Biotechnology and Sustainable Industrialization for National Development

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ABSTRACT

The sector that is reputed to be the engine of growth, wealth creation and the ultimate pillar for sustainable national development in any economy is the industrial sector. Its ability to create employment, reduce poverty and consequently contribute to gross domestic product (GDP) cannot be over-emphasized. This paper examines biotechnology its potential impact on sustainable national development. It highlights that biotechnology is the technological industry that could change and transform human life in the 21st century by overcoming hunger and environmental problems. It could influence the global biological and chemical competitive power of the industrial sector, offer new business opportunities with high quality of jobs and lead to improved legislation on intellectual property rights. The paper recommends a strategic plan of biotechnology industrialization for sustainable national development. It concludes that a stable polity is the fulcrum for leveraging success, as a country in turmoil cannot develop industrially. It urges Nigerian industrialists to identify areas in which the country has a comparative competitive advantage and organize entrepreneurial ventures in this all important industrial sector.

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INTRODUCTION

Development is a value word used to describe the process of the economic, social transformation and advancement that enables people to realize their potential, build self-confidence and lead lives of dignity and fulfillment. Okigbo (1987, 46) remarks that the process of development involves the application of national resources, (human, mineral, agricultural) for the purpose of enriching the lives of the population. It is this enrichment that constitutes development. Development is thus regarded as the creation of positive socio-economic changes accompanied by overall growth and the improvement of the life of the people. As the process of improving the quality of human life, it manifests itself in raising the standard of living of the people and the creation of a conducive environment for the growth of people's self-esteem. In strictly economic terms, development traditionally means the capacity of a natural economy whose initial economic condition has been more or less static for a long time to generate and sustain an annual increase in its gross national income (GNI) at rates of 5.0 to 7.0 percent or more (Todaro and Smith, 2009:, 14). A common alternative economic index of development has been the use of rates of growth of income per capita to take into account the ability of a nation to expand its output at a rate faster than the growth rate of its population. Yesufu (2000:410) sees development as a process and result of improving the well being of people – not a category of people, but all persons within the national economy, the totality of the citizens, from the baby just born to the oldest man or woman whose life is about to expire. Accenting the above (Mohammed, 2008, 6) defines development as the achievement of economic growth for improved living standards of people, especially through the use of a country's or society's human, material and institutional resources.

It is appropriate to point out here the difference between economic growth and economic development. Economic growth refers to increase over time in a country's real output of goods and services. When an economy is able to provide more goods and services for each consumer, then without doubt, it is a period of economic growth (Zurekas, 1979, 7; Baurol and Blinder 1998:57). Economic growth refers to the increase in gross domestic product (GDP) or gross national product (GNP) at constant prices. A clear distinction should therefore be drawn between economic development and economic growth. While economic growth connotes an increase in the productive capacity of the economy, leading to an increased availability of goods and services in the economy over a period of time (Ohale and Onyema, 2001, 238) or a quantitative sustained increase in the country's per capita output or an increase accompanied by expansion in its labour force, consumption, capital and volume of trade (Jhingan, 2003, 106), economic development is growth accompanied by change (Zurekas, 1979, 7). As Todaro and Smith, (2009, 16) put it, economic development must be conceived of as a multidimensional process involving major changes in social structures as well as the acceleration of economic growth, the reduction of inequality and the eradication of poverty. Economic development, therefore, must represent the whole gamut of change by which an entire social system tuned to the diverse basic needs and desires of individuals and social groups within that system moves away from a condition of life widely perceived as unsatisfactory toward a situation or condition of life regarded as materially and spiritually better. No one has identified the human goal of economic development as well as Amartya Sen, perhaps the leading thinker in the meaning of development. As Sen (1999) puts it, "Economic growth cannot be sensibly treated as an end in itself. Development has to be more concerned with enhancing the lives we lead and the freedom we enjoy." Dudley Seers, the famous British economist (quoted in Todaro and Smith, 2009, 15)

remarks, "The questions to ask about a country's development are therefore: what has been happening to poverty? What has been happening to unemployment? What has been happening to inequality? If all three of these have declined from high levels, then without doubt this has been a period of development for the country concerned. If one or two of these central problems have been growing worse, especially if all three have, it would be strange to call the result 'development' even if per capita income doubled."

The above assertions are neither idle speculations nor the description of a hypothetical situation. For instance a number of developing countries experienced relatively high rates of growth per capita income during the 1960s and 1970s but showed little or no improvement or even an actual decline in employment, equality and the real incomes of the bottom 40 percent of their population. By the earlier growth definition, these countries were developing; by the newer poverty, equality and employment criteria, they were not. In the 1990s, while the United States, the United Kingdom and other high income countries enjoyed a strong economic boom, average incomes declined in Sub-Saharan Africa, and the number of people in the region living in extreme poverty on less than one dollar per day rose by some 50 million.

The World Commission on Environment and Development (1987) contended that sustainable economic development refers to development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. In its report of "our common future" the commission noted the following seven (7) critical objectives for any sustainable development policy:

- Reviving growth

- Changing the quality of growth (with more emphasis on development than growth)
- Ensuring a sustainable level of population
- Conserving and enhancing the resource base
- Re-orienting technology and managing risk and
- Merging environment and economics in decision making

As Adeniyi (1999, 9) observes, a key requirement for development is that it must have something to do with people being better off in some way on their own terms. It is perhaps for this reason that the World Bank remarks in its 1999/2000 World Development Report that economic growth must encompass important social goals – reduce poverty, improve the quality of life, enhance opportunities for better education and health and more. The objective of this paper is to discuss biotechnology and its industrialization as a basis for sustainable national development. The paper examines the diverse areas of biotechnology applications in industry, pointing out the driving forces for such development. The paper also highlights the strategic plan for biotechnology industrialization in the Nigerian environment.

INDUSTRIALIZATION AND BIOTECHNOLOGY: THEORETICAL ISSUES

Virtually every country that experienced rapid growth of productivity and living standards over the last 200 years has done so by industrializing. Countries that have successfully industrialized turned to production of goods, taking advantage of economies of scale. The concept of industrialization has been defined by different scholars in various perspectives. The definitions that will be used in this study will therefore be drawn from the review of industrialization as perceived by different scholars whose works are available to the researchers.

Industrialization is seen as a sequence of interdependent and linked procedures that at every stage consume one or more resources (employees' time, energy, machines, money) to convert inputs (data, material, parts etc.) into outputs. These outputs then serve as inputs for the next stage until a known goal and or result is reached (www.businessdictionary.com). It can be seen as a process of social and economic change whereby a human society is transformed from a pre-industrial state to an industrial state. From the perspective of www.peopleandplanet.net, industrialization is a development path based on expanding a country's capacity to process raw materials and manufacture products for consumers, business and exports. This approach to development, first seen in northern Europe in the Industrial Revolution, typically entails heavy financial investment in factories and power plants and a rapidly growing demand for energy. Industrialization for Thomas and Kemp (1985) relates to a historical phase and experience – the overall change in circumstances accompanying a society's movement of population and resources from farm production to manufacturing production and associated services. For this paper, industrialization is seen as the process of changing from an agricultural produce era to a socio-economic order in which industry is dominant. Industrialization constitutes a key factor in the promotion of the social and development and economic welfare of any people.

For its part, biotechnology represents a fusion or an alliance between biology and technology. Biotechnology is thus a field of applied biology that involves the use of living organisms and bioprocesses in engineering, technology, medicine and other fields requiring bioproducts. The United Nations Convention on Biological Diversity defines biotechnology as any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for

specific use (United Nations 1992). The term biotechnology was introduced in 1917 by a Hungarian engineer, Karl Ereky. He used the term for large-scale production of pigs by using sugar beets as the source of food. Ereky cited in (Satyanarayana, 2009) defines biotechnology as all lines of work by which products are produced from the raw materials with the aid of living things. However, this definition was ignored for many years. Biotechnology is as old as human civilization and is an integral part of human life. Biotechnology is thus a newly discovered discipline from age-old practice. There are records that wine and beer were prepared in as early as 6000 BC, bread and curd in 4000 BC. But it is well known today that all these are processes based on the innate capabilities of microorganisms (Satyamarayana, 2009). Biotechnology draws on the pure biological sciences (genetics, microbiology, animal cell culture, molecular biology, biochemistry, embryology, cell biology) and in many instances is also dependent on knowledge and methods from outside the sphere of biology. Chemical engineering, bioprocess engineering, information technology, biorobotics are intimately entwined and dependent on the methods developed through biotechnology and what is commonly thought of as the life sciences industry.

A series of derived terms have been coined to identify several branches of biotechnology, (Zaid et al, 2001) for example

- ***Bioinformatics*** is an interdisciplinary field that addresses biological problems using computational techniques and makes the rapid organization and analysis of biological data possible. The field may also be referred to as computational biology and can be defined as "conceptualizing biology in terms of molecules and then applying informatics techniques to understand and organize the information associated with these molecules on a large scale" (Gerstein, 2007). Bioinformatics plays a key role in various areas such as functional genomics,

structural genomics and proteomics and forms a key component in the biotechnology and pharmaceutical sector.

- ***Blue biotechnology*** is a term that has been used to describe the marine and aquatic applications of biotechnology, but its use is relatively rare.
- ***Green biotechnology*** is biotechnology applied to agricultural processes. An example would be the selection and domestication of plants via micro propagation. Another example is the designing of transgenic plants to grow under specific environments in the presence or absence of chemicals. One hope is that green biotechnology might be used to produce more environmentally friendly solutions than traditional industrial agriculture (www.fao.org/biotechindex glossary.asp)
- ***Red biotechnology*** is applied to medical processes. Some examples are the designing of organisms to produce antibiotics and the engineering of genetic cures through genetic manipulation.
- ***White biotechnology,*** also known as industrial biotechnology, is biotechnology applied to industrial processes. An example is the designing of an organism to produce a useful chemical. Another example is the use of enzymes as industrial catalysts either to produce valuable chemicals or to destroy hazardous/polluting chemicals. White biotechnology tends to consume less in resources than traditional processes used to produce industrial goals (Zaid et al, 2001).

The investment and economic output of all these types of applied biotechnologies is
called bioeconomy.

BIOTECHNOLOGY AND ITS APPLICATIONS IN INDUSTRY AND OTHER ECONOMIC ACTIVITIES

Biotechnology is not limited to medical/health applications (unlike biomedical engineering which relies heavily on biotechnology). Although not normally thought of as biotechnology, agriculture steadily fits the broad definition of "using a biotechnological system to make products," so that the cultivation of plants may be viewed as the earliest biotechnological enterprise: agriculture has been theorized to have become the dominant way of producing food since the Neolithic revolution. The processes and methods of agriculture have been refined by other mechanical and biological sciences since its inception. Through early biotechnology, farmers were able to select the best suited crops having the highest yields to produce enough food and raw materials for industrial purposes to support a growing population.

For thousands of years, humans have used selective breeding to improve the production of corps and livestock for food. In selective breeding, organisms with desirable characteristics are mated to produce offspring with the same characteristics. For example, this technique was used with corn to produce the largest and sweetest crops (Thieman and Palladino,, 2008).

In 1917, Chaim Weizmann first used a pure microbiological culture in an industrial process, that of processing corn starch using *Clostridium acetobytylicum* to produce acetone, which the United Kingdom desperately needed to manufacture explosives during World War I (Springham et al, 1999).

Biotechnology has led to the development of antibiotics. In 1928 Alexander Fleming discovered the mold *Penicillium.* His work led to the purification of the antibiotic penicillin by Howard Floreyi, Ernst Boris Chain and Norman Heatley. In 1940, penicillin became

available for medicinal use to treat bacterial infections in human (Thieman and Palladino, 2008).

The field of modern biotechnology is thought to have largely begun on June 16, 1980 when the United States Supreme Court ruled, in the case of Diamond vs. Chakrabarty (United States Supreme Court, 1980), that a genetically modified microorganism could be patented. Indian-born Ananda Chakrabarty, working for General Electric (GE), had developed a bacterium derived from the *Pseudomonas* genus capable of breaking down crude oil which he proposed to use in treating oil spills.

Rising demand for biofuels is expected to be good news for the biotechnology sector, with the Department of Energy estimating that ethanol usage could reduce U.S. petroleum-derived fuel consumption by up to 30 percent by 2030. Biotechnology has allowed the United States farming industry rapidly to increase its supply of corn and soyabeans – the main inputs into biofuels - by developing genetically modified seeds such are resistant to pests and drought (Friedman, 2008).

Genetically modified food

Using the techniques of modern biotechnology, one or two genes may be transferred, to a highly developed crop variety to impart a new character that would increase its yield (Smartstax from Monsanto in collaboration with Dow Agro Sciences will use 8, starting in 2010 (Asian Development Bank, 2001).) However, while increases in crop yield are the most obvious applications of modern biotechnology in agriculture, it is also the most difficult one. Current genetic engineering techniques work best for effects that are controlled by a single gene. Many of the genetic characteristics associated with yield (e.g., enhanced growth) arc controlled by a large number of genes, each of which has a

minimal effect on the overall yield (Bruce and Bruce, 1999). There is, therefore, much scientific work to be done in this area.

Reduced vulnerability of crops to environmental stresses

Crops containing genes that will enable them to withstand biotic and abiotic stresses may be developed. For example, drought and excessively salty soil arc two factors that limit crop productivity significantly. Biotechnologists are studying plants that can cope with these extreme conditions in the hope of finding the genes that enable them to do so and eventually transferring these genes to more desirable crops. One of the latest developments is the identification of a plant gene, At-DBF2, from *Arabidopsis thaliana*, a tiny weed that is often used for plant research because it is very easy to grow and its genetic code is well mapped out. When this gene was inserted into tomato and tobacco cells (see RNA interference), they were able to withstand environmental stresses like salt, drought, cold and heat far better than ordinary cells. If these preliminary results prove successful in larger trials, then At-2 genes can help in engineering crops that can better withstand harsh environments. Researchers have also created transgenic rice plants that are resistant to rice yellow mottle virus (RYMV). In Africa, this virus destroys the majority of the rice crops and makes the surviving plants more susceptible to fungal infections. (National Academy of Science, 2001).

Increased nutritional qualities

Proteins in foods may be modified to increase their nutritional qualities. Proteins in legumes and cereals may be transformed to provide the amino acids needed by human beings for a 'balanced diet. "A good example is the work of Professors Ingo Potrvkus and Peter Beyer in creating Golden rice (Zaid et al, 2001).

Improved taste, texture or appearance of food

Modern biotechnology can be used to slow down the process of spoilage so that fruit can ripen longer on the plant and then be transported to the consumer with an improved reasonable shelf life. This alters the taste, texture and appearance of the fruit. More importantly, it could expand the market for farmers in developing countries due to the reduction in spoilage. However, there is sometimes a lack of understanding by researchers in developed countries about the actual needs of prospective beneficiaries in developing countries. For example, engineering soybeans to resist spoilage makes them less suitable for producing *tempeh*, which is a significant source of protein in Indonesia that depends on fermentation. The use of modified soybeans results in a lumpy texture that is less palatable and less convenient for cooking.

The first genetically modified food product was a tomato which was transformed to delay its ripening. Researchers in Indonesia, Malaysia, Thailand, Philippines and Vietnam are currently working on delayed-ripening papaya in collaboration with the University of Nottingham and Zeneca. (Martineau, 2001).

Reduced dependence on fertilizers, pesticides and other agrochemicals

Gianessi *et al.* (2002) report:

> *Most of the current commercial applications of modern biotechnology in agriculture are on reducing the dependence of farmers on agrochemicals. For example, Bacillus thuringiensis (Bt) is a soil bacterium that produces a protein with insecticidal qualities. Traditionally, a fermentation process has been used to produce an insecticidal spray from these bacteria. In this form, the Bt toxin occurs as an inactive protoxin, which requires digestion by an insect to be effective.*

> *There are several Bt toxins and each one is specific to certain target insects. Crop plants have now been engineered to contain and express the genes for Bt toxin, which they produce in its active form. When a susceptible insect ingests the transgenic crop cultivar expressing the Bt protein, it stops feeding and soon thereafter dies as a result of the Bt toxin binding to its gut wall. Bt corn is now commercially available in a number of countries to control corn borer (a lepidopteran insect), which is otherwise controlled by spraying (a more and difficult process).*

Bioremediation and Biodegradation

Biotechnology is being used to engineer and adapt organisms, especially microorganisms, in an effort to find sustainable ways to clean up contaminated environments. The elimination of a wide range of pollutants and wastes from the environment is an absolute requirement the promotion of sustainable development of our society with low environmental impact. Biological processes play a major role in the removal of contaminants, and biotechnology is taking advantage of the astonishing catabolic versatility of microorganisms to degrade/convert such compounds. New methodological breakthroughs in sequencing, genomics, proteomics, bioinformatics and imaging are producing vast amounts of information. In the field of environmental microbiology, genome-based global studies open a new era providing unprecedented *in silico* views of metabolic and regulatory networks, as well as clues to the evolution of degradation pathways and to the molecular adaptation strategies to changing environmental conditions. Functional genomic and metagenomic approaches are increasing our understanding of the relative importance of different pathways and regulatory networks to carbon flux in particular environments and for particular

compounds and they will certainly accelerate the development of bioremediation technologies and biotransformation processes (Diaz, 2008).

Marine environments are especially vulnerable, since oil spills of coastal regions and the open sea are poorly containable and mitigation is difficult. In addition to pollution through human activities, millions of tons of petroleum enter the marine environment every year from natural seepages. Despite its toxicity, a considerable fraction of petroleum oil entering marine systems is eliminated by the hydrocarbon-degrading activities of microbial communities, in particular by a remarkable recently discovered group of specialists, the so-called hydrocarbonoclastic bacteria (HCCB) (Martins, 2008).

THE DRIVERS OF THE BIOTECHNOLOGY DEVELOPMENT

The arduous task of transforming the Nigerian economy to a modern economy where manufacturing will take its pride of place is non-negotiable if we do not want to be left out of the comity of industrialized nations. Biotechnology offers this great nation a chance of waking up from its deep slumber, since this economy has no future outside of manufacturing and agro-industry, most especially when our huge and vibrant youthful population is taken into account. This is because the next industry with the brightest future after information technology (IT) age is the bio-industry, especially in comparison with the long-standing hope of the nation, the petro-chemical industry. (*See figure 1.*)

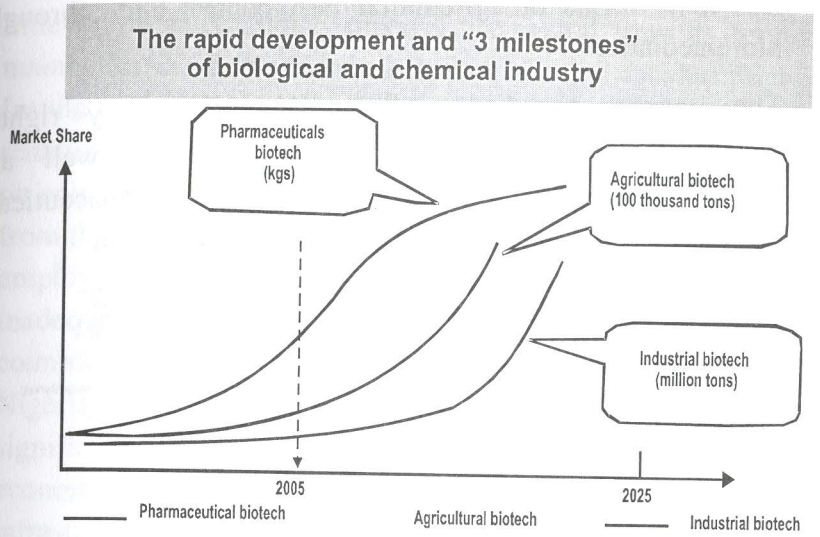

Figure 1: *Source: Xiucail.* Bio-Excellence: The Opportunity of Biotechnology Industrialization in China. *Xinjiarg: Cathay Market Industrial Biotech, 2010.*

The reasons for this assertion are listed below:

- Slow innovation in the traditional chemical industry (petro-chemicals being the next most likely engine for industrial growth).
- The rising cost of energy and the lack of chemical raw materials.
- The serious competition in the chemical industry market (Figure 2).
- The fast development of biotechnology. Rising demand for biofuels is expected to be good news for the biotechnology sector, as discussed above.
- The innovation of biotechnology can result in reduced costs and improved protection of the environment., both through

less toxic forms of agricultural pest control and through bioremediation

- The impetus for improved intellectual property rights legislation and enforcement world wide as well as strengthened demand for medical and pharmaceutical products to cope with an ageing and ailing population.

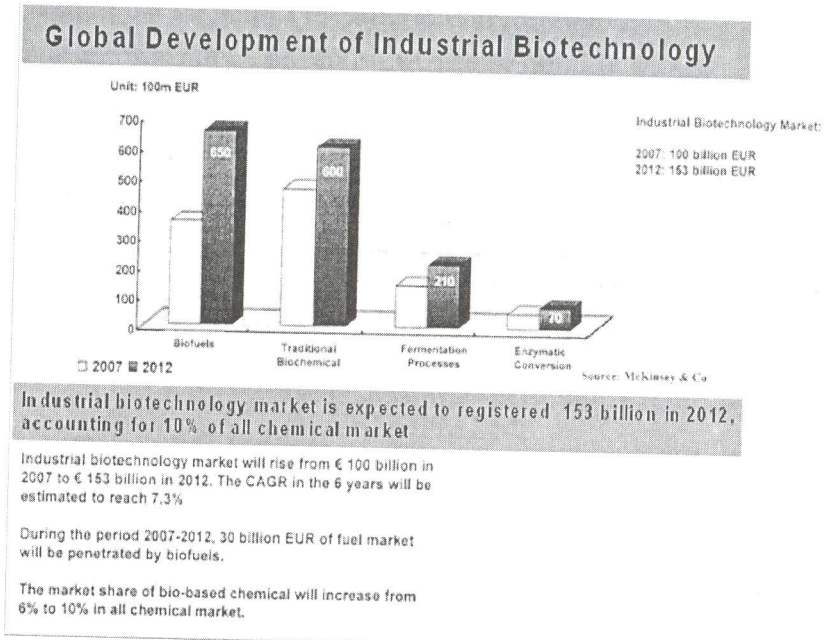

Figure 2: Xiucail. Bio-Excellence: The Opportunity of Biotechnology
Source: Industrialization in China. Xinjiarg: Cathay Market Industrial Biotech, 2010.

SUSTAINABLE INDUSTRIALIZATION FOR NATIONAL DEVELOPMENT

The fate of industrialization in budding economies like Nigeria has been far from successful as they are characterized by dualism in the sector. The majority are small-scale and informal, while the formal sector (mostly semi-modern and capital intensive), with

little or no international linkages, is geared towards production mainly for the domestic market, with a small residue for export. Inspite of the efforts in these economies, their industrial sector has remained essentially underdeveloped and has impacted negatively on economic growth and the welfare of the society; this is evident from the low capacity utilization, declining output growth rate, low employment generation, the winding down of industries and inadequate linkages with other sectors of the economy in these countries (Imevbore, 2005). This is a classical description of the Nigeria case, where her industrial sector has failed to record significant progress when compared with other developed economies, mostly due to policy somersaults and decaying infrastructure, *e.g.* power and communications. The Manufacturers Association of Nigeria (MAN) remarks that power supply accounts for as much 30 percent of members' operating costs. (Chigbo, 2011). Table 1 shows the differences in power generation capacities, among comparable and competing countries relative to the consumption requirements of the population.

Country	Population (Million)	Power Generation (Megawatts)	Per Capita Generation (Kilowatts)	Per Capita Power Capacity in Watts per person
Brazil	180	90,000	500	480
Germany	83	115,000	1,385.50	1,050
Ghana	21	1,800	85.70	85
Nigeria	150	4,000	29.67	29
South Africa	47	43,000	914.89	849
Thailand	70	40,000	571.43	530
United	60	77,000	1,283.33	1,191

Kingdom				
United States of America	300	937,000	3,123.33	2,900

Table 1: Power Generation by Countries and per Capita Power Capacity per Person.

Source: Chigbo, Newswatch, *June 6, 2011, p. 15*

**Per Capita Power Capacity per Person computed by the authors

For a country, whose population is expected to hit 200 million by 2020, this means that the energy needs of the population will not be met. We need to generate about 40,000 megawatts to meet the much-touted goal of becoming one of the 20 largest economies in the year 2020.

Nigeria's experience with industrialization has been a classic case of tragedy as the sector has had a chequered history of growth and under-development, in common with most economies (See table 2).

YEAR	Average Manufacturing Capacity Utilization rates	Manufacturing Sector Contribution to GDP	Gross Domestic Product (GDP)	Manufacturing Sector Contribution to GDP (%)*
1981	73.3	13338.9	251052.3	5.31
1982	63.6	15056.2	246726.6	6.1
1983	49.7	10629.2	230380.8	4.61
1984	43	9436.4	227254.7	4.15

1985	38.3	11307.4	253013.3	4.47
1986	38.8	10867.5	257784.5	4.21
1987	40.4	11421.8	255997	4.46
1988	42.4	12889.4	275409.6	4.68
1989	43.8	13101.5	295090.8	4.44
1990	40.3	107114.5	328606.1	32.6
1991	42	15411.1	328644.5	4.69
1992	38.1	14666.4	337288.6	4.35
1993	37.2	14060.7	342540.5	4.1
1994	30.4	13934.1	345228.5	4.04
1995	29.29	13167.8	352646.2	3.73
1996	32.46	13299.4	367218.1	3.62
1997	30.4	13339.3	377830.8	3.53
1998	29.29	12819.1	388468.1	3.29
1999	32.4	13267.8	393107.2	3.38

2000	36.1	13743.5	412332	3.33
2001	42.7	14318.76	431783.2	3.32
2002	54.9	15892.19	451785.7	3.52
2003	56.5	16776.56	495007.2	3.39
2004	55.7	18454.25	527576	3.49
2005	54.8	20220.45	561931.4	3.59
2006	53.3	22106.58	595821.6	3.71
2007	54.6	24118.28	634656.6	3.8

Table 2: Nigeria's Industrial Sector Contribution to GDP from 1981 – 2007 (N million)

Source: CBN Statistical Bulletin, *December, 2007.*

* Percentage values computed by authors

Table 3 shows that Nigeria remains a predominantly agricultural economy. This means that the contributions of biotechnology to agro-industry have an especially large potential for generating sustained economic grown.

S/N	Sectors	Percentage (%)
1.	Agriculture	42.07
2.	Crude oil and Natural Gas	17.54
3.	Wholesales and Retails	7.33
4.	Manufacturing	4.13

5.	Finance and Insurance	3.79
6.	Building and Construction	1.83
7.	Telecommunication and Postal Services	2.90
8.	Hotels and Restaurants	0.46
9.	Solid Minerals	0.31
10.	Others	9.63

Table 3: Sectoral contribution to GDP in Nigeria (in percentage, 2008)

Source: *National Bureau of Statistics, 2008.*

Jhingan (2005) argues that industrialization as experienced by developing countries has not brought about the expected economic and social benefits because it has failed to boost growth, reduce inequalities of income and wealth, unemployment and regional imbalances. The above can be related to the Nigerian scenario. Despite several efforts geared towards boosting the industrial sector with such blue prints and policies such as the Structural Adjustment Programme (SAP), Vision 2010, the National Economic and Empowerment Development Strategies (NEEDS) and, most recently, vision 2020, it remains grossly underdeveloped (*Newswatch*, 2011). The country has instead witnessed de-industrialization, leading to a dwindling state of capacity utilization and continuing loss of international market share. This has resulted in the country being a heavy importer of food, raw materials and machineries – further dwindling her foreign exchange earnings. Other emerging markets have consistently outperformed Nigeria in terms of structure of production percentage of Gross Domestic Product (GDP) (See table 4.0).

S/N	Country	Agricultural sector	Industrial sector	Service sector
1.	Brunei	3	46	51
2.	Indonesia	16	44	40
3.	Malaysia	11	45	44
4.	Philippines	18	32	49
5.	Singapore	0	35	65
6.	Vietnam	26	32	42
7.	Thailand	11	39	50
8.	Chile	8	35	56
9.	Mexico	6	29	66

Table 4: Economic Structure of Emerging markets:
Structure of Production Percent of GDP
Source: IMF, Directory of Trade Statistics *(2000:2)*

According to a UNIDO (1988) report, Nigeria, with a manufacturing value added-worth of about $3.4 billion dollars in 1985, ranked as Africa's largest manufacturing economy after Egypt and the twelfth among developing countries of the world. The country ranked 4th in Africa in terms of industrial output according to *The Economist* 2003 World Industrial Output Report. The situation today is different as the same UNIDO report for 2005 shows that the manufacturing performance index of Nigeria declined from 8.4 percent in 1980 to 5.5 percent in 1999 and to 4.6 percent in 2005. The Central Bank of Nigeria 2005 Annual Report went further to state that the results of the sector has been unimpressive, as it stagnated with an index of manufacturing production put at almost 145.7, almost the same as in 2004. Today, the Nigerian manufacturing sector accounts for less than 10% of GDP, with capacity utilization remaining below 35% for most of

first decade of this century (Ekesiobi and Ibekilo, 2010, 3). The misfortune of the industrial sector in the country has persisted ,owing to many inhibiting variables, prominent among them being a difficult operating environment that includes unpredictable government policies and infrastructural deficiency, especially in the generation of electricity/power (Anyanwu, 1994; Igwe, 2008).

STRATEGIC PLAN FOR INDUSTRIALIZATION OF BIOTECHNOLOGY AND ITS DEVELOPMENT IN NIGERIA

The world, as we know, shrinks more each day into a global village, and market forces are overtaking traditional economic relationships, competition becoming more fierce. Only productive economies with a sound financial and technological base can endure and thrive. There is therefore an urgent need to reposition the productive capacity and capability of the Nigerian economy which to a large extent depends on her industrial sector as the engine growth for sustainable development. A great has happened within during the past fifty years since the genesis of industrialization in Nigeria towards achieving a robust and viable industrial sector through different policies and strategies.

Having come this far in espousing the benefits the country stands to derive from biotechnology industrialization, the researchers firmly believe that

- Biotechnology is the technology that could change human life in the 21st century by overcoming poverty, food and environmental issues.
- Biotechnology could influence the global competitive power of the biological and chemical industry subsectors and offer new business opportunities with a high quality of job opportunities.

- Biotechnology is a success story that could improve greatly the agitation for improved intellectual property rights legislation; delay in becoming a major player in this area would mean losing a foothold in the global industry.

The strategic plan for the industrialization of biotechnology and its development must as a matter of urgency include the following:

a. Improvement of foundation for creation of biotechnology industry.

b. Promotion of technology development and enhancement of industrialization support.

These policies involve the promotion of technology development for practical use. They will contribute to the overcoming of environmental, energy and food problems through the use of biotechnology, using such strategies as:

a. Establishment and strengthening of the social aspects of biotechnology. This involves:
   i. A build-up of appropriate research and development systems conducive to original basic research. This is because basic research results are easily commercialized in biotechnology area.
   ii. Establishment of an effective technology transfer system
   iii. Protection of intellectual property

b. Promotion of public acceptance: This involves informing the public of the value of research and development to generate technologies, research results and technologies developed.

c. A deliberate plan by governmental agencies, non-governmental organizations (NGOs) and civil society to disseminate relevant biotechnology breakthroughs through meetings, symposia and multimedia.

d. Targeted research into relevant emerging economic models methods of industrialization that could be adapted to our own peculiar environment with its halting approach to biotechnology industrialization.

e. Government policies that allow foreign investors in biotechnology industrialization to come in, invest and create jobs, with clear requirements for skills to be understudied, acquired and transferred. Skills acquired in this way would lead to a more productive and stable workforce.

CONCLUSION

From the genesis of industrial development in Nigeria, a period or more than five decades, much has happened. Present realities reveal that despite a small measure of achievements recorded, the sector remains in its doldrums. Consequently, the need to adopt a more proactive strategy via biotechnology industrialization seems to be the way forward. For this to happen, the need for a stable polity is non-negotiable. A country in turmoil cannot develop industrially. Provision of infrastructure should be stepped up as construction of infrastructure also constitutes development, which is a precursor of an effective state. An effective state is one which harnesses the energy of private businesses and individuals, acting as a catalysts The Nigerian industrialist should, as a matter of urgency, enter and enter into areas that for which the country has special potential and competitiveness in the biotechnology race and organize entrepreneurial ventures that give them the comparative advantage. The country cannot afford to be a bystander in all this important industry.

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