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The Role of Biotechnology in the Attainment of the Millennium Development Goals in Africa

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ABSTRACT

Recently, the world has been challenged with two major crisis; global climate change and rapid population growth. These impediments have led to hunger, poverty, socioeconomic crisis, political instability, increase disease burden and mortality rate. In an effort to circumvent these challenges, the united Nation in 2000 officially established in a summit the Millennium Development Goals (MDGs). This paper describes the MDGs stating its objectives to improve standards on health, socioeconomic status and education by tackling poverty, hunger and disease, increasing educational opportunities in the world's poorest countries and creating a global development partnership. It also describes biotechnology as one of the leading technologies to foster development in the world, outlining its application in the health and agricultural sector, in environmental protection and chemical, agro-alimentary industries and how it can be exploited to attain the MDG. The impediments hindering the growth of this technology in Africa are also discussed stating various measures and means to accommodate and promote its growth in this continent of the globe. In conclusion, biotechnology is acclaimed to stand at the forefront in achieving the MDGs in Africa. However, more effort is need from policy makers to institute and build capacity in order to promote the growth of this technology in Africa so as to alleviate poverty, hunger, diseases, other socioeconomic problems of major concern and foster development in Africa.

Keywords: Millennium Development Goal, Biotechnology, Development, Technology, Africa.

1. Introduction

Within the last two decades of the 20th century, the world's economy and development has been challenged by two major crisis; global climate change and rapid population growth. These two major challenges have placed the entire globe in a state of dilapidation. The impediments have led to hunger, poverty, socioeconomic crisis, political instability, increases disease burden, mortality rate etc. Most of these problems are well duelled in developing countries particularly the African continent and most especially the sub-Saharan Africa region. In an effort to circumvent these challenges, the united nation in 2000 officially established in a summit the Millennium Development Goals called the MDGs.

The aim of the MDGs is to improve standards of health, socioeconomic status and education by tackling poverty, hunger and disease, increasing educational opportunities in the world's poorest countries, to sustain the environment and create a global partnership for development[14]. The objectives were set to be attained by the year 2015. We are now more than two-thirds of the way through the program, and from the overall assessment, progress towards the goals has been patchy, with significant improvements in the rising economies such as China and India, but little progress in some other countries particularly in the sub-Saharan Africa region. One way to attain these objectives in Africa is to enhance development through technological advancement. In addition to financial motivation and development partnership, technological advancement requires the creation and institution of innovative academics fields to meet the demands of the challenging economy.

Among the emerging academic fields, biotechnology in recent time has emerge to be very instrumental in the development and economic boom of the developed world and even to new rising economies such as Brazil, India and China.

Biotechnology, a field of applied science that studies living organism and their processes for various applications in industries and the environment to improve on the well-being of humans has widely been embraced by the western world. Following the discovery of genetic engineering usually termed modern biotechnology; the application of this technology is very vast spanning from environmental protection, agriculture, industrial purpose, health and socioeconomic developments. Environmental protection through bioremediation has been very instrumental to remove and reduce pollution. Agricultural yield has been improved through the use of transgenic plants and animals, biofertilizers and biopesticides. This has help to reduced food scarcity and hunger. Products of chemical industries such as enzymes, acids, alcohols have been used as starting materials for other industries while products from agro alimentary industries have been for direct consumption by man such as yogurt, alcohols etc. The medical sector has greatly benefited from the outcomes of biotechnology. Base on this technology, there is hope for vaccines against malaria and HIV. Various pharmaceutical products such as insulin, hormones, plantibodies and plantigens have easily been produced and cure of certain diseases have been made possible by gene therapy [7].

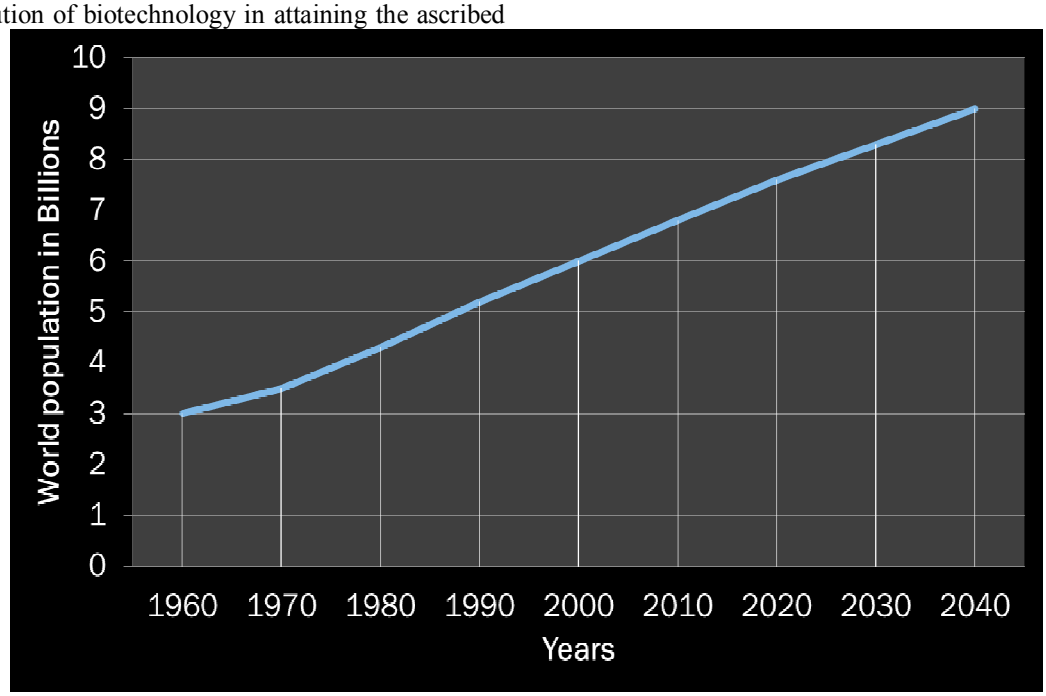
In general, the socioeconomic development of biotechnology has been enormous in countries that fully exploit this technology. However, despite all efforts put in place to achieve the MDG, this technology is still at its infancy in Africa. This, paper tries to explained the global challenges that led to the adoption of the MDG in 2000, stating its aim and the progress made so far. It also exposes the contribution of biotechnology in attaining the ascribed goals but outlining the challenges faced in Africa and suggest possible ways to support the growth of this technology in Africa to meet the MDG 2015 objective.

2. Socioeconomic impact of climate change and rapid pollution growth

In recent time, the world has been challenged with two major setbacks; climate change and a rapid increase in population growth. Currently at 6.7 billion people, the world population increased from 3 billion in 1959 to 6 billion by 1999, and is projected to grow to 9 billion by 2040 [21], (See figure 1). At a 3.1% growth rate, Africa's population was about 200 million 30 years ago; it is 520 million today and is projected to increase to 1.3 billion in the next 25 years (Ndiritu). This continent has the highest population growth rate in the world. Poorer countries faced a 40 percent increase in their food imports bill in 2008. Food prices experienced in 2008 are believed to have pushed 100 million people into hunger worldwide. This continuous increase in world population further strains food supplies as well as poverty.

Global warming as a result of the depletion of the ozone layer, caused by the emission of greenhouse gases into the atmosphere is a major aspect of climate change which is daring to the human population [11]. Poor agricultural yield due to shortage of arable land, inadequate rainfall, hunger, poverty, increase in disease burden etc. are the possible outcome.

Generally, the level of disease burden in the world is greatest in Africa particular sub-Africa. Countries in this region are classified as the poorest in the world. On the other hand, most developed worlds which are rich are least affected by infectious diseases. Drawing a mathematically relationship between wealth and disease shows an inverse relationship. This suggests that the poorer a country is, the more likely the people will be in poor health (Figure 2).



Source: U.S. Census Bureau, International Data Base (IDB), 2008

Fig 1: World Population Growth (1960-2040)

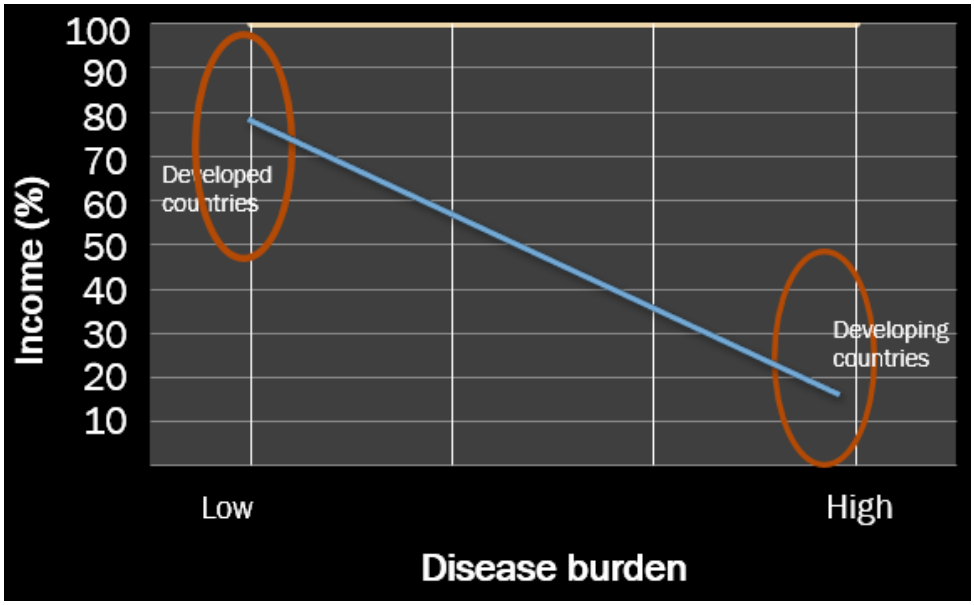


Fig 2: Graphical relationship between Wealth and Disease Burden

3. United Nation Millennium Development Goals

To overcome the challenges faced by the world, United Nation in 2000 officially establish in a summit following the adoption of the United Nation Millennium declaration, the Millennium development goal called MDGs [20]. 189 United Nations member states and at least 23 international organizations agreed to achieve this goal by 2015. The eight goals established included; eradication of extreme poverty and hunger, achieve universal primary education, promote gender equality and empowering women, reduce child mortality rate, improve maternal health care, combat HIV/AIDS, malaria and other diseases, ensuring environmental sustainability, and develop a global partnership for development. Among these eight international goals, their major concern is to alleviate poverty, hunger, education and improve on health care and diseases.

4. Progress report in Africa towards the Millennium Development Goals

In September 2010, at the UN Millennium Development Goals High-Level Summit in New York, the international community reaffirmed its commitment to the MDGs, acknowledged the progress made so far, and noted that the global achievement of the MDGs by 2015 is still possible through strengthened international partnerships, closer collaboration between national authorities and development partners, and clear-sighted political will at the national level [9].

The overall assessment of Africa's progress toward the MDGs reveals that, while progress has generally been positive, performance has been mixed across indicators and countries, and based on current trends, the overall pace of progress is insufficient to achieve the MDGs by the target date of 2015. Indeed, the recent progress toward achievement of the MDGs occurred against the backdrop of global food, fuel, and financial crisis. The crisis invariably had adverse effects on a wide range of MDG indicators. Food hikes have to some extent continued since 2008, with price levels above pre-crisis figures to the detriment of lower-income groups who have become more vulnerable in the face of rapidly declining real incomes. Climate change poses yet another formidable challenge to Africa's agricultural production, food security and livelihoods, as demonstrated by the recent floods in Southern and West Africa, and the drought in Eastern Africa. Progress on health indicators has generally been weak. While a few countries have made commendable advances, overall the African continent lags behind other global regions in terms of maternal and child health. The level of unemployment still remains high. Unemployment can lead to political instability, as witnessed in the recent events in Tunisia and Egypt.

5. Achieving progress through development by creating innovative academic fields

Most developed and wealthy nations in the world are those with technological advancements. High through-put technologies have boosted the economy of emerging economies such as China, Brazil, India etc. A mathematic relationship of wealth and technology is shown in Figure 3. To attain the MDG 2015 objective in Africa there is need to enhance development through technological advancement. Technological advancement requires the creation and institution of innovative academics fields to meet the demands of the challenging economy.

In academics, the major scientific fields that first originated where biology, chemistry, physics and mathematics. With the discovery of material science, new fields such as biochemistry and engineering emerged. As technology advanced with high through-put techniques, the discovery of more innovative fields emerged such as molecular biology, biotechnology, genetic engineering, nanotechnology, petrochemical engineering and chemical engineering. Also, new fields such as bioinformatics, chemoinformatics and information technology are one of the most recent fields after the discovering of information science. New innovative academic disciplines are shown in Figure 4.

6. Biotechnology; a tool for development

Biotechnology which greatly interferes with molecular biology and genetic engineering is one of the most exploited fields in recent time to foster development [8]. Biotechnology, defined as a set of tools that uses living organisms or their parts to make or modify a product, improve plants and animals, or develop microorganisms for specific uses to improve on the well been of man, is shown to have potential contributions to development and at the forefront in achieving the Millennium development goal by alleviating poverty,

hunger and improve on health care and disease (Soetan, 2011).

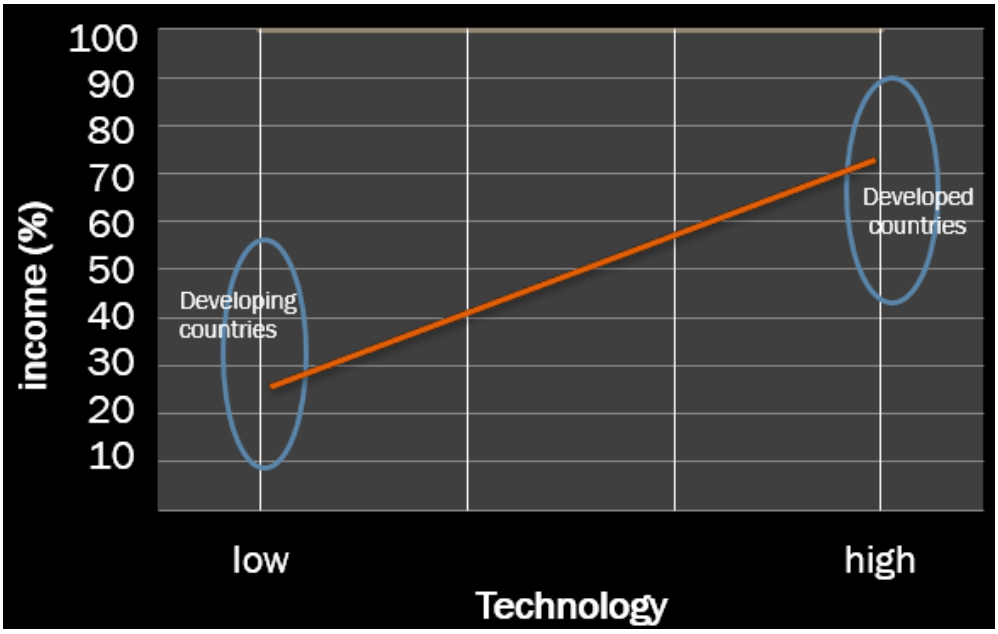


Fig 3: Graphical relationship between Wealth and Technology

Fig 4: New Innovative Academic Disciplines

	Biology	**Chemistry**	**Physics**
	Mathematics		
Material science	Biochemistry		Engineering
	Biotechnology/ Molecular biology	Chemical engineering	Nanotechnology
	Petrochemical engineering		
Information science	Bioinformatics	Chemo-informatics	Information technology

Biotechnology existed several thousands of years ago. Selective breading was exploited by man to improve on the production of crop and life stock for consumption [22]. Other arms of this traditional biotechnology such as fermentation processes and tissue culture emerged in the early 20th century and have now been revolutionized to modern biotechnology through the use of genetic engineering technique. Genetic engineering, defined as the deliberate manipulation of an organism's genetic makeup to achieve a planned and desired result is considered as an extension of traditional biotechnology. The development of recombinant DNA technology has revolutionized biotechnology from traditional biotechnology whose origin can be traced back to the use of yeast

for baking bread and fermentation of alcohol to modern biotechnology using genetically modified organisms in agriculture, industries and medicine [3].

The four main arms of biotechnology include; Blue biotechnology which describe the marine and aquatic use of biotechnology but its use is relatively rare, Red biotechnology which applies to medical processes usually exploited for health applications, Green biotechnology applied to agricultural processes and the environment and White biotechnology also known as industrial biotechnology which applies mostly to chemical and agro-alimentary industrial processes.

7. Agricultural biotechnology

Agricultural biotechnology is the term used in crop and livestock improvement through biotechnology tools. The biotechnology tools that are important for agricultural biotechnology include conventional plant breeding, tissue culture and micropropagation, and genetic engineering and genetically modified crops [5].

a) Conventional Plant Breeding

Since the beginning of agriculture eight to ten thousand years ago, farmers have been altering the genetic makeup of the crops they grow. Early farmers selected the best looking plants and seeds and saved them to plant for the next year. The selection for features such as faster growth, higher yields, pest and disease resistance, larger seeds, or sweeter fruits has dramatically changed domesticated plant species compared to their wild relatives. Plant breeding came into being when man learned that crop plants could be artificially mated or cross-pollinated to be able to improve the characters of the plant. Desirable characteristics from different parent plants could be combined in the offspring. When the science of plant breeding was further developed in the 20th century, plant breeders understood better how to select superior plants and breed them to create new and improved varieties of different crops (Sun, 2008). This has dramatically increased the productivity and quality of the plants we grow for food, feed and fibre.

b) Tissue Culture and Micropropagation

Some plants and trees on the other hand need several years before they flower and set seeds, making plant improvement difficult. Plant scientists have developed the science and art of tissue culture to assist breeders in this task. Tissue culture is the cultivation of plant cells, tissues, or organs on specially formulated nutrient media. Under the right conditions, an entire plant can be regenerated from a single cell. Plant tissue culture is a technique that has been around for more than 30 years [2]. There are several types of tissue culture depending on the part of the plant (explant) used. Micropopagation is a tissue culture method developed for the production of disease-free, high quality planting material and for rapid production of many uniform plants. Actively-dividing young cells (meristem) are placed in a special medium and treated with plant hormones to produce many similar sister plantlets. Since the meristem divides faster than disease-causing virus, clean materials are propagated and hundreds of uniform plantlets are produced in a short time. Through micropropagation, it is now possible to provide clean and uniform planting materials in plantations. Micropropagated plants were found to establish more quickly, grow more vigorously and taller, have a shorter and more uniform production cycle, and produce higher yields than conventional propagules.

c) Genetic Engineering and Genetically Modified Crops

Over the last 30 years, the field of agricultural biotechnology has developed rapidly due to the greater understanding of DNA as the chemical double-helix code from which genes are made. Genetic engineering is one of the modern agricultural biotechnology tools that is based on recombinant DNA technology [6]. With conventional plant breeding, there is little or no guarantee of obtaining any particular gene combination from the millions of crosses generated. Undesirable genes can be transferred along with desirable genes or while one desirable gene is gained, another is lost because the genes of both parents are mixed together and re-assorted more or less randomly in the offspring. These problems limit the improvements that plant breeders can achieve, eating time and funds along the way. In contrast, genetic engineering allows the direct transfer of one or just a few genes, between either closely or distantly related organisms. Not all genetic engineering techniques involve inserting DNA from other organisms. Plants may also be modified by removing or switching off particular genes and genetic controls (promoters).

Agricultural biotechnology is applicable to plants, animals and even the soil. So many plants have been genetically modified either to add new characteristics such as addition of an essential amino acid, essential oils, vitamins and other nutrients of high value to man [18, 23]. Some plants have been genetically modified to develop resistance against diseases. Animals such as cattle's have been genetically modified to produce more milk, to grow fast and resist diseases. Biofertilizers such as Nutrient recycling bacteria in the soil have been genetically modified to boost agricultural yields [10]. Certain biomolecules known as biopesticides have been generated for crop protection [4].

8. Medical application of biotechnology

The medical application of biotechnology has many areas of application. So many pharmaceutical products are from biotechnological processes. Most enzymes, hormones needed by the body are genetically modified in animals. Human insulin has been produced in pigs and microorganism which are genetically modified [17]. Gene therapy which is done by altering DNA within cells in an organism to treat or cure a disease is one of the most promising areas of biotechnology research. New genetic therapies are being developed to treat diseases such as cystic fibrosis, AIDS and cancer. Peptido or nucleo-mimetics has been exploited to produce pseudo-peptides or nucleotide sequence which can bind DNA, mRNA and alter the expression of certain genes who's over expression is responsible for certain diseases. Recombinant DNA technology is now highly exploited in the production of vaccines. Biotechnological processes through recombinant DNA technique and Polymerase chain reaction are now been used to fight and control disease.

In the World Health Organization report on genomics and health care in 2000 suggest that genome based solutions have the potentials to meet the demands of developing countries. An international panel of 28 scientists, experts of biotechnology and on global health issues identified 10 Top technologies for health to meet the MDG by improving on health care [1]. They include; molecular diagnostics, recombinant vaccine, vaccine delivery system, bioremediation, sequencing pathogen genome, female-control protection against sexually transmitted disease, bioinformatics, nutritionally enhanced genetically modified crops, recombinant therapeutic proteins and combination chemistry

Molecular diagnosis will permit early detection of disease, timely

intervention and help prevent spread of infection. Dipstick assay based on immunological methods have been develop for the detection of malaria parasite, salmonella typhi, HIV virus etc.

Recombinant vaccines particular cloning subunits of antigen DNA sequences and expressing them in vehicles has been achieve with reduced risk compared to attenuated vaccine. Recently a malaria subunit vaccine RTS'S is in phase 3 clinical trial and is forecast for distribution by 2015 [12]. Improved methods for vaccine and drug delivery systems have been developed such as gene gun through biolistic particle bombardment which are needle free technology to reduce risk of infection transmission such as HIV. Sequencing of genome and vector with the help of bioinformatics has been exploited to create databases with algorisms that can identify gene sequences, active sites of proteins and homology of sequences to boost search for novel vaccine and drug and improve understanding of disease mechanism.

Production of recombinant proteins in transgenic plant and animal is cheaper method to obtain proteins of therapeutic interest than isolating and purifying them from their original surface. Recently, plant-derived antibodies and vaccines known as plantibodies and plantigens respectively have been developed to serve as edible plants for passive immunization and protection against diseases [7].

Combinational chemistry which studies the effect of various combination of chemical compound is now a rapid method used to produce new drugs. Two new classes of drug inhibitors of leishmania Mexicana cysteine protease have been discovered following a combination screening of 150,000 compounds.

Nutritionally genetically modified crops enhance with essential amino acid, essential oil, micronutrients have been develop to combat malnutrition and nutrient deficiency diseases. Vitamin A deficiency is a common problem in poor countries. The Rockefeller Foundation is sponsoring research on "golden rice", a crop designed to improve nutrition in the developing world. Rice breeders are using biotechnology to build Vitamin A into the rice [1].

Bioremediation a strategy to remove environment pollutants using microorganism is a way to improve on health. This strategy has been used to remove arsenic from water by transforming arsenite to arsenate which is soluble and less toxic.

Female-control protection against sexually transmitted disease can be achieved by developing products that can prevent transmission of STDs. A novel mendelic acid condensation polymer blocks binding of HIV and herpes simplex to cell has been developed.

9. Industrial biotechnology

Industrial biotechnology applies the techniques of modern molecular biology to improve the efficiency and reduce the environmental impacts of industrial processes like textile, paper and pulp, and chemical manufacturing. For example, industrial biotechnology companies develop biocatalysts, such as enzymes, to synthesize chemicals. Enzymes are proteins produced by all organisms. Using biotechnology, the desired enzyme can be manufactured in commercial quantities. Commodity chemicals (e.g., polymer-grade acrylamide) and specialty chemicals can be produced using biotech applications. Traditional chemical synthesis involves large amounts of energy and often-undesirable products, such as HCl. Using biocatalysts, the same chemicals can be produced more economically and more environmentally friendly. An example would be the substitution of protease in detergents for other cleaning compounds. Detergent proteases, which remove protein impurities, are essential components of modern detergents. They are used to break down protein, starch, and fatty acids present on items being washed. Protease production results in a biomass that in turn yields a useful by-product, an organic fertilizer. Biotechnology is also used in the textile industry for the finishing of fabrics and garments. Biotechnology also produces biotech-derived cotton that is warmer, stronger, has improved dye uptake and retention, enhanced absorbency, and wrinkle- and shrink-resistance. Some agricultural crops, such as corn, can be used in place of petroleum to produce chemicals. Fermentation processes have been exploited to produce yogurts, alcohols, beers using genetically modified microorganisms in agro-alimentary industries. The crop's sugar can be fermented to acid, which can then be used as an intermediate to produce other chemical feedstock for various products.

10. Environmental biotechnology

Environmental biotechnology is the biotechnology that is applied to and is used to study the natural environment. It can simply be described as "the optimum use of nature in the form of plant, animal, bacteria, fungi and algae, to produce renewable energy, environmental protection, food and nutrients in a synergistic integrated cycle for profit making process. Environmental biotechnology has greatly been used for biodegradation and bioremediation. Biological processes play a major role in the removal of slurry in the environment and contaminants. Biotechnology is taking advantage of the astonishing catabolic versatility of microorganisms and understanding the metabolic pathway to degrade and convert these compounds. The new methodological breakthrough in recombinant DNA technology has develop molecular adaptation processes to changing environmental conditions to accelerate the development of bioremediation technologies and biotransformation. Marine environment are high vulnerable to oil spills at coastal region and constitute sea pollution. In addition to pollution through human activities, petroleum oils enter marine system and greenhouse gases are constantly emitted into spaces (the major cause of global warming). The exploitation of Biotechnological processes in the environment is of major concern.

11. Challenges of biotechnology in Africa

Biotechnology has highly been exploited in the western world but still remains at its infancy in Africa. In a few countries (South Africa, Kenya, Zimbabwe and Egypt) that biotechnological processes have been exploited, majority of them have focus on agricultural biotechnology (Thomson**,** 2004). Biotechnology is still a new field which is rarely instituted. Very few institutions and universities do offer this course. The naivety of most African governments and policy makers towards the field contributes a lot to its failure. Poverty in Africa is a major barrier for biotechnology, little or no budget is allocated for its promotion to support entrepreneurs and enterprises in this domain. Lack of research institutes and poor infrastructural settings adequate for research is paramount to its decline. The biosafety of the technology and its products remain a major challenge. The local population is very sceptical to consume certain genetically modified products due to their religious background and considers it as 'playing God'. Also there is the fear for genetically modified organism (animals, plants and microorganisms) to develop to mutants which can affect human health causing diseases just as the case of Dutch elm disease which was introduced into a new area while testing genetically modified bacteria in fungi [19].

12. The Way Forward for Biotechnology to Meet the Millennium Development Goals Objectives in Africa

Although many initiatives have been taken to put in place structures and mechanisms for development of biotechnology in Africa, major differences exist between countries in relation to the level of application. To circumvent these challenges and promote biotechnology in Africa, there is need for the public awareness and development of a knowledge base in institutions for appropriate understanding and in decision making on the use of biotechnological processes. There should be priority setting for biotechnology aimed at solving specific problems of national importance and so need full involvement of the government. Also establishment of policy and regulatory structures for biosafety and intellectual property protection will be of interest to ensure safety and patent its products. Capacity development for enhancement of the above issues and establishing linkage and cooperative mechanisms for biotechnology development, its transfer, and sustainable applications in Africa is of paramount importance.

13. Conclusion

Following the 2000 millennium declaration for the adoption of the MDG, there has been some progress in the achievement of the MDG in Africa. However, based on the current trend, the overall pace of the progress remains insufficient to attain the MDG objective by the year 2015. Though at its infancy in Africa, biotechnology, with its wide range of application in the agricultural, environmental, industries and medical sectors stands at the forefront of meeting the MDG objectives. Substantial effort is needed from policy makers to institute and build capacity so as to promote the growth of this technology to alleviate poverty, hunger, diseases, other socioeconomic problems of major concern and foster development in Africa.

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