An Overview of Agricultural Mechanization and Its Environmental Management in Nigeria

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ABSTRACT

Nigeria's agriculture requires a very strong boost because of increasing population and decreasing land resources due to environmental factors. This paper discussed the dynamics of agriculture and the important role of mechanization in providing the needed boost. The national agricultural policies and their impact on Nigeria's agriculture were highlighted emphasizing the previous and present roles of various organs of the government. After discussing the assets and liabilities of Nigeria's agriculture, the paper posits that the agricultural environment must be properly managed for sustainable agricultural productivity in view of emerging information technology. The future expectations and challenges facing the Nigerian agricultural engineers, agriculturists, scientists and environmentalists were also highlighted.

Keywords: Agriculture, engineering, environment, inputs, management, Nigeria.

1. INTRODUCTION

While agriculture is the practice of cultivating the soil and raising livestock to produce plant and animals useful to humans and in some instances animals, agricultural inputs relate to those vital elements to be used to make agriculture both possible and profitable. These inputs are resources required to cultivate the land, produce crops including forestry, livestock including fishery, process, and store and distribute them. Agricultural inputs must therefore include diverse elements such as land, capital and labor as well as research, education, communication/information, and engineering/technology. All these inputs and many more constitute agricultural mechanization which must be harnessed, controlled and organized for improved agricultural practice. For mechanization management to succeed, some other inputs upon which it will strive must be available. These include good and focused political manner of governance capable of formulating and implementing policies and laws that can accelerate the process of economic growth and development. Mechanization management should address the challenges facing the future of food demand and supply as enunciated by Raoult-Wack and Bricas (2001). The agricultural system practiced in Nigeria needs to exit from excessive reliance on fickle weather conditions (rain-fed) for year-round (irrigated) production of raw materials in the right quality and quantity at the right time for agro-industrial development. There is the need to increase the research and development efforts as well as extension outreach. To progress technologically, the educational and technological capacities of the rural farmers must be improved in order to develop a true rural entrepreneurial capacity for aggressive competitive access to markets both locally and internationally. Even though women are included as rural farmers, there is need for special programmes targeted on them because of their roles as the dominant agricultural producers, traders and nutrition providers.

Agricultural development involves three approaches namely bio-chemical, socio-economic, and engineering known as the trio of technologies (Mrema and Odigboh, 1993). The bio-chemical approach includes the development of improved animal and plant species, animal and plant nutrients (fertilizer and feed) and plant and animal protection (veterinary drugs, pesticides and herbicides). The socio-economic approach includes financial packages and management programmes (economics, business management, accounting, sociology, extension services, agricultural marketing and pricing strategies). The engineering approach deals with the provision of agricultural machines and equipment (be they human, animal or mechanically powered) for production and post harvest systems, handling and storage systems and farm structures, erosion control measures, water resources development as well as irrigation and drainage structures, meteorological systems, and the technologies for optimally utilizing the above and their proper and economic use and management.(Ani and Onwualu,2002; Ampratwum et al., 2004; Onwualu and Pawa, 2004).

Agriculture is an important occupation in Nigeria with over 70% of her population depending on it directly or indirectly for livelihood. It provides the bulk of employment, income and food for the rapidly growing population as well as supplying raw materials for agro-based industries. World current agricultural production has an average growth rate of 1.8% as compared to the 3% in the 1960s and therefore at a lesser pace than the demographic growth. The World Bank has shown that in Sub-Saharan Africa (to which Nigeria belongs) the annual food increase needs to reach 4%, i.e. more than double the current figure in order to achieve food security (IBRD, 1989). She suggests that this can be reached through a significant progress in plant and animal breeding that plays a key role in the development of the agricultural sector as well as a significant impact using appropriate farm mechanization (Pawlak et al., 2002).

Due to a number of factors, which include rising population, increasing pressure on land resources, natural and man-made disasters such as drought, desertification, soil erosion and degradation (Raoult-Wack and Bricas, 2001), the problem of sustainable agricultural production in Nigeria has assumed greater importance than ever before.

Nigeria and some Third World countries must recognized that food and raw materials independence is an internal affair of their countries and that if a properly articulated agricultural development plan is given priority in practice, it will lay the foundation for modernizing the entire economy. The rate of growth of agricultural production in Nigeria should increase appreciably in order to mitigate hunger, starvation, diseases, raw materials dependence on foreign sources and food importation, as well as to improve on the quantity and quality of food per person and the well-being of the farmer and his family. This can be done by increasing agricultural productivity through mechanization. This has been done in such other countries like in China (Li, 2005) and in Oman (Ampratwum et al., 2004). Mechanization of agriculture helped transform American agriculture from the situation where one farmer fed 5 people in 1880 to that where one farmer could feed 80 people in 1982 (Ani and Onwualu, 2002). With 90% of Nigeria's agricultural work done with hand tools, 7% with animal-drawn tools and only 3% with engine powered technology, it is understandable that with the over 70% of the population engaged in agriculture, self-sufficiency in food still a mirage (Onwualu and Pawa, 2004).

Nigerian agriculture has been very internationally uncompetitive in terms of quality, quantity, grades, hygiene, pricing and markets and will remain so until infrastructures are upgraded,

and policy and institutional measures favoring it are put in place. Improvements in infrastructure – particularly productive investments in land improvements and water control, markets, processing and roads – are a key to overcoming the constraints imposed by high levels of population growth, combined with a shift in the ratio of rural to urban population. It is mechanization that will completely revolutionize the Nigerian agriculture.

1.1 Dynamics of Agriculture

Engineers and scientists deal with forces and forces are vectors. Agriculture is an embodiment of various forces and would be considered as a vector with four components which must be thoroughly resolved to produce the desired effect of cultivating the land, producing crops and raising animals.

Component I – What: This component defines and visualizes agriculture as a way of life, occupation or business to produce the 5 F's: food, feed, fiber, fur and fuel. Without any alternative means or methods of producing these basic necessities, their output levels remain static making this component constant and bounded.

Component II – When: This component deals with timing of crop and livestock production and varies in space because of the dependence of agricultural production on soil, climate and weather. Despite slight modification of this component by components III and IV below, it is largely stable for any geographical location.

Component III – How: This component deals with the art of producing crops and livestock through acquired skill and practice. It is the application of the skills into farming. This is the mould or framework which may become a bottleneck when wrongly applied. It is highly influenced by component IV below.

Component IV – Why: This is the science or facts of agricultural activities. This component consists of a systematical organized body of knowledge about farming and interrogates all the other components and integrates them as follows:

On Component I, it makes modifications by the addition of or substitution with improved and high yielding varieties or breeds or species used in production.

On Component II, it introduces modifications in soil and weather e.g. tillage, fertilizers and irrigation as well as crop protection methods and equipment. It has altered crop production calendars, while feed lots have effectively substituted grazing and range feeding in livestock production.

On Component III, its influence is highly ramified. It is the reason for scientific research in agriculture, it provides the platform for public policy in agriculture; it is susceptible to active opposition or resistance from man. The difference between success and failure of Component IV to make any impact on this Component III shows the level production. Whenever Component IV fails to make sizeable impact on Component III, agriculture stabilizes at the level of occupation (a job by which someone just earns a living). But where it favorably influences Components III, II, and to some extent Component I, agriculture becomes a business (a profession; a commercial activity by a company or other organization that buys and sells goods, makes products, or provides services). (Encarta World English Dictionary, 2005). It differentiates between small-scale and large-scale production.

From the above scenario, it is clear that Component IV which is essentially engineering technology and mechanization must strongly influence all the other components to make agriculture worthwhile as a business. The failure or problem of agriculture in Nigeria could be traced to poor planning and execution of policies and lack of understanding and selection of appropriate mechanization technology.

2. PROBLEMS OF NIGERIAN AGRICULTURE

The problems which have confronted Nigerian Agriculture can be divided into two broad areas – policy/strategy and technical.

2.1 Overview of Nigeria's Agricultural Policies

In the Ten Year Development Plan (1946 – 1956) the Colonial masters emphasized commodity crop production mainly oil palm, cocoa, rubber, cotton and groundnuts. The document contained very little or no proposal for increased food production.

The first National Development Plan (1962 – 1968) sought to increase the production of export crops through better seed distribution and more modern methods of cultivation as well as through the increase in area under cultivation. Farm settlements and cooperative (nucleus) plantations as well as Tractor Hiring Units were established. There were farm implements, such as the hydraulic hand presses for expression of palm oil and a greatly expanded agricultural extension services among others. The component regions were largely autonomous in terms of agricultural policy formulation and implementation. This Plan Period was a success. Agriculture was a major sector of the economy, the major source of income and employment to both the Government and the rural people (Agric. Policy, 1988). The cash crops accounted for about 80% of our total export and 45% of the gross domestic product (GDP). However, no mention was made of the food sector in this plan that had 11.6% capital allocation by both Federal and State Governments to Agriculture (Osakwe and Ojo, 1986).

The Second National Development Plan (1970 – 74) specified the creation of rural employment opportunities with no definitive programme for their achievement. Capital (9.9% of the Budget for both Federal and State Governments) allocated to agriculture (Osakwe and Ojo, 1986) for crop production, irrigation, research, credit (as loans or subsidy), mechanization, man-power and agricultural extension services, declined. In 1973, the National Agricultural and Cooperative Bank (NACB) was established to facilitate agricultural financing to farmers. The National Accelerated Food Production Programme (NAFPP) was initiated which laid emphasis on agricultural research and extension support to farmers. With massive exploration of crude oil, the oil boom came and stood astride the Nigerian economy contributing more than 98% of total export value and 73% of GDP (Opara, 2006). With focus on crude oil, the agricultural policies and programmes were clumsily executed and virtually abandoned by succeeding military regimes (Osakwe and Ojo, 1986). The cocoa plantations suffered serious setback, the cotton and groundnut pyramids disappeared, hides and skin became food for the embattled Nigerian populace, and the oil palm plantations which were battle fields during the Biafra/Nigeria Civil War died natural death due to neglect. The disaster on agriculture was enormous, and Nigeria has not ameliorated the effects till date.

The Third National development Plan (1975 – 80) was the first to spell out provisions for food production because there was obvious decline in national food supplies due to poorly executed or neglected past agricultural policies and the effects of the civil war. The oil boom

precipitated massive rural-to-urban drift made up mainly of the younger generation. Several crop farms suffered "death" because of inadequate or zero maintenance and there was serious deficit in food production (Alatise, 2001). In 1976, the Operation Feed the Nation (OFN) programme was inaugurated. This first major agricultural policy pronouncement and effort by Government generated awareness among Nigerians about the consequences of an empty national food basket. The programme focused on building the spirit of dignity of labor and reengaging the idle hands back to land. In the same year, and consequent upon the plan document, Marketing Boards were abolished. Production and Marketing Companies were established such as National Grain Production Company for food grains and National Root Crop Production Company for root crops. Other policy and strategic measures taken by Government during this period were the establishment of River Basin Development Authorities (RBDAs), National Seed Multiplication Scheme, Agro-Service Centers, Agricultural Development Projects (ADPs). Many research and tertiary institutions were established to formulate and implement research programmes aimed at improving agricultural food production. Even with all these policies, the total Capital allocation to Agriculture by both Federal and State Governments further declined to 7.1% (Osakwe and Ojo, 1986). This goes further to show that Government was not supporting the agricultural sector with adequate financial backing for proper execution of the programmes.

The Fourth National Development Plan 1981 – 85 saw the emergence of the Green Revolution which tried to give more powers and impetus to the River Basin Development Authorities and the ADPs to produce more food for the nation with more Capital (12.7%) allocated to the agricultural sector (Osakwe and Ojo, 1986). Even though these efforts seemed to have been guided by genuine concerns, they failed to make the necessary impacts in the agricultural sector because of fundamental structural problems in the economy. There was obvious decline in the agricultural sector share of the GDP to about only 20% in the 1981 -1985 Plan period (CAADP, 2004); underdevelopment of the sector; frequent changes in government policies and implementation strategies; no serious agricultural mechanization policy; poor infrastructures and facilities; poor research and development work. There was increasing shortage of food evidenced by increased food imports and increased high prices. Agricultural exports dwindled at an alarming rate as well as decline in labor force for agriculture.

In 1986 the Federal Military Government introduced the Structural Adjustment Programme (SAP). Importation of major foods was prohibited to enhance local production and price competitiveness of locally produced foods compared to those imported (Bamgboye and Jekayinfa, 2006). The Directorate of Food, Roads and Rural Infrastructure (DFRRI) was established to provide the Nigerian rural populace with infrastructural facilities (roads, electricity, water boreholes and pumps, agricultural inputs) to enhance food production, processing and evacuation of their produce to urban markets and to stem rural-urban migration. Interest was aroused in farming but labor became very expensive and most often difficult to get at peak season, as it followed the law of supply and demand. The increased farm labor cost increased the cost of agricultural produce. Due to untimely operations of manual land preparations, hand planting, manual weeding and fertilization, as a result of labor shortage the expected yields declined. However, because of its rural target, this latest policy options produced an increase in overall agricultural production (higher than pre-intervention period) with an understandably high cost of food. Nigeria's agricultural

production rose by an estimated 2.5% in 1987, 4.58% in 1989 and 4.8% in 1991, while grains alone increased by 4.8%, 6.9% and 7.5% respectively (CBN, 1991). The Directorate of Employment (NDE) was established in 1988 to address unemployment of graduate school leavers. It provided training and some initial take-off grants to participating beneficiaries who wanted to go into food crop as well as animal production and processing.

Experience from the above three Plan Periods convinced Government that there can be no alternative to well-designed and articulated agricultural policies as instruments for promoting agricultural growth and development in Nigeria (Igbeka, 2003). In 1988, the Federal Government published the first ever agricultural policy document for Nigeria aimed at redressing the underdevelopment of agriculture, streamlining policies in all tiers of government and ensuring policy stability (Opara, 2006). Again, the implementation of this policy ran against many problems including: poor funding and poor state of infrastructure; poor administration of government support to agriculture and abandonment of projects midstream due to political reasons; poor private sector participation and investment in agriculture due to inconsistency and instability of macro economic policies which tend to discourage medium and long term investments in agriculture; lack of appropriate technology to reduce drudgery in agricultural production and processing and inadequate availability of inputs such as improved seeds and breed stock. Despite these problems, agricultural production in Nigeria increased steadily at the rate as high as 6.4% annually between 1988 and 1992 (Okunmadewa, 2002).

From 1992 - 1998, succeeding governments saw that the problem of food shortages was grim and in a bid to control population decreed the one man four children policy. Since women involvement in agriculture was high, government policies then centered on women. Programmes such as Better Life for Rural Women; Family Support Program (FSP); Family Economic Advancement Programme (FEAP) were initiated. These were meant to empower the women for more and better involvement in agriculture and other rural activities. The programmes were aimed at providing some form of mechanization to agriculture by way of cottage industries in rural areas. It was hoped that these would enhance the production of food and agricultural raw materials. The National Land Development Agency (NALDA) was established in 1992 to provide support for land development for agriculture. The National Agency for Science and Engineering Infrastructure (NASENI) was established in 1992 to establish and nurture an appropriate and dynamic Science and Engineering Infrastructure. Some of the facilities (staff and machines) at the various NASENI Centers can be used for the manufacture of agricultural machines and for empowering Small and Medium Enterprises (SMEs) in agriculture (Onwualu and Pawa, 2004).

In Nigeria today, the present government (1999 – 2007) is implementing different reform programmes on privatization, commercialization, deregulation, corruption and financial crimes. These are meant to stabilize the economy and make it more productive ensuring that the era of subsidies and over-protection of key sectors of the economy including agriculture is over. With regard to post-harvest agricultural activities, clearly the days of expensive government involvement in most agro-processing facilities are past, and future emphasis will be very much on commercial involvement by the private sector (Van Otterdijk, 2005). In 2001 a New Agricultural Policy and the Integrated Rural Development Policy were initiated to ensure national food security, attain self-sufficiency in basic food production, enhance employment opportunities and achieve high growth rate for the economy. These were to be

achieved through the introduction of and adoption of improved technology, efficient utilization of resources by the farmers and a broad based organization and mobilization of the rural masses so as to enhance their capacity. These policies are being implemented by the National Economic Empowerment and Development Strategy (NEEDS) – a medium term economic reconstruction agenda aimed at value reorientation, wealth creation, poverty reduction, job creation and elimination of corruption. In order to fast track the gains of the 2001 New Agricultural Policy, there came the Presidential Initiatives in Agriculture (PIA) (2004) and the National Special Food Security Program (NSFSP) and FADAMA II (2005). The PIA gave priority to four different crop-based expansions of production and utilization programmes (e.g. cassava, rice, tree crops and vegetable oil) and livestock and fisheries programme with a view to curtail the huge foreign exchange expended in their importation and their importance in the revival of industries based on their raw materials. The NSFSP and FADAMA II are targeted at the resource poor rural farmers and aimed at raising their agricultural productivity and production to eliminate their poverty and through them attain food security. In 2006, the National Agricultural Development Fund was established with a take off capital of N50 billion with a view to address the problem of inadequate funding of agriculture on a sustainable basis.

The above policies lend support to The New Economic Partnership for Africa's Development (NEPAD) as well as the Lagos Plan of Action (LPA) acknowledgement that agricultural mechanization and environmental stability are a *sine qua non* for increased food production and food security (Faborode, 2005). The present administration signed the Comprehensive Africa Agriculture Development Programme (CAADP) of NEPAD Protocol, to best respond to the widely recognized crisis situation of African agriculture especially as it pertains to food. This Protocol focuses on investment into (i) extending the area under sustainable land management and reliable water control systems; (ii) improving rural infrastructure and market access; and (iii) increasing food supply and reducing hunger. Nigeria's agriculture and its sub-sectors have for long been starved of funds/investments. The prolonged neglect has resulted in a poorly productive, uncompetitive and declining sector. The farms are coping but they are weak and neglected. NEPAD's intervention is the injection of new capital. While this is a welcome approach, Nigeria's agriculture needs a lot of internal adjustments to make the intervention work. Some of these adjustments have been discussed by Mijinyawa and Kisaiku (2006).

2.2 Technical

The Second National Development Plan (1970 – 74) had stated: "No realistic change can be expected from the present nature of Nigerian Agriculture, due to the drudgery attached to it, until the farmer finds an alternative to the hoe and cutlass technique of production. The clearing of bush, preparation of land, the sowing of seeds, the various post-planting operations are all processes in which the farmer's present tools can do little for high productivity per man day or per acre". The over reliance on hand tool technology (over 70%) for agricultural production is one of the greatest technical problems facing the present generation of Nigerian farmers. This is because with the low work rate efficiency of less than 10% in the humid tropics, using hand power is arduous, inefficient and can barely produce enough to feed the family. With hand tool technology, farming in Nigeria has remained an occupation untouched by Component IV.

Even today the bulk of Nigeria's rural farmers do not have labor saving devices that would ensure that all field operations are performed on time, and do not have at their beck and call

harvesting and processing machines. The intensity of mechanization of farming activities in Nigeria is still quite low at 18W/ha as compared to 37W/ha in Africa and 783W/ha in the United States of America in 1977 (Anazodo et al., 1987) and as such the agricultural energy consumption is not yet as high as in the developed countries. However, the key to economic development lies in raising agricultural productivity which directly involves the utilization of more energy resources (Jekayinfa, 2006). The reason why Nigeria's agriculture has not made any tangible forward movement is that there has been very little engineering put into it by government, agricultural engineers and farmers. There is the need to put more power into Nigeria's agriculture. These include both general and engineering infrastructures. The general infrastructures include electricity, communication facilities, roads, transport facilities, irrigation and water pumping facilities. The engineering infrastructure includes those engineering skills, workshops and machines required for production of capital goods. There are relevant prototypes of agricultural machines developed in some Universities and Research Institutes all over the country. These functional prototypes have not crossed the corridors of these Institutions to the end-users (the farmers) because of lack of entrepreneurship. Until recently government policies did not address mechanization through articulated local manufacture of agricultural machinery. With the establishment of the National Centre for Agricultural Mechanization (NCAM), the Nationally Coordinated Research Program (NCRP), and the National Agency for Science and Engineering Infrastructure (NASENI), the government has once more proposed yet another sound policy with great technical input.

3. OVERVIEW OF ENGINEERING INPUTS INTO AGRICULTURAL PRODUCTION IN NIGERIA

In the discussion on the dynamics of agriculture, it was noted that component IV, which dealt with science and engineering "interrogates and integrates all the other components". It means that without science and technology and engineering ingenuity all the other components would not have any meaningful contribution to make in agricultural production. Scientists, technologists and engineers have a duty to ensure that their contributions in the other three components of agricultural dynamics are scientifically and technologically sound. Thus, they should ensure technology availability, adaptability, reliability and affordability, so that the assets and liabilities of Nigerian agriculture will be properly and adequately taken care of.

3.1 Assets

The assets, those useful things or attributes that contribute to the success of Nigerian agriculture are as follows:

- Diversity of cultivated, semi-cultivated and wild crops and diversity of genetic potentials in indigenous crop and tree species and breeds of livestock.
- Ecological adaptation of species and breeds.
- Ecological efficiency of various groups of crops and livestock
- Large areas of cultivated and cultivable land.
- Large, ready, but undefined internal market and potential external market.

These assets which are all-encompassing seem very few compared to the following liabilities.

3.2 Liabilities

These are the things that hold the success of Nigerian agriculture back. They constitute a bottleneck to it.

- Rapid decline in soil productivity under intensive use.
- Accelerated soil wastage through erosion (wind & water) and desertification
- Absence of local sources of soil amendments or nutrients
- Unbalance between crop water requirement and natural precipitation – needing irrigation facilities.
- Large numbers of preferred food crops as a result of zonal preferences
- Absence of sustained policies and basic adaptive research for improvement of local crops, livestock and processes.
- Declining work-force on the farm due to drift of labor from rural to urban areas, disease, old age and absentee farmers
- Lack of local fabrication and maintenance facilities for appropriate-capacity energy-saving production, processing and handling equipment.
- Inadequate stock of scientific knowledge of soils, crops, livestock, the environment, food preservation, conservation and combination.
- Heavy burden of diseases, pest, flood and drought.
- Preponderance of cultural and religious diversity

With the above liabilities, there is no doubt that Nigeria's agriculture requires a lot of power to engineer and propel it past its present status, give it more life and nurture it to real growth of international repute. There should be self-sufficiency in food for the populace, agricultural raw materials for agro-industries and sufficient processed agricultural products for export. Engineering and technology will enhance production as consumers demand consistent supply of top quality products and services, placing emphasis on quality, safety, functionality and sustainability of agriculture (Opara, 2002)

3.3 Technical/Engineering Inputs Management

From the above discussions, it is obvious that agriculture is a complex biological production process which implies more than the known conventional factors of production and embraces the political, cultural and religious characteristics of the people. Thus the environment of agricultural production is conditioned by resource inputs which are not homogenous in character, location and mobility. Sustainability and profitability of agricultural production depend heavily on good management practices and capabilities to adapt to technical, economic and social changes. It requires making and implementing decisions involved in organizing and controlling a farm enterprise towards an objective, making purposeful use of limited resources with less complete information due to the role of various factors (Cros et al., 2003). Managing the technical/engineering inputs into agricultural production is expected to satisfy some of the above demands of society on agriculture which has been discussed by Munack (2002). They are to:

- Enhance the capacity to bring more land under cultivation. This will include field engineering in land clearing, cultivation, planting and harvesting.
- Enhance the capability to improve cultural practices and suitable irrigation and Fadama cultivation practices. This will include irrigation structures and equipment such as sprinklers, canals, field channels, drop structures, dams, spillways and reservoirs.
- Ensure high productivity and sustainability in the use of farmland by proper control of erosion and other forms of environmental degradation. This will include engineering inputs as in soil and water conservation by the provision

of levees, terraces and structures to ameliorate soil erosion and wind breaks to stop desertification and desert encroachment.

- Ensure proper handling, processing and storage of farm produce to minimize post-harvest losses, which if not controlled can negate all efforts on increased farm production. This will include processing machines (millers, threshers, washers, crackers etc.), cribs and silos and their attendant conveyors.
- Ensure a proper operational and maintenance culture for agricultural equipment and farm machinery. This includes farm systems maintenance and administration including proper selection, application and maintenance/repair of equipment and control of obnoxious pests and diseases (Mijinyawa and Kisaiku, 2006).
- Ensure the development of a new crop of entrepreneurs in agricultural economics, extension, science and engineering who can aggressively market the achievement, developments and gains in agricultural engineering, systems and processes. This will include engineering input in training at tertiary level to produce middle and high level manpower and in research to develop appropriate machines, techniques, processes and general technology of adaptive nature.
- Ensure proper design and construction of facilities and infrastructure for agricultural production e.g. farm roads, water supply system, electricity in the farm, and farm houses for residential and livestock including cages. These must be environment friendly.
- Provide appropriate design and structures for aquaculture (ponds and water supply system for fish farming).
- Provide input in engineering consultancy e.g. in preparation of feasibility studies required in processing bank credit facility or agricultural loans for farmers.
- Encourage village type industries based on local agricultural output with specific emphasis on food production/food processing activities including packaging and marketing.
- Encourage the growth of rural industrial support efforts such as handicraft, blacksmithing for repairs and production of rural mechanical contraptions and spare-parts fabrication.
- Encourage the training of relevant personnel, drawn from the rural areas, in areas of servicing, maintenance and installation of facilities for rural improvement and industrialization as well as environmental cleanliness.
- Ensure sustainable (competitive, protecting the environment, socially compatible) production techniques by design of intelligent machinery, use of information technology, biotechnology and genetic engineering.
- Ensure the reduction of energy dependence from fossil sources through the use of renewable resources (biodiesel, bio-gas, bio-ethanol)

3.4 Present Scenario

Okigbo (1988) summarized the engineering and technological inputs presently used in traditional and “modern” conventional farming systems (Table 1). However, it is obvious that to transform Nigeria’s largely traditional farming system to a modern one, there should be injected in the system substantial engineering and technological inputs that are properly managed in terms of both environment and existing/potential technologies. For the

agricultural development programmes to succeed, agricultural production, processing and utilization must necessarily move from the present subsistence nature to a commercial nature through mechanization which must be environment-friendly. Efforts are being geared towards the replacement of human operator with mechanical systems including automated ones (Raji and Alamutu, 2005) as human operations are inconsistent and less efficient.

There is ample evidence to the effect that the contribution of internally generated technology in Nigeria's agricultural development is substantial, from Tertiary Institutions and Research Institutes, Ministries of Agriculture, the National Centre for Agricultural Mechanization (NCAM) and some private companies (Onwualu and Pawa, 2004). Appreciable achievements have been made in respect of food processing and storage especially at the family (small-size) levels. Development of grain silos and other storage systems has enabled the long-term

Table 1.Inputs or technologies used in traditional and "modern" conventional farming systems

DESCRIPTION	TRADITIONAL	MODERN
Land Area	Small (1 – 5ha)	Large (10-100ha or more)
Tools	Simple: Fire, hoe, axe, digging sticks, machetes	Complex: Tractors and implements, threshers etc.
Crops	Many species (5 – 80) landraces, no genetic improvement, wide genetic base	Few species (1 – 3) Improved narrow genetic base
Animals	Several Species	Usually 1 or 2 species
Labour	Manual, human energy or animal power	Mechanical, Petroleum fuels, electric energy
Soil fertility maintenance	Fallows, ash, organic manures	Inorganic fertilizers, sometimes manures, soil amendments, e.g. lime etc.
Pests and Disease management	Physical/Cultural	Mainly mechanical/chemicals, (Insecticides, fungicides, etc)
Crop Management	Manual	Growth regulators for defoliation, control of flowering, fruit drop, etc.
Harvesting	Manual or with simple tools	Mechanical – Tractors plus implements: threshers, combine harvesters,
Post harvest handling and drying	Simple sun-drying or over fires	Mechanical forced air, artificial drying using petroleum fuels, sometimes refrigeration.

Source: Okigbo 1988

storage of particularly bulk grain produce. Silos (5 – 2500MT capacities) and warehouses (200 – 5000MT capacities) have been built by Government Agencies (e.g. The National Strategic Grain Reserve Unit) for the storage of grain products at strategic locations all over Nigeria as intervention efforts and for research purposes to prevent food shortages; while private agencies utilize them for storage of bumper harvests. Warehousing of bagged grains stacked on pallets in well-ventilated buildings is widely used in research institutes and the National Seed Service Centers (NSSC) in Nigeria (Adewumi et al., 2005). The Crop Storage Unit (CSU) has developed on-farm storage units most relevant to each ecological zone. In an effort to reduce human drudgery, minimize labor costs and enhance overall productivity and efficiency, the national research system has designed, fabricated and tested an array of

agricultural tools and equipment suitable for use under Nigeria's socio-economic environment and conditions. These need to be commercialized after proper field testing and distributed to farmers, even at cost.

Government in putting in place appropriate infrastructure for mechanized agriculture in Nigeria, established NCAM at Ilorin for the development of low cost labor saving devices, machinery testing and machinery standardization in co-operation with Standards Organization of Nigeria (SON) and strengthened the Rural Agricultural Industrial Development Schemes (RAIDS) for the manufacture of intermediate prototype processing machines with World Bank assistance. The African Regional Centre for Engineering Design and Manufacturing (ARCEDEM) was established in Nigeria by some African member states to develop and produce equipment prototypes in priority areas, including agriculture, for the creation of small and medium scale industries in Africa. The Agricultural Machinery Mechanics and Operators Training Centre (AMMOTRAC) was established to train operators and mechanics to drive and maintain farm machinery.

Scientists in research institutes have developed improved varieties of different local crops of cowpea, soybean, cassava, plantain/banana, rice, using a lot of engineered tools and equipment. The increased production of most crops in the northern part Nigeria is due mainly to improved varieties and increased engineering input including irrigation facilities. The Fadama projects are also contributing a lot of technical inputs into Nigeria's agriculture by using lowlands for increased agricultural productivity targeted at the resource-poor farmer.

The Cassava Enterprises Development Project (CEDP) goal is to diversify and strengthen rural economy in selected geo-political zones in Nigeria using cassava as the engine of growth. This CEDP is administered by the International Institute of Tropical Agriculture (IITA). It is targeted at resource-poor producers, micro- and small-scale processors, most of who are women as well as fabricators, traders, agribusiness entrepreneurs and consumers, as secondary beneficiaries. The Cassava Initiative (CI) has shown encouraging statistics: production rose to 40m T of tuber in 2005. In the same year garri (processed cassava) was exported to Sierra Leone and first 40 MT of cassava chips to China (Opara, 2006). With the mechanization of the CI it is expected that production will reach 150m T of tubers by 2008.

The Rice Initiative (RI) is being facilitated by the National Cereals Research Institute (NCRI) in collaboration with the West African Rice Development Association (WARDA) with the objective of attaining an output of 9m T of milled rice in 2007.

The Vegetable Oil Initiative (VIO) aims at developing large hectares of oil palm, groundnuts, cotton seed, soybean, sheanut, castor oil, melon, sunflower, beniseed, with the attendant mechanization for increased production and increasing the Nation's capacity for edible oil production. With the ban on the importation of vegetable oil, the organized private sector in Nigeria has taken the challenge and has sustained local consumption.

For the Tree Crops Initiative (TCI) Government's objective is the rapid multiplication and distribution of high yielding, disease resistant and early maturing planting seeds, seedlings and plantlets to farmers at subsidized rates. These trees are meant to mitigate the devastating effects of deforestation, improve wood and timber resources as well as non-timber forest products (NTFP): fruits, leaves, bark, fuelwood, bushmeat and medicinal plants (Spore, 2006).

The Livestock and Fisheries Initiative (LFI) aims at increasing production and enhancing the animal protein intake of Nigerians. The 2006 bird's flu menace in Nigeria was a litmus test to this LFI and Government showed great leadership by promptly evolving appropriate control and eradication measures. This curbed the spread of the virus.

Koinyan (1987) enumerated some agricultural engineering inputs to Nigeria rural development through the DFRRI. These include:

- Design and publication of the technical specifications for the manufacture of simple equipment and devices e.g. ruwatsan (water) pump and accessories for shallow wells; hand and tractor pulled road rollers; plastic screen slotting machine.
- Provision of infrastructural facilities of roads, water and electrification.
- Improved rural housing
- Farm mechanization
- Agricultural products storage, processing and marketing.

All these facilities and equipment requirement, equipment use and maintenance are direct engineering activities, which involve design, construction, supervision and management. Agricultural engineers, scientists and technologists are actively engaged in providing the required inputs into these activities that have increased and improved agricultural productivity in Nigeria. These technocrats have developed interest in producing their own raw materials locally, in investing in agricultural production and in processing, employing their own engineering and scientific experience in the process. In spite of all these a substantial percentage of food consumed in Nigeria is still been imported due to the inadequate domestic production and preservation which is what the various interventions and initiatives are presently addressing. In large part, the previous drop in agricultural production in Nigeria resulted from the small percentage of machine power invested in agricultural production, processing, storage and marketing. The steep rise in prices of tractors and other farm machines and comparatively little growth of agricultural income, with attendant high food cost, have lowered the purchasing power for farm machines by rural farmers. The problem of high cost of farm machines and implements can only be tackled through appropriate government policy on local machinery production/manufacture.

World agriculture is being greatly influenced by information technology (IT). Agriculture is building its computerized plants and animal factories as well as precision farming (Sigrimis et al., 1999).

3.5 World Agricultural Perspectives

Automated farming is as difficult an engineering problem as automated manufacture and since agriculture is restructuring world over, it will need new machines, new farming methods, and a human-friendly environment. Precision agriculture (including precision farming) depends on:

- Precise monitoring of the processes (sensors on temperature, quantity, quality and others).
- Establishing the end result with a (biological production) model, and
- Computational tools to simulate and evaluate different scenarios, seeking a decision or control estimate that will maximize efficiency or profit after which the required precision machines or smart actuators will be used to actualize the decision made.

In all, precision agriculture depends strongly on Electronics, ITs and communications and evidently takes a highly trained and skilled manager to use these technologies effectively.

In the world today, the demands on agriculture imposed by different groups are numerous Munack, 2002):

- The society asks agriculture for competitiveness, protection of the environment and social compatibility.
- The consumer wants qualitatively excellent products at low prices, all over the year; palatable, healthy and nutritious foods (functional foods) (Spore, 2006); nice landscape with no disturbance by noise or odor.
- The industry demands are: high-quality, low-cost food and raw materials; renewable resources; pharmaceutical products.
- The farmers demand general increase of income; labor safety and reduction in working time; clear and reliable legal principles for future development of the farm.
- The politicians want promotion of organic farming; high standards of animal production; raising food security and food quality (protection of consumers); securing environmental protection; promotion of sustainable production processes in farming, fishery and forestry.

Based on the above, some of the new technical means for agricultural production and environmental protection as opined by Munack (2002) are summarized below:

- Precision agriculture requires advanced technical tools for plant production (land preparation, sowing, fertilization, irrigation, weed and pest control, and harvesting) that is site specific.
- Animal production requires animal-specific treatment (feeding, weighing, milking and milk inspection, optical inspection, and health care) that may involve sound or voice analysis for animals (Jahns and Walter, 2002).
- Reduced emissions and immissions of dusts and gases in animal production may require precision feeding with reduced nitrogen content as well as construction of the housing system for low emission, filtering of outlet air, covered manure storage, and manure distribution near the ground. Also the contour of the surrounding of the animal house, the wind direction, speed and turbulence class are considered.
- A lot of information flow is required to make communication in the new IT possible. There should be standards for information exchange with a management information system (MIS) and for compatible data exchange among subsystems.
- Presently, agriculture is contributing enormously to reducing the energy dependence from fossil sources through bio-diesel, bio-gas, bio-ethanol as in Brazil and Germany. This has the advantage of reducing environmental pollution and high cost of fossil fuels.

The above new trends have shown that agricultural engineering research has moved from nuts and bolts to broader tasks that are highly relevant to society for more and higher quality of food, reduction of world poverty, raising farmers' income, reducing/controlling pollution, reducing drudgery, conserving resources and making the workplace safer (Stout, 2000).

3.6 Future Expectations

This section aims at enumerating what agricultural engineers expect from themselves, other scientists/professionals, farmers and governments:

- Agricultural engineers have to get involved in the training of the needed manpower or experts in agricultural sciences and engineering including IT to develop and execute a sustainable agricultural production system in Nigeria; be actively involved in funding and promoting Seminars and Workshops for disseminating knowledge in agricultural production technology. The experienced staff with good background in different aspects of engineering and agriculture will be required to manage resources that will improve agricultural production and at the same time be environmentally friendly.
- Agricultural engineers and scientists who are familiar and experienced in the production technology, biotechnology and information and communications technology (ICT) required by agro-industrialists are needed in the area of industrial extension services to provide detailed information on capital investment, type of plant and machinery, source of equipment and materials, skills required for the production of intended goods to be produced.
- To achieve integrated rural development, the various activities involved that have lots of science and engineering content, would require the services and expertise of engineers and scientists. Therefore, there must be co-operation with each other and other stakeholders (including the rural farmers) to make the agricultural programme of Nigeria successful.
- There is no gainsaying the fact that local machinery manufacture is the lasting solution to making agricultural development and the development of local maintenance capability available. Government should enunciate policies that would encourage engineers, technicians, technologists, and fabricators to engage in local manufacture of agricultural machines and implements. And encourage local manufacturers through organization of exhibitions, recognition and awards for useful inventions and manufactured products.
- The nation's ADP's, RBDAs', DFRRI, NARP, FEAP, NEEDS, RAIDS, CEDP, and other initiatives must know that the national research system is supposed to provide the technological back-up and support for the success of their programmes. Linkages with the Universities, Research Institutes and Polytechnics as well as Industrialists, Manufacturers, Fabricators and NASENI and its Development Centers will close the technological gap existing between these Institutions and the farmers.
- Engineers and scientists should be involved in policy formulation at all levels. Agricultural engineers and scientists should make contributions on agricultural production policies and help to formulate clear and well conceived policies and directives which are basic to the successful implementation of any agricultural programme for increased productivity.
- There should be an urgent policy initiative relating to agricultural machinery and equipment development and manufacture. Government must endeavor to protect local manufacturers of agricultural machinery and equipment from foreign imports. Government should also ensure solid technological base for self-sustaining local fabrication and mass production of tested prototypes by (a) initiating and promoting the rapid and wide-spread development of foundries and associated refractory materials. (b) initiating and accelerating the pace of development of materials science and engineering, including steel mills, heavy engineering plants, alloy metals and special steels as areas of focus, and (c) by initiating development and copy-creativity activities in the area of machineries, tools and spare-parts.

- Government should advance a policy that makes it compulsory for importers of machineries for agriculture and allied industries to establish assembly plants as well as factories to produce or assemble spare parts locally in the country.
- Agricultural engineers and environmentalists should be ready to embrace the influence of IT in agriculture and the environment which are thought by some as the growing giant consumers of information and communication and electronic technologies.
- Agricultural engineers should exploit the full potentials of information and communication services and applications for the social, cultural and economic benefits of everybody.
- Agriculture, being a big potential market for new IT products, challenges agricultural engineers to develop innovative applications and innovative solutions that are "use-inspired" and "user-fruitful" for the promotion of agricultural mechanization and production in Nigeria.
- Agricultural engineers should lead and guide developments in agro-bio-technological evolution leading to better understanding of biological processes and properties of biological materials to coincide with technological developments in the field of electronics, computers, communications, materials science and machinery (Sigrimis et al., 1999).
- Traditional agricultural engineering training is too limited and should be expanded to include new areas such as emerging technologies, information and communication technologies.
- Agricultural engineers must cooperate with designers, costumers and farmers to get the right and successful ideas for the development of agricultural machines which are characterized by very high and complex technological standards, a strong pressure on cost, a simplicity in construction and a permanent demand for innovations (Harns, 2003). There is the need for team work.

4. THE CHALLENGES

This nation Nigeria is undoubtedly abundantly blessed with human and material resources. There is not enough progress in our agricultural production because there is not enough engineering and science and management been put into agricultural programmes. Yet the scientific and technological achievements are here in quantum and quality. Because of poor policy implementation in the past and the heavy decline in agricultural raw materials, Chinese exports in merchandize is on the increase in Nigeria making some clothing and other local manufacturing industries to close shop, thus heightening unemployment. Also, the steel industry which should provide raw materials for most machine manufacturing plants and fabrication outfits in Nigeria has not been fully developed, with Chinese manufacturers sweeping nearly all before them as their exports expand all over the world. In most hardware stores in Nigeria these days the chances are that most of the tools on display come from China or India or South Korea. This is a great challenge to the local manufacturing industries. The efforts of NASENI's six Development Centers; (i) Scientific Equipment Development Institute, Enugu (SEDI-E); (ii) Scientific Equipment Development Institute, Minna (SEDI-M); (iii) Centre for Adaptation of Technology (CAT), Awka; (iv) Engineering Materials Development Institute (EMDI), Akure; (v) Hydraulic Equipment Development Institute (HEDI), Kano; and (vi) National Engineering Design Development Centre (NEDDEC), Nnewi and their Machine Building Workshops on agricultural machines and tools have not been felt because the Agency is interested in process lines and pilot plants manufacture rather

than individual unit operations machines. So they cooperate with partners who may have developed such agricultural machines as laboratory prototypes (Onwualu and Pawa, 2004). Why don't NASENI make bold to expand and direct their efforts also to agricultural machines whose prototypes abound in higher institutions in Nigeria?

However, proper agricultural production management considers the decision taken and the process of implementing the operations decided together with the complex dynamics of the biophysical process underlying the production process (Cros et al., 2003). The decisions must take into consideration the sustainability of the environment through proper management. This can now be enhanced by the use of ITs, ICT and intelligent machines. Agricultural engineering when linked with advances in biotechnology, materials technology and IT including electronics will play important roles towards another agricultural and environmental revolution in the world (Takakura, 2002).

4.1 Management of Land Resources

Land is a major resource for agricultural development worldwide. Land is made available through reclamation in which case a place that is hitherto waterlogged is drained and used for crop production. Poorly managed agricultural land may also be reclaimed by the provision of field drains and farm ditches. Land clearing involves felling of trees and removal of vegetation. Different types of equipment are used for land development and once land is opened up for agricultural purposes, it should be protected against erosion. Agricultural land should not be cleared with heavy equipment to avoid soil structural degradation and compaction. Desert encroachment and wind erosion is managed by planting drought-resistant trees as wind breaks while soil erosion is mitigated by mechanical, biological and cultural approaches.

4.2 Management of Capital

Capital is another very vital resource that should be properly managed. Agricultural financing is very delicate. Agricultural credits should be applied directly to what agricultural businesses they were obtained for. Loans should be used to expand the agricultural land, buy machinery and other inputs (fertilizer, pesticides, herbicides, seeds and seedlings) for increasing agricultural production. Government of Nigeria has directed commercial banks in the country to put aside some percentage of their transactions to agriculture and give them as loans to farmers with good feasibility studies and the capacity to repay the loans. It should not be given to absentee farmers. Also, there should be sustained policy on tax relief for key agricultural inputs.

4.3 Management of Labor

Labor is the most important resource in agriculture, since labor includes the manager and the operator of any agricultural business. Labor schedules and operates the resources for agriculture including machinery. Labor maintains and repairs them. Labor may include the scientists, technologists and engineers that bring about the innovations in agricultural practice. Labor should be well trained, regularly retrained and properly motivated to sustain interest in and for agriculture and its natural environment. However, with the abundant unskilled labor in the rural areas of Nigeria, care must be taken to develop machinery that will empower them and be user-friendly.

4.4 Management of Water Resources

Without water there will be no agriculture. It is strategic in agricultural production. Nigeria's agriculture has been largely rain-fed. However, with the development of dams on rivers in the northern part of the country for agricultural production, hydroelectricity and domestic use, it becomes imperative to manage river resources properly. Rivers have been used as sinks for the disposal of waste materials and effluents. Pollution, rising demands and climate change limits water resources availability. Management, conscientious use and conservation of water resources includes monitoring, controlling and reducing river water pollution and making it available for irrigation, industry, hydroelectric power generation, navigation and wastewater treatment plants' effluent dilution. Groundwater aquifers are also used in agriculture as they are hydraulically linked to rivers. Demand management encourages the use of less water principally through reduction of waste.

4.5 Management of Agricultural Power and Machinery

Many tractors and machines for agriculture may have been imported into or manufactured in Nigeria. Managing them should include scheduling them for work timely, for maintenance and repair with genuine spare parts to make them operable and making sure that only properly trained operators operate them to achieve their optimum field capacities by reducing time losses during operation. Managing them also means, making sure that proper records are kept on each equipment and machine. Management of these machines also means that they are used optimally for the work they are supposed to do by matching the machine capacity with the work to be done and matching the machine with the power source available. In Nigeria most of the agricultural machinery are imported, and their maintainability difficult. Many unserviceable machines litter many institutions making the environment unsightly. With the use of IT and ICT technologies scheduling and monitoring of machinery use could be made easier.

4.6 Management of Storage Facilities

Storage is an essential phase between harvesting, processing and consumption. Traditional grain storage with cribs, rhombus, gourds, sacks, by hanging on roof tops, trees and fire places and barns have not provided adequate protection from rain, insects and rodents, resulting in 20 – 65% loss annually in Nigeria. Modern silos and warehouses of different makes (metal, concrete, wood, mud and composite) and sizes to handle between 5 – 2500 metric tones of grains are available in Nigeria. Managing grain storage means that the prevailing environment of low moisture, relative humidity, temperature and oxygen is maintained so that sprouting, mould, rot and black spot growth, respiration rate, heat and moisture transfer, micro-organisms, insects and rodents will be minimized, if not mitigated. Mechanical aeration and controlled atmosphere storage system are management options for successful storage. Also, inert atmosphere storage and composite silo systems are recommended for the environmental management of grain storage systems.

4.7 Management of Livestock Manure

Manure constitutes an unavoidable by-product of any livestock production system. It needs to be managed effectively and efficiently and in a suitable manner (Laguë et al., 2005). Management of livestock manure is by recycling and may be by 1) direct recycling as a feed ingredient for livestock; 2) on-farm or 3) off-farm recycling for crop production; 4) recycling for non-agricultural uses; and 5) discharge to the environment (Richard, 1998). The different and highly variable physical, chemical and biological properties of livestock manure impinge on the environment and can result in both positive and negative impacts on air, soil, water,

fauna, and flora (Statistics Canada, 2000). Manure can become an important source of pollution when the management systems are deficient (AAFC, 1980).

4.8 Management of IT Inputs

Because horizontal production (profit/hectare) is giving way to vertical production, which is the value of the products that society is willing to pay for (Sigrimis et al., 1999), the new farmer will need new machines and completely integrated information systems and spend his time interacting on high management decisions. In precision agriculture, where ITs, global positioning systems (GPS) and geographical information systems (GIS) are applied to the management of farms, the goal is to improve the efficiency of operations and the quality and consistency of agricultural products by compensating for the spatial variability of the soil environment. Precision farming has the potential to make a major contribution towards improving agricultural practice in order to reduce the impact on the environment from agrochemical wastage (De Baerdemaeker, 1995). Information technology and biotechnology present themselves as advanced tools to tackle complex problems in agricultural mechanization and environmental management. They should be properly managed for the best interest of the farmer. The farmer professional education should be enhanced to enable him benefit from the new technology in order to monitor and manage his land, protect and improve his income and advance his living environment.

4.9 Management of other Inputs

The management of Nigeria's research and education in agriculture should focus on her indigenous crops and animals, many of which are getting extinct. The ingenious cultural practices should be modernized to be influenced by science, technology and engineering through communication of relevant information on new approaches and innovations in agriculture. Fertilizers, pesticides and herbicides should be applied as at when due and in the appropriate quantity to avoid pollution of water resources systems. Rural farmer education is as critical as any other resource for increasing agricultural productivity through agricultural mechanization and environmental management.

5. CONCLUSIONS

Agricultural scientists and engineers should make haste to transform Nigeria's agriculture through the development of technologies that are appropriate and acceptable to a majority of farmers, the sort of technologies that ensure, among other things, improved varieties and species of plants and animals, provision of appropriate types and quantities of agro-chemicals, provision of adequate and sustainable sources of irrigation water, the speedy completion of farm operations, safe processing and storage of farm products, enhanced job satisfaction to the farmers, increasing their income base and ensuring their comfort which will generally preserve the human muscle power. Nigeria's agricultural engineers need to mechanize food production and processing to catch up with increasing population; empower the farmers with mechanization (improved inputs including IT) in order to produce the required results. Since the world is shifting emphasis from the traditional nut and bolt technology in agriculture to a wider spectrum through information technology, Nigerian agricultural engineers and environmentalists should brace up and get involved in the new technologies for the best interest of the farmer and his environment. To exploit the full potentials of the information and communications technologies, agricultural engineers and environmentalists must develop innovative applications and solutions for the farmer, and lead

and guide developments in agro-bio-technological evolution This is important because of the many demands on agriculture by the society. However, the most difficult aspect in promoting farm mechanization in Nigeria is how to promote it where the farmer's purchasing power is not only low but weak. Agricultural scientists and engineers and the government must find the mechanization technologies suitable and relevant to Nigeria's ecological zones, and fund their spread through granting credits to the farmers. Designers of products, processes and machines should make them from local materials so that they may be readily available, adaptable, reliable and affordable as well as being manageable and environment-friendly. Without this approach, it will be difficult, if not impossible, to solve Nigeria's food problems through agricultural mechanization and environmental management.

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