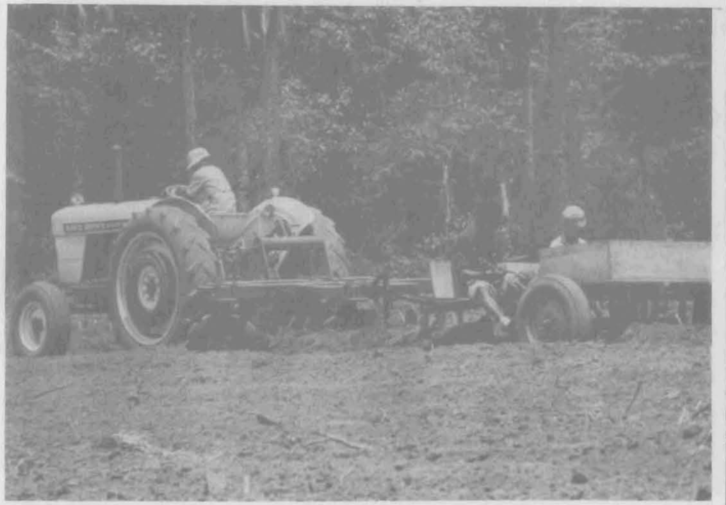

Plate 6: The Cassava—Stem—Cutting Planter Undergoing Field Test

Plate 7: Cassava stem Cutting planted on Freshly Made Ridges

Plate 8: A traditional Method of Planting Cassava stem Cuttings

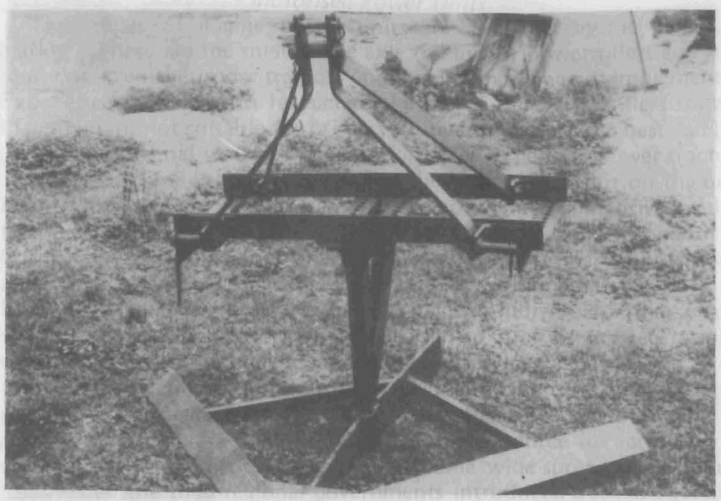

Plate 9: The Cassava Root Digger

Plate 10: The Cassava Root Digger Undergoing Field Test

Plate 11: A sample collection of Roots bifted with the Digger

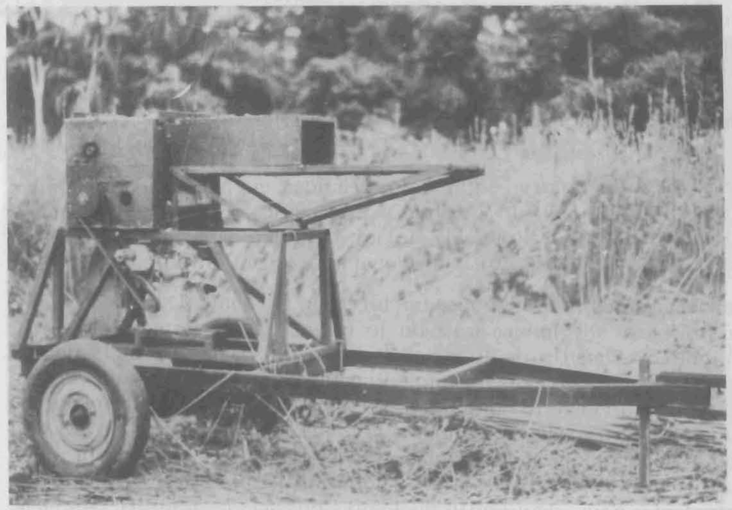

Plate 12: Side view of the Kenaf Decorticator

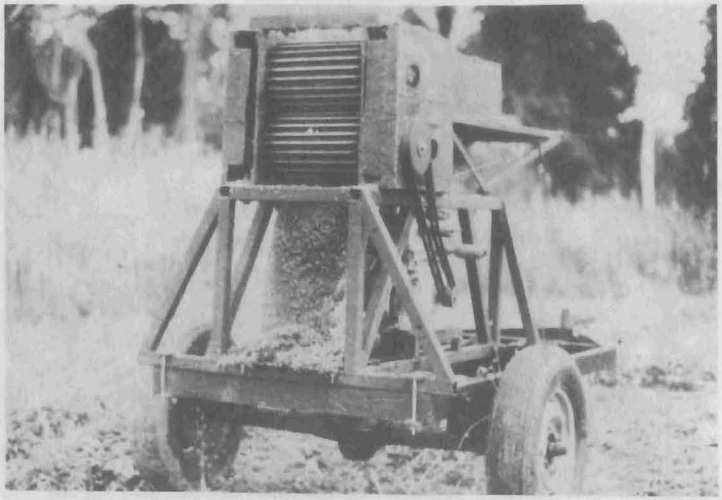

Plate 13: The Kenaf Decorticator showing the Decorticating Rolls

Plate 14: The Decorticator Undergoing Field Test

Plate 15: Another view of the Decorticator Undergoing Field Test

Plate 16: A sample collection of Freshly Decorticated Kenaf Backs

(vi) The practice of mixed cropping in which different types of crops are grown on the same plot simultaneously, making the use of machines for some of the cultural operations difficult.

(vii) Progressively increasing age of the farming population.

Secondly, the accelerating rate of migration of labour away from our rural areas and the introduction of the Universal Primary Education will eventually result in systematic erosion of the cream of the labour force from agriculture unless some alternative power sources are made available to replace the human muscle. In the developed countries of the world, mechanisation programmes were developed to release labour from agriculture to other sectors of the economy. Unlike these countries, migration of labour from Nigerian agriculture results directly from the compulsion of youths to seek easier and better paid jobs in the cities and indirectly from lack of satisfactory mechanisation programme. In consequence of this, it is obvious that one of the cardinal roles of agriculture in Nigeria must be to stem, and if possible, reverse this frightening rate of rural migration to our cities. This dictates that urgent action be taken to improve the quality of rural life and supplement its declining work force through a planned and carefully phased programme of mechanisation which employs the right type of technology.

Thirdly, there exists an abiding awareness that efforts to introduce machines and encourage their wide-spread usage in agricultural operations in this country have become significant only over the last thirty years. Over this short span of time, all forms of mechanisation ranging in diversity from land preparation to post-harvest treatment of produce have become available. The Nigerian farmer, for whom all this is intended, has thus been denied the advantage of that process of gradual evolution in the use of farm machines which his counterpart in the advanced countries of the world experienced, over a time span of more than three hundred years. This, of itself, is not necessarily a bad thing. However, it lends emphasis to the fact that the time-frame of change in bringing mechanisation to the farmer has been very rapid and that there exists hardly any real empirical experience from the past upon which we can reliably fall for guidance.

THE CHALLENGES

Against the background of this complex mixture of conflicting contentions and difficult problems there emerges one unifying problem which constitutes the supreme task confronting contemporary agriculture in Nigeria and the primary challenge of its mechanisation: This is: To bridge the ever-widening gap in Nigeria between the demand for and the supply of good quality for food; and to feed Nigeria's budding agro-based industry with a dependable stream of good quality raw materials.

Envisaged Improvement in Agricultural Production

In order to fulfil the task before it, the Nigerian agriculture industry will undergo major improvements some of which will be along the following lines:

(a) The output of food and cash crops and livestock products will progressively increase from the low levels of peasant production to economically profitable level per farming unit. Research efforts will result in higher yielding, disease resistant crops and livestock breeds. These improved varieties of crops and better breeds of livestock and the increasing size of farming unit will require greater use of machinery, fertilizer, herbicides and eventually lead to high harvesting, bigger post harvest handling, processing and storage systems and more advanced marketing techniques. Other auxilliary farm activities that will increase in response to increased output include farm waste management, soil and water management, rural housing and livestock structures, and extension advisory services.

(b) The average size of land holding will become larger; and because of increasing cost of labour and other farm inputs the marginal size of the farming unit and associated agricultural enterprise will also become larger.

(c) Investment in agriculture will improve considerably. In addition, vertical integration from the farm level through to marketable products will develop. A good example of such integration which is already in evidence, is the practice of some poultry farmers whereby they grow their own feed grain, prepare their livestock feeds and market the poultry products in a single integrated organisation.

(d) The present stage of poor infrastructure characterized by lack of good access roads, electricity, water supply, medical care, schools, etc., in the rural areas must improve in an attempt to reduce rural-urban migration. In addition, the introduction of these basic necessities will facilitate the establishment of small scale industries and processing units in the rural areas. It must be said that the mere provision of urban amenities in the rural areas will not necessarily decrease rural urban migration by itself. But such amenities will need to be accompanied by new opportunities for jobs and higher rural income so that the rural population can enjoy and maintain the services which have been provided.

It is against the background of the envisaged improvement in agricultural industry that one must look at the role of farm mechanisation and the challenges posed. It is, therefore, necessary to examine some of the issues raised in terms of the type of mechanisation that should be encouraged; the processes that must be mecahnised and so on. Having examined some of these issues it will be useful to speculate on what might be available *modus operandi* to achieve the desired results.

Selective Mechanisation

The importance of suitable soils, the use of improved seeds, fertilizers, the location of farms with respect to the market, the transportation system, the machines, skilled mechanics and technicians must be taken into consideration when planning an agricultural production system. These factors, in combination with others, determine to a large extent, the economic limits to agricultural mechanisation. The underpinning concept of selective mechanisation is to choose areas in a country where the minimum essential ingredients for successful mechanisation are guaranteed or can be developed. This requires choosing the right type of soils in a place with favourable climatic conditions. The programme for the production of each crop must then be carefully scrutinized to determine what operations must be mechanised. The machines to carry out these operations must be carefully selected. In some cases, combinations of the different levels of mechanisation may be the most appropriate. It is important to stress the significance of correct decisions at this planning stage because if mechanisation is to have lasting impressions, it must pay for itself through increased production per hectare or through increased area under production. It is useful to note that the ultimate beneficiary of a successful mechanisation programme is not only the farmer but also the consumer.

Two-wheel or four-wheel tractor

The inadequacy of human energy to meet the power requirements for a sustained agricultural production and productivity has been highlighted earlier on. It is not only necessary that mechanical power should be made to replace human power so that the farmer can devote his energy, abilities and talents to the more rewarding tasks involving management decision making in his enterprise, but that the farmer should have an acceptable form of prime mover in agriculture. It is necessary, therefore, to spend some time at this juncture to discuss what type of tractor—a two wheel or four wheel version—that is more likely to meet the needs of the farmer and at what power range.

It is a proven fact of life that under continuous work, human beings can be relied upon to produce barely one-tenth of a kilowatt. It is, therefore, attractive to suggest that a two-wheel tractor of 6 to 8 kilowatt capacity will have an output equivalent of between 60 to 80 men and will be most adequate to meet the aggregated farmer's needs for power. This is, of course, an over simplification of the problem. The efficiency of application of power to productive work is much higher in human power application than mechanical power application. The human being is able to discriminate and apply judgment in expenditure of his muscle power thereby economising his energy and carrying out only the most essential part of the job. For example, if he is weeding a plot, he usually decides to pull out the weed with his hands when he finds this method the most convenient and least energy consuming. He also decides to apply different levels of force to his weeding hoe depending on the variation in the resistance of the weeds and soil conditions. In some cases he leaves overgrown shrubs and uses a cutlass to cut these down in a later operation. However, a mechanical weeding hoe is not able to discriminate along similar lines. It performs a once-for-all operation removing all weeds with roughly the same energy input and in the same manner. The mere fact that a tractor has a power output many times that of the farmer's muscles is, therefore, not the most important consideration. The suitability of the tractor to the farming system is a more important consideration in deciding which type of tractor to buy. In fact, emprical experience to date in the different states of the country, shows that the few farmers who had been able to purchase their own tractors have bought 4-wheel tractors and have indeed not considered the purchase of the 2-wheel tractor as rational investment.

The Case Study of Japanese Success Story

It is perhaps useful and instructive to consider the Japanese experience which has become a popular case study and presents us with one of the few successful applications of the 2-wheel tractor. The factors responsible for this success are summarised as follows:

(a) The climate which is relatively temperate with soils and cropping system (swamp rice cultivation) suited to working by tractors of low power output.

(b) Predominance of small farm holdings which are highly productive per hectare per annum.

(c) The countryside which has been tailored for the use of small tractors and machines particularly as regards farm access and transportation.

(d) The farming population who are individualistic with an attitude for machinery at farm and village level.

(e) The fact that Japan is an industrial nation and although highly populated, there has been a drift to the towns and many farmers are part-timers consequently relying more heavily on the use of machine to get their farming processes accomplished.

(f) Japanese industry which has seized the opportunity of a vast home market where there has been great competition to design low cost machines to meet local conditions.

To these may be added the contributory effects of the development in the Japanese industrial sector:

(i) Rapid expansion in the industrial sector absorbing virtually the whole population increase. Agricultural employment virtually constant, both land and labour productivity rising, the latter about 70 percent more rapidly.

(ii) Accelerated urbanisation with towns growing more rapidly than total population.

(iii) Rapidly rising per capital income in the peasant sector; the rise being used to finance agriculture. Coupled with this is an even more rapid rise in the manufacturing sector. Modernisation was achieved, therefore, without reducing rural living standards.

(iv) The development of powerful indigenous elite, the improvement of human capital, the expansion of physical capital, the evolution of modern business class, the crystallisation of an efficient marketing system, the formation of a skilled disciplined work force, the raising of labour productivity in all sectors, the stimulation of higher propensities to save and the construction of workable financial institutions, the inculcation of an entrepreneurial outlook and the development of effective forms of economic organisation. All these to a significant extent generated cultural, social and psycological resources upon which the industrialisation of Japan was nurtured.

These conditions are not fully met under Nigerian situation and it is unlikely that the application of single axle tractors for use under conventional dryland farming system will be successful.

The European countries in which the two wheel tractor has found some acceptance are those countries with farms situated along the foot of the Alpine hills. 2-wheel tractors are used in these areas because the type of farming is essentially horticultural. In some instances the slope of the land is so high that it is unsafe to use the regular four-wheel tractors. The average size of such lands is also small. It is significant to note that in the low lands of the same countries, farmers use small four-wheel tractors of 20 to 25 kilowatt which have been developed to meet the specific needs of horticultural farmers. These special small articulated four-wheel tractors of about 20 to 25 kilowatt, capable of manoeuvring in difficult and restricted areas in orchards, cost the same amount of money as the conventional four-wheel tractors of 35 to 40 kilowatt and certainly cost more than a two-wheel tractor that can otherwise be adequately used for the farming operations. Yet farmers buy these special tractors in preference to the conventional four-wheel tractors equipped with bigger power units.

Considering the points raised in the preceeding section, it may be inferred that two-wheel tractors will find application principally only in wet-land rice production. There may be some application in horticultural operations.

Expected Composition of Tractor Demand

Agricultural machines serve the same purpose in agriculture as production machines in the manufacturing industry. The expenditure on such machines is an investment on capital. In the case of the farmer, three motives are usually responsible for investment. These are (a) profit making, (b) desire to benefit from technological advancement in agricultural machines, and (c) prestige.

In a way, the first two motives are related and weigh heavily in a farmer's decision to purchase new equipment. This is because technological advancement usually leads to better production methods which in turn leads to greater profits.

Ideally, there is an optimum amount of tractor power needed to generate the required level of agricultural output. The pattern of ownership of the production machines should not, in the long run, change the amount of power requirement. Where the farm sizes are too small for individual ownership of a tractor and the matching equipment, it is expected that some grouping either through co-operative ownership or custom hiring will take place to ensure economical and optimum use of each tractor. However, the pattern of ownership will be influenced by the size of tractor and equipment available on the market.

At the present time, allowing for all mechanical energy sources used on the farm, the estimated value of mechanisation level is about 15 percent. Taking the possible development in agriculture into consideration, three sizes of farms may become identifiable during the next 20 to 25 years. The small farms of a few hectares each, the medium size farms of a few hundred hectares each and the industrial farms of a few thousands hectares each.

Judging from the experience of many countries, it is expected that, during the remaining portion of this century, the growth of mechanisation level in Nigeria is most likely to have the pattern described in Figure 3. Consequent on this, the percentage composition of tractors of different power units appropriate to different levels of mechanisation will be as illustrated in Figure 4.

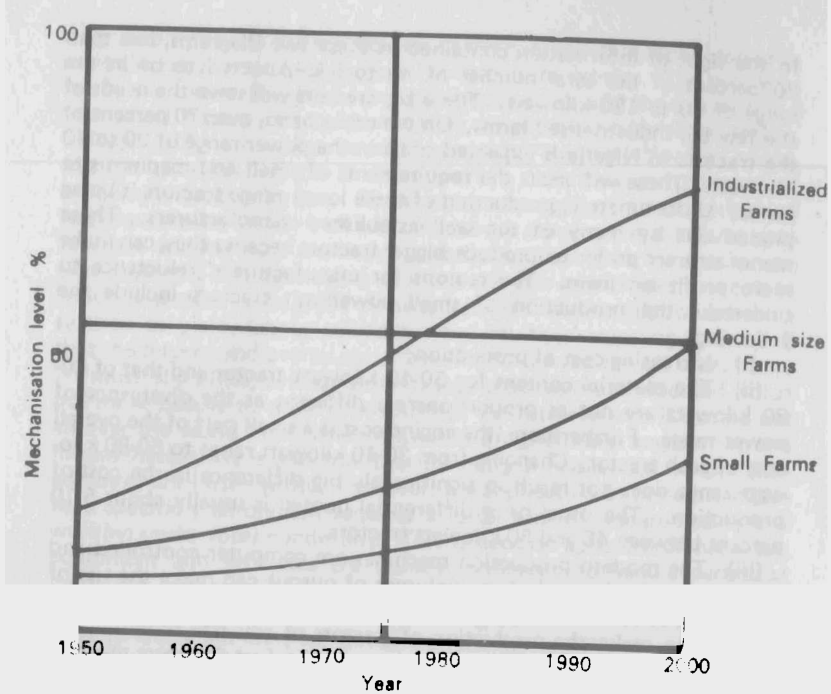

Fig. 3 Models of expected growth of mechanisation level for farm of different sizes in Nigeria.

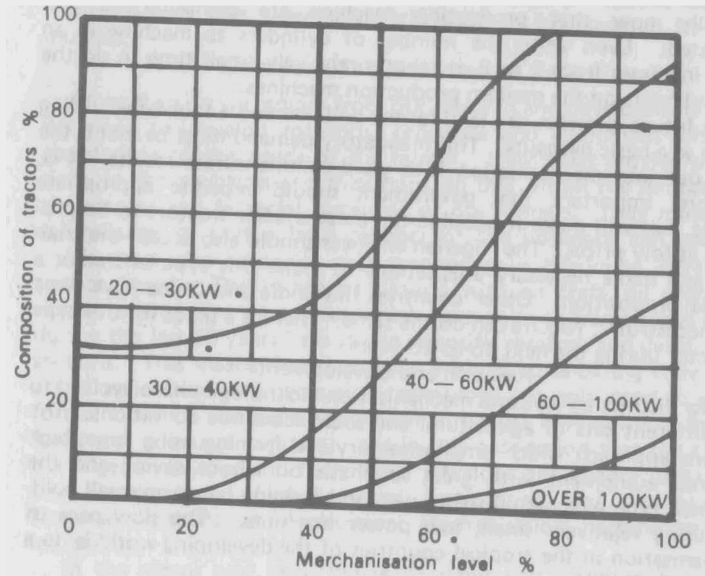

Fig 4: Percentage composition of tractors at different mechanisation levels.

In the light of information contained in these two diagrams, less than 30 percent of the total number of tractors is expected to be in the range of 60 to 120 kilowatt. These big tractors will serve the needs of the few big industrialised farms. On the other hand, over 70 percent of the tractors in Nigeria is expected to be in the power range of 30 to 40 kilowatt. These will meet the requirements of small and medium size farms. Unfortunately, production of these lower range tractors is being phased out by many of the well established manufacturers. These manufacturers prefer to produce bigger tractors because they can make more profit on them. The reasons for manufacturers' reluctance to undertake the production of small power-unit tractors include the following:

(i) Increasing cost of production.

(ii) The material content for 30-40 kilowatt tractor and that of 60-80 kilowatt are not as proportionately different as the divergence of power range. Furthermore, the engine cost is a small part of the overall cost of each tractor. Changing from 30-40 kilowatt range to 60-80 kilowatt range does not result in significantly big difference in the cost of production. The usual price differential quoted is usually about 5-10 percent between 45 and 60 kilowatt tractors.

(iii) The modern production machines are computer controlled and of such a scale that only large volumes of output can make the use of the machines economically justifiable. All the manufacturers claim that in order to make the production of tractors of any size economically viable a market of 20,000 units a year over the first 10 years must be guaranteed per factory.

(iv) A skilled machinist will spend almost the same time machining a 4 cylinder 30 kilowatt block and a 4 cylinder 60 kilowatt engine block, especially now that production machine are computerized and automated. Even when the number of cylinders to machine in an engine increases from 2 to 6, it takes a relatively small time to do the extra cylinders on the modern production machines.

The future Nigerian dry land farmer will demand a four-wheel riding tractor as a basic necessity. This mandatory demand must be met if the effort put into mechanisation is to yield commensurate results. It is, therefore, important that government should expedite appropriate policies that will make it possible for these smaller tractors to be produced at low prices. The Nigerian engineer should also accept the challenge and make necessary adaptations to make this type of tractor a feasible proposition. Other countries like India and China have done this successfully, Nigeria can do the same. There is a place for this type of tractor during the next 15 to 25 years.

Research and Development

Two distinct agricultural mechanisation technologies have evolved to suit different sets of agricultural and socio-economic conditions. The Western approach which emphasises dryland farming using large, high powered equipment with great emphasis on labour saving and the Japanese type which emphasises wet-land farming based on small holdings using relatively small, low power machines. The slow pace of mechanisation in the tropical countries of the developing world is, to a large extent, due to the inadequacy of the two available technologies to meet the requirements of the small farmer in the tropics. The problems facing the use of the small low power equipment and the conventional four wheel tractor and equipment have already been highlighted earlier.

Nigeria like any other developing country cannot afford to adopt, without question, all the western world's objectives and patterns of agricultural mechanisation. The western approach of mass production techniques with the aims of reducing labour input and maximising convenience and comfort are not necessarily applicable to the mechanisation problems in a developing country. What is more important and to which attention should be focussed is the relationship of machine systems to yield, labour utilization and multiple cropping to the end that the returns and overall social benefits to the society are maximised. We must, therefore, develop systems that produce more food and which put more people to work productively. A lot of research is carried out all over the world into different aspects of agricultural engineering and mechanisation. It is also true that the basic principles can be established anywhere in the world. However, the application of these principles to a specific environment requires a local pool of research personnel working under local conditions. This is because agricultural machines, equipment and processes are usually developed to handle particular crops and systems of farming. Moreover, crops, soils, rainfall and other climatic conditions vary from region to region.

It is important that we direct our energies to the more rewarding problems. For example, with respect to the hoe and cutlass, no amount of improvement in their efficiency and management, no greater effort in terms of use of better materials and no amount of improvements in the design of handles can transcend the technical limitations that result from the fact that these tools still have to be powered by human muscles.

Direction of Future Research Efforts

What then do we require from our research and development efforts. We need to develop methods, processes and equipment which are appropriate to the needs of the farmer. They must provide the solutions to the problems and they must do this within the limitations of the mental and financial resources of our farmers. They must create self-reliance so that a large number of the populace can use them.

We must also recognise that technology is becoming increasingly science based. The industries dealing with air craft, oil processing, nuclear energy and electronics which have enjoyed tremendous growth during the last 50 years have strong scientific research and development sections. This means that those who wish to advance the state of the art in agricultural mechanisation technology not only need to acquire formal body of scientific knowledge but must have suitable environment and adequate support. It is in this connection that the roles of the Nigerian Science and Technology Development Agency, the University Departments of Agricultural Engineering and the proposed National Institute of Agricultural Mechanisation become very — important.

In the recent past, man has made significant technological strides and this has made it possible for him to exploit the vast potentialities of his natural environment. But unfortunately, these technological advances which have brought such profound change to the living conditions in our big cities have not been sufficiently applied to improve conditions in our rural areas. Even in the face of accelerated rate of migration from the rural areas, the greater proportion of our population still lives in these areas. We must, therefore, make conscious efforts in our research and development programmes to change the trend whereby our rural areas have become places from which to move way. The engineer's responsibility in making this possible is very great.

The engineer is a professional problem solver. Engineering methods have been employed successfully to solve many of the problems facing mankind in various walks of life. Contemporary achievements of the agricultural engineering profession in many parts of the world have become note worthy and compelling. Living testimonies to the ingenuity of the engineer in the agricultural industry include equipment such as the combine harvester, the forage harvester, the tractor, the cassava planter, the threshing machine, the sprinkler irrigation system, and a wide variety of other sophisticated and complex agricultural machinery and physical facilities on the farm. As an engineer, I have a strong belief and conviction that the mechanisation of Nigeria's agriculture is as reliable as it is inescapable.

Local Manufacture of Agricultural Machines

During the early stages of agricultural equipment development, those who worked on the land fashioned the tools themselves. As agricultural equipment developed in sophistication, the source of its manufacture moved steadily away from the farmers. The development of techniques of metal working marked the advent of craftsmen who began to specialise in the production of agricultural tools. The production of agricultural implements moved even further away from the activities of the farmers with the introduction of animal drawn equipment. The final stages of the evolution stemming from the application of sophisticated mechanical power equipment to agricultural operations encouraged the growth of agricultural machinery manufacturers from regional through national to the modern international firms such as Massey Ferguson, Ford, John Deere, International Harvester, Ransomes, to mention a few.

Nigeria should benefit, and rightly too, from the experience of these international companies especially in the manufacturing of the more sophisticated and complicated machines. The conventional method of co-operation between a country like Nigeria and these companies is to sign an agreement with the companies to set up manufacturing plants which will start with local assembly in the first instance. The agreement usually contains a programme of development of local personnel and physical facilities for eventual 100 percent local manufacture. Many countries have developed their manufacturing industry like this. The results are bound to be rewarding if the planning and subsequent implementation are properly carried out.

In this connection it is of interest to note that the Federal Government has entered into agreements with the firms of Steyr-Daimler Puch Ag and Fiat to produce agricultural tractors in Nigeria. It is perhaps of

some relevance to raise a question, at this point, why in fact none of the reputable manufacturers whose brands of tractors have achieved reasonable reliability over the last 30 years, on the Nigerian market has been successful in entering into a partnership with us for the local manufacture of a proven technological package. This is particularly strange as many of these manufacturers have expressed their wish to do so to the Federal Government.

With respect to the manufacture of other agricultural machines it is important not to underestimate the volume of locally developed machines. As an important step towards commercialisation of these machines, the Federal Department of Agriculture should set up a study team immediately to carry out the following:

(a) Compile a list of local manufacturing industries and workshops producing agricultural equipment.

(b) Compile a list of all agricultural equipment in use in the country and identify those for which arrangements should be made for immediate local production.

(c) Categorise the machines that cannot be manufactured immediately into: (i) those that need some modification before they can be manufactured, (ii) those that show great promise of commercial exploitation but still needs extensive development.

(d) Make a forecast of probable demand of each machine over the next five to ten years.

(e) Suggest plans and programmes by which government cannot only encourage inventiveness and innovations in agricultural machinery but develop necessary infrastructural facilities to encourage production of the machines.

THE ROLE OF THE UNIVERSITY OF IFE

Our activities in the Department of Agricultural Engineering like any other Department in the University are threefold. These are teaching, research and service to the community.

In our teaching programme, we are particularly mindful of the traditionally weak technical background of the average engineering student at the time he or she enrols on our programme. We have, therefore, made conscious efforts in all our programmes to relate our teaching to practice. This philosophy is embodied in the objectives of our degree programme in Agricultural Engineering. I seek your permission to reiterate these objectives and emphasise the areas that are particularly relevant to the point I made concerning the background from which our students come:

(a) To train engineers capable of applying engineering principles and practice to agricultural mechanisation, crop production, preservation and storage, soil and water conservation and utilization, farm and agricultural management, farm structures and rural electrification.

(b) To train engineers for the economic selection, optimum ultilization, *operation, maintenance,* and *repair* of labour saving equipment that are used in agriculture with the objective of maximising the benefits derived from them.

(c) To train engineers who can relate their activities to the needs of the society in general and to develop in them a sense of responsibility that is required for their professional work; and

(d) *To identify the limitation of our students and to make a real effort to provide compensating corrective measures.*

Of course we have no other alternative. Agricultural Engineering in any country includes working with a first hand knowledge of the training skills required for carrying out all related technical, craft and agricultural operations. The reason for this is three-fold. In the first place, the engineer can best understand and perfect the machine, the system, the process or the structure he develops if he has the training and skill to operate, instrument and test it. Secondly, he must understand the training and skill of the technicians, craftsmen and farmers if he is to properly direct his design applications to the most effective use by those who must build and those who must operate them. Finally, the engineer directs these technicians, craftsmen and fellow engineers that he has available to him for the purpose of carrying out his work assignments. He can better direct these technicians and craftsmen if he himself is reasonably proficient in some of the skills required of these men and has a good understanding of their training and skills.

It is in pursuance of these objectives that we give each student a specific problem in his final year as a project. This project usually involves analysis of the problem, design and fabrication in the shop and finally field testing of the machine or process. Our experience in the design and research project for our students have been particularly rewarding. At the beginning of each year, the students complain about the excessive amount of work involved. More often than not, they detest it. But as the work progresses to the fabrication and testing stage and they start to see concrete result of their toils, their attitudes change. At this stage, the more concentious ones among them work until late hours in the workshop. This is not surprising because it is the first real-life situation in which they have to put together the engineering, mathematical and other forms of knowledge to obtain a satisfactory solution to a given specific problem. We cherish and preserve these machines and processes built by our students. We are developing many of them into commercially exploitable units. In this connection it is proper to acknowledge publicly the tremendous amount of time put by members of staff into the supervision of these projects.

The Department has made a significant step forward in its contribution to the advancement of agricultural engineering education by admitting the first set of post graduate students in October 1977. This will not only help to strengthen our research efforts, but also help in augmenting our contribution to the overall development of the profession.

In our research programmes, we have directed our efforts at assisting the government and the farmers in their endeavours to meet the declared objective of increased agricultural production. It is appropriate, therefore, to record, for example, that within the space of six years, our farm machinery development activities have resulted in machines like the portable grain planter, a cowpea sheller, a cassava stem-cutting-planter, a cassava root digger and a kenaf decorticator.

Plate 1	shows the portable planter while
Plates 2 and 3	show the planter during a field trial.
Plates 4 and 5	show the cowpea sheller.
Plates 6 and 7	show the cassava-stem-cutting planter in operation on the field.
Plate 8	shows one traditional method of carrying out the planting
Plate 9	shows the cassava root digger while
Plates 10 and 11	show respectively the digger during a field test and a sample collection of cassava roots lifted with the machines.
Plates 12 and 13	show two views of the kenaf decorticator, while
Plates 14 and 15	show the machine undergoing field trials.
Plate 16	shows a sample of freshly decorticated kenaf backs.

As part of our contribution to the Isoya Rural Development Project of our Faculty of Agriculture, we have helped in building a wood fired drier which some of the farmers now use as a guide for building their own individual driers. Our department has since then completed a detailed engineering and scientific study aimed at optimising the performance of this type of drier. The farms in the villages of the Rural Development Project have provided us ideal situations for testing the machines we are developing for the small scale farmers.

The University of Ife has the prerequisities for playing a leadership role in the field of agricultural mechanisation. We have one of the best Faculties of Agriculture in the country. We also have a relatively younger but active Faculty of Technology. With your permission, I will like to state publicly that we would be a stronger Faculty of Technology when we have a full complement of viable Departments of Civil, Mechanical and Electrical Engineering and a functional Central Technological Workshops and Laboratories.

We feel it is right to expect our Department of Agricultural Engineering to fulfill this University's aspirations of playing a pioneering leadership role in the field of agricultural mechanisation, agricultural engineering education and research. With the kind co-operation of our colleagues in the other departments in the Faculty of Technology and the Faculty of Agriculture, we are determined to achieve no less.

CONCLUSION

In concluding this presentation, I will like to emphasize some aspects which require urgent and appropriate action in order that the agricultural mechanisation programmes in this country may be fruitful. Due attention must be paid to the following:

(i) Adaptation of existing technologies to suit our system of production of the various major crops.

(ii) Development of appropriate power units, machines and processes suitable for our cropping techniques and environment and which are in phase with the developments in the methods of agricultural production.

(iii) Development of suitable farming processes in response to the new class of farmers who are now going into farming on commercial scales.

(iv) Development of acceptable farm energy input by developing renewable energy sources and better use of solar energy.

(v) Development of manufacturing and necessary infrastructural facilities of agricultural machines and their spare parts.

(vi) Immediate establishment of the proposed National Centre for Agricultural Mechanisation.

(vii) Enlargement of efforts and facilities for the training of agricultural engineers, agricultural mechanics and farm machine operators.

(viii) Provision of employment opportunities and greater participation of agricultural engineers in the programmes of the different Agricultural Research Institutes and Establishments in the country.

Finally, it is reasonable and logical to expect that the techniques, the resources and the opportunities for production in Nigerian agriculture are bound to change in order to increase the volume and quality of output of crops and livestock products. It is equally reasonable and logical to expect that agricultural engineers as well as the other professional groups serving agriculture and the farmers, given the right incentives and favourable conditions, are capable of making this change possible. It is my humble prediction that the only other alternative to the expected favourable change in our agricultural fortunes in this country is a progressive escalation in the cost of food culminating ultimately in a famine. I am confident that Nigeria has the natural, human and other resources for preventing such a catastrophy.