

Biotechnology in Bangladesh

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Introduction

Biotechnology in its simplest connotations may be defined as a technology based on biological systems – plants, animals and microbes or parts of it (cell, tissue, gene or DNA) to derive the best goods and services for the benefit of human being. Although the practice of biotechnology principles was very old, as in the case of fermentation processes like making of alcohol, yogurt, preparation of cheese, bread etc, the term ‘biotechnology’ itself got its due place after the principles of recombinant DNA technology or genetic engineering came into picture. And now when we talk of biotechnology we usually mean the technology derived primarily through the use of ‘recombinant DNA’. But recombinant DNA technology in principle although sounds to be simple (taking gene from one organism and putting into another) but in practice it is quite complex, tenacious, costly and challenging.

It is for this reason that for the use of modern biotechnology, although started long back during late 1970s, many countries, both the developed

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and developing ones, could not enter into the arena because of lack of adequate fund, manpower, infrastructures and the political will as well. The countries of the Asian region although have a good agricultural land, good climate for agricultural production and also good climate and manpower for industry, in reality most are poor. Over population, coupled with high degree of illiteracy, have kept many countries of this once prosperous region below poverty level. Therefore, to overcome the situation in reasonably early period of time cultivation of modern science like 'biotechnology' is highly essential. The opportunities of utilization of biotechnology for mitigating the sufferings of teeming millions of the region are enormous but the challenges for doing so are also quite hard. It is heartening to note that Research and Information System (RIS) for the Non-Aligned and other Developing Countries took the initiatives for discussing this highly important issue in a Workshop, held in New Delhi, on February, 26-27, 2002. In the following paper the opportunities and challenges of biotechnology and development in the region vis-a-vis Bangladesh will be discussed and suggestions to overcome the bottlenecks will be put forward for due consideration.

Bangladesh Economy

In the region of Asia, Bangladesh is comparatively a very small country with only 55,598 sq. miles of land (1,43,999 sq km) in between primarily big neighbouring country – India bordering almost two-third of the territory. The other immediate neighbours of Bangladesh are Burma to the east and south and small stretch of Nepal to the north. But, within this small area of land Bangladesh has nearly 130 million people to live in. The population density is nearly 2000 per sq miles – one of the highest in the world. Most of the people live in the villages – rural: 85 per cent and Urban: 15 per cent. The population growth rate at present is 2.3 per cent per annum which is also quite high in comparison with any developed countries.

Bangladesh basically is an agricultural country and agriculture is the major industry upon which 80 per cent people depend. Fertile alluvial soil of the Ganges-Meghna-Brahmaputra (GMB) delta, coupled with high rainfall

(average 100 cm) and easy cultivation, has made this small riverine country coveting for many outside settlers from time immemorial which is the root cause of thick population. Rice is the major food crop, which is cultivated round the year and jute had been the major cash crop till recently. The per capita income is at present nearly US \$ 400 which has increased to this level during the last 5-7 years from below US\$ 300.

Beside agriculture the other major resource at present is the natural gas which is estimated to be between 25-40 trillion cubic feet.

Universities and Research Organisations of Bangladesh

Bangladesh has at present five General Universities, two Engineering Universities, two Agricultural Universities and a Medical University. In addition, the government has very recently taken due initiatives for starting with 12 science Universities. Besides, there are nearly 30 private Universities in Bangladesh, mostly located in and around Dhaka. But, the curriculum of these private universities is mostly limited to computer science and business administration only. The number of government. universities is very less compared to enrolment pressure and usually more than 50 candidates appear for one seat in a government university. The total capacity of all the government universities will be less than 100,000. The following important research organisations are now functioning in Bangladesh.

- Bangladesh Atomic Energy Commission (BAEC)
- Bangladesh Council of Scientific and Industrial Research (BCSIR)
- Bangladesh Rice Research Institute (BRRI)
- Bangladesh Agricultural Research Institute (BARI)
- Bangladesh Jute Research Institute (BJRI)
- Bangladesh Tea Research Institute (BTRI)
- Sugarcane Research and Training Institute (SRTI)
- Bangladesh Institute of Nuclear Agriculture (BINA)
- Sericulture Research Institute (SRI)
- Bangladesh Livestock Research Institute (BLRI)
- Bangladesh Fisheries Research Institute (BFRI)

Most of these institutes have been functioning for more than 30 years and the total number of scientists working in different institutes will be nearly 3000.

Research work in Bangladesh till recently was mostly carried out by individual scientists in a fragmented manner. Previously there was no separate research budget for this purpose. At present separate R&D budget is given by the government for this carrying out research work. In addition, a special grant of Tk 120 million is provided by the Ministry of Science and Technology every year for R&D in physical, biological and engineering sciences. However, the annual expenditure per scientist in a year will not exceed US\$ 500.

Present Status of Biotechnology in Bangladesh

The programme on plant biotechnology in Bangladesh was initiated in late 1970s in the Department of Botany, Dhaka University with tissue culture of jute. Thereafter within a span of 10-12 years tissue culture research laboratories have developed in different universities and R&D organisations, like Dhaka University, Rajshahi University, Chittagong University, Jahangirnagar University, Khulna University, Bangladesh Rice Research Institute, Bangladesh Jute Research Institute, Bangladesh Agricultural Research Institute, Bangladesh Council of Scientific and Industrial Research, Bangladesh Atomic Energy Commission, Bangladesh Institute of Nuclear Agriculture, Bangladesh Forest Research Institute and Institute of Post Graduate Studies in Agriculture. A few NGOs like DEBTECH and PROSHIKA are also working on plant tissue culture. As a result of intensive work on plant tissue culture protocols on plant regeneration and micro-propagation have been developed on different crops, forest plants ornamental and fruit trees as well as vegetables. These *in vitro* regeneration protocols are now awaiting for commercial exploitation. It is expected that with the establishment of private entrepreneurs commercial utilization and expansion of tissue culture techniques will gradually find its due place in Bangladesh.

Animal and Insect Biotechnology and Aquaculture

In animal biotechnology Bangladesh Live-stock Research Institute (BLRI) and Bangladesh Agricultural University (BAU) have already taken modern biotechnology programmes. These include embryo transfer technology, multiple ovulation embryo transfer and artificial insemination programme. But, the programme of animal gene transfer through genetic engineering technique has yet to be started. However, livestock biotechnology produced 11 types of veterinary biologics for the treatment of infectious diseases in livestock and poultry, vaccines for foot and mouth disease and rinder pest. Biotechnology in fisheries induces spawning in carp, pabda, catfish, koi and others. With this technology 50,000 kg of different fish species can now be produced annually.

Sericulture Research Institute, Rajshahi has been working for a long time for the improvement of sericulture production in Bangladesh. During recent past genetic engineering techniques have also been adopted for the purpose. At the Bangladesh Atomic Energy Commission low dose of gamma radiation to the silkworm has been employed for the enhanced production of silk. Significant progress has been achieved on sterile insect technique (SIT) by utilizing gamma radiation. Besides, hormonal and pheromonal control of insects and also the integrated pest management (IPM) programme are now being adopted for insect management. Isolation and characterization of *Bacillus thuringensis* strains for the control of Lepidopteran insects has been initiated at the university of Dhaka.

Industrial Biotechnology

In the field of industrial biotechnology Bangladesh is yet to make real breakthroughs. Modern biotechnological programmes involving gene transfer technology have yet to be started in real earnestness. Whatever has been possible is through classical/old biotechnology methods. However, the results are quite encouraging and a good number of projects are in advanced stage which can be taken up for commercialization. Some of these research programmes are:

- Bioconversion and bioprocessing of agricultural and agro-industrial residues for feed, fuel and chemical.
- Genetic improvement of industrial micro-organisms like citric acid production by *Aspergillus niger* through gamma radiation.(has reached commercial stage)
- Mass scale production of *Spirulina* (has reached commercial stage).
- Production of biofertilizer (has reached commercial stage).
- Production of amylase and gluco-amylase for scarification of low cost starch.
- Production of microbial biomass protein and single cell protein.
- Production of tannery enzymes.
- Production of alcohol from agroindustrial residues – a few distilleries in the country are already utilizing >50,000 MT of molasses for the production of ethyl alcohol.
- Preservation of fruits, vegetables and spices by radiation and bioprocessing.
- Bioenrichment of cereal food by microbial fermentation.

Bioenergy and Environmental Biotechnology

A significant achievement has been made in the field of 'BIOGAS' production from animal excreta (cowdung) and agricultural residues. The Institute of Fuel Research and Development (IFRD) has been working since long in this field. As a result of research findings and its subsequent development in collaboration with Department of Energy (DOE) at present more than 10,000 biogas plant have been installed in rural areas. An extended programme to set up about 100,000 biogas plants throughout the country has also been taken up by the government which is now under implementation.

In case of environmental biotechnology Bangladesh is yet to start its programme by utilizing modern biotechnological techniques. Whatever has been possible is through conventional methods. But, because of excessive population pressure and overall industrial activity, environmental pollution is gradually increasing day by day and is causing a real threat to human health and ecological balance. Industrial effluents, municipal

garbage and sewerage are discharged with minimum or no treatment at all into the surface water, causing water pollution. The Department of Environment (DOE) of the Government of Bangladesh is doing some routine work only. Among the limited activities Bangladesh Atomic Energy Commission (BAEC) has installed advanced facilities to analyse harmful agrochemical residues at a very low concentration. Microbial technology could be a useful tool to minimize the solid waste and effluents causing pollution. What is needed is a broadbased 'bioremediation' programme involving modern biotechnological approach including the development of microbes capable of degrading Xenobiotics and recalcitrant pollutants.

Bangladesh is yet to start, in real earnestness the techniques of genetic engineering for the improvement of plant, animal, and industrial micro-organisms and also to combat environmental pollution problems, etc. At present only a limited number of laboratories are working to introduce and utilize the gene transfer technology for the improvement of crops like rice, jute and also for obtaining better strains of industrial microbes. Research and development of animal genetic engineering is particularly very limited at present. The list given below tells about what research work is being carried out at present in different universities and research institutes:

- Agrobacterium mediated genetic transformation of jute: being carried out at the Institute of Food and Radiation Biology, AERE, BAEC, Dhaka and Bangladesh Jute Research Institute.
- Genetic transformation of pulses for fungus resistance: initiated at the Department of Botany, Dhaka University (DU).
- Genetic transformation of rice and jute for salinity tolerance and fungus resistance: being carried out at the Department of Biochemistry, DU.
- Use of DNA probes for the diagnosis of diseases: being initiated at the Institute of Nuclear Medicine, BAEC, Dhaka.
- Development of food, fibre and energy through recombinant DNA technology: being carried out at the Department of Zoology, Rajshahi University (RU).
- DNA finger printing of rice and jute at the Department of Biochemistry, DU.

The National Institute of Biotechnology

The concept of a National Institute of Biotechnology in Bangladesh was developed as early as 1984 and a Project Proposal was submitted to the government by the same year. Thereafter, the matter was subjected to different examinations and evaluation by the government for several years. Subsequently in a meeting in 1993 of the National Council for Science and Technology (NCST) it was decided that an Institute of Biotechnology would be established in Bangladesh. Accordingly, a Project Proposal was submitted to the Planning Commission. The Planning Commission advised that before the establishment of such an institute, a feasibility study report needs to be submitted. So, accordingly a feasibility report was prepared at a cost of TK. 35 lakh and was submitted to the government with a strong recommendation for the establishment of a 'National Institute of Biotechnology'. Based on this report, a Project Concept Paper was prepared by the Planning Commission in 1995 and submitted to the Pre-ECNEC meeting. And this, after many proposals and counter proposals, and revisions, was finally approved by the government in a meeting of ECNEC, held on May 12, 1999 and accordingly a Project Proposal was prepared with an estimated cost of Tk 2021.20 lakh. However, very soon it was realized that the floor space of the laboratories in the original Project Proposal was too meager for any good Biotechnology Research Institute. Therefore, before the initiation of the construction work a revised Project Proposal was prepared with an estimated cost of Tk 2768.24 lakh, having a total floor area for laboratories 2250 sq. m. instead of 1116 sq. m. The salient features of the institute are as follows:

- Name of the Project: National Institute of Biotechnology.
- Sponsor Organization/Ministry: Ministry of Science and Technology Government of Bangladesh.
- Estimated cost: Tk 2768.24 lakh (revised)
- Total Area of Institute Building: 3700 sq. m.
- Total Floor space of the laboratories: 2250 sq. m.
- No. of Laboratory: 6
- Total No. of Scientists to work: 100
- Expected year of completion: June, 2004.

The proposed six Laboratories/Divisions of the institute are:

- DNA Laboratory
- Plant Biotechnology
- Animal Biotechnology
- Fish Biotechnology
- Fermentation and Bioprocessing
- Bioenergy and Fertilization

The physical construction of the institute has already been started and the main laboratory building is expected to be completed by June 2002. Appointment of scientists for the project period is also underway.

NIB Objectives

The National Institute of Biotechnology, Bangladesh is going to be established with an aim to accelerate the research activities in the field of biotechnology in order to meet the ever-increasing demands in food, medicine, energy and industrial sector in the country. The institute will cater to the dual activities of taking up important research programmes in agriculture, health, medicine, industry and environment sector as well as giving support and guidance to other institutions working in the same areas in the country. Overall, the institute may cater to the following areas in order to boost up the application of biotechnology in the country:

- Research work on priority problems in agriculture, food, industry, veterinary and human health.
- Networking of important national projects like genome project, field testing, etc.
- Human Resource Development – manpower training in biotechnology, capacity building, bioinformatics and holding of regular seminars and symposia in order to disseminate the up-to-date knowledge on the subject.
- Policy Planning – act as a national focal point on biosafety, bioethics and biosurveillance, and also technology alert and assessment system.

- Technology Resource Centre – act as national centre for making use of proven, economically viable biotechnology on the shelf for fostering remunerative employment and also act as a seat of Biotechnology Park.

Some important research projects which may be initiated by NIB are:

- Improvement of productivity, nutritional quality and shelf life of food and animal feed products.
- Development of plant cultivars tolerant and/or resistant to stress from factors such as pests and diseases.
- Promotion of use of under utilized crops of possible future importance for human nutrition and industrial supply of raw materials.
- Development of improved diagnostic techniques and vaccines for prevention and spread of diseases of human as well as useful animals (livestocks).
- Utilization of various biotechnological techniques to improve the yield of fish, algae and other aquatic species.
- Development of appropriate methods to minimize the requirement for unsustainable synthetic chemical input and to maximize the use of environmentally appropriate products.
- Development of processes to reduce waste generation, treatment of waste before disposal and make use of biodegradable materials.
- Development of techniques to remove pollutants from the environment where conventional techniques are not available or are expensive, inefficient or inadequate.
- Development of processes to increase the availability of planting materials, particularly the indigenous varieties, for use in afforestation and reforestation and to improve sustainable yield from the forest.
- Promotion of the use of integrated pest management based on the judicious use of biocontrol agents.
- Promotion of the appropriate use of biofertilizers within national biofertilizer programmes.
- Promotion of the use of biotechnology relevant to the conservation and scientific study of the biological diversity and the sustainable use of biological resources.

R&D Priorities

In fixing the priorities in R&D activities in biotechnology, the sectors which are considered important for our country are health, energy, agriculture, industry and environment. Biotechnology can play a great role in development activities in all these sectors if R&D programmes are taken up judiciously and such programmes are supported adequately. Development of vaccines against viral, bacterial and protozoal diseases through modern genetic techniques. Vaccines for fertility regulation, production of drugs and pharmaceuticals, etc. call for proper investment in R&D activities in biotechnology and genetic engineering.

R&D activities should give priority to improvement of industrial strains of micro-organisms for production of those food supplements, drugs, vitamin, hormones, solvents and other chemicals which are now solely imported from abroad. Bioconversion of agricultural wastes into food, feed and fuels is another important area. Optimization of process parameters for maximising productivity so as to efficiently convert raw materials to finished products call for inter-disciplinary approach to the biological process with heavy input from chemical engineering.

Priorities in R&D work should include programmes on development of high yielding, stress tolerant varieties of food crops through modern genetic engineering techniques, biological nitrogen fixation, biofertilizers, bioinsecticides, etc. Emphasis should be given on the conversion of lignocellulosic wastes to biofuels, improvement of biogas technology from organismal and environmental (better bioreactor) point of view, development of energy plants, etc. Development of efficient activated sludge process for waste treatment, development of organisms for treatment of industrial pollutants, xenobiotics, etc. should get research priority.

In September 1993, a National Committee on Biotechnology Product Development was formed by the Government of Bangladesh to select potential biotechnological projects which could be leased out for commercialization. The committee, after careful considerations, recommended the following projects for utilizing under commercial venture:

- Rhizobial inoculants for use as biofertilizer.
- Yeast as protein supplement for poultry feed.
- Tissue culture derived post exposure anti-tuberculosis vaccine.
- Tissue culture based foot and mouth disease vaccine.
- Bamboo saplings by *ex-vitro* and *in-vitro* methods.
- Biogas technology for fuel, fertilizer and environmental pollution control.
- Production of high quality potato seeds by using tissue culture.

Some of these projects are now being exploited on commercial basis. Besides, an MOU has been signed with one entrepreneur and one of the high yielding patented mutant strain (318/14) is under industrial trial for citric acid production by *Aspergillus niger*.

Biosafety Regulations

With all the benefits, which accrue from the bio-tech revolution, it appears that some of them are associated with potential risk as well, as has been described below:

- (a) It is estimated that over the last three decades about half of the varieties of the world have been lost. One of the major risks in view of this arises from the fact that novel varieties which are commercially attractive, may replace some of the existing varieties unless proper attention is given to bio-conservation. Again, the genetic uniformity in plants and animals makes them vulnerable to pest and diseases. An epidemic caused by a mutant bacteria, pest or virus can cause havoc to a large number of plants or animals.
- (b) So far farmers in the Third World have been able to develop varieties, organise production and also able to control the spread of disease as they were familiar with the indigenous plant or animals they were cultivating or breeding and the diseases which were likely to affect them, either by taking preventive measure or by providing the necessary treatment. With the introduction of bio-tech seed the dependence of farmers on the supplier would increase, as the supplier alone would have the total information, if any, on how to control

disease problem. Because of the patent rights of biotech products the farmer would not be able to further develop the variety, or experiment with it. This would turn the Third World farmers and breeders into mere workers. The problems of terminator gene has created serious controversy in this regard.

- (c) It is apprehended that biotechnology may also result in the substitution of a large number of natural products, such as flavours, added to beverage, food and other products. Their production, through cloning to increase the quality and quantity of a particular flavour, may affect production of indigeneous aromatic and medicinal plants. It may also affect the present genetic diversity, with consequent disadvantages, as mentioned earlier.
- (d) The genetically controlled animal produced in animal farms would be cloned for increased quantities of proteins, but it may not suit the taste of consumers. The attempt to introduce casein gene in rice, though successful, may result in rice which taste like milk?
Again experiment on human genome has raised many ethical questions which deserve serious attention.
- (e) Finally, environmental release of genetically manipulated products, where one does not know the possible impacts they would have on other living forms, may result in disaster particularly when a large number of them are released for testing or for specific purpose, i.e. to combat pests, etc. without assessing other possible harmful side effect.
- (f) There is a tandency on the part of multinational companies to test biotech product without adequate safeguards over a period of time to know long term effects. If the laws of the country do not permit and cannot be violated, then the tests might be done offshore or in the Third World countries unless those countries are guarded by strong biosafety regulations.
- (g) Scientists in their desire to gain name and fame or to earn large financial benefits by undertaking research in manipulating genes to develop new forms of life tend to violate the laws of the country and undertake tests without considering the environmental impart.

For proper handling of genetically modified plant, animal and micro-organisms it is essential to have safety guidelines, and for field

application safety regulation is must to protect our environment from harmful effects of any of genetically modified organisms. The Ministry of Science and Technology, in collaboration with Plant Tissue Culture Society of Bangladesh, organized a workshop on Biosafety Regulation on 7-8 December 1997. A Task Force was formed to formulate biosafety guidelines and biosafety regulation, in the light of the recommendation of the workshop. And a biosafety guideline has been prepared which has recently been approved by the government.

Bioethics

‘Bioethics’ refers to the ethical or moral obligations/rules of behaviour/professional standard of conduct dealing with biological research. Although literally the term ‘Bioethics’ refers to all biological research activities, actually the term has practically been evolved after the advent of biotechnological research activities.

Biotechnology in its present connotation is the science which primarily deals with the basic life substance, i.e. DNA or gene, and through genetic engineering technique it has now been possible to transfer gene from one organism to the other which are even totally unrelated. Thus, it has now been possible to have a gene of protein (insect toxin) from a bacterium like *Bacillus thuringiensis* (Bt) and integrate with the genome of a plant like cotton, maize, etc. and get an insect resistant variety. Earlier, before the introduction of biotechnology/genetic engineering techniques, such an act of unrelated gene transfer was not possible. Again, through the introduction of tissue culture techniques it is now possible to raise plants from cells, tissues or even protoplasts. Likewise animals like Dolly – a sheep – has been possible to be cloned from a single somatic cell. And it is now being aimed to raise human beings also from single cells (human cloning).

But, all the spectacular activities of biotechnological research have aroused a big question whether it is ethical to do all such type of research and what should be the guidelines or moral boundaries for working with ‘gene transfer technology’ as it contains potential danger too. And from this

point of view the concept of 'bioethics' has emerged in the recent past.

In the advanced countries there have been quite lot of controversies regarding the bioethical guidelines. In the US alone till very recent past, biotechnological research were conducted under very stringent guidelines. Although at present in the US biotechnological research work, specially genetic engineering, is done under more relaxed guidelines, in other advanced countries strict rules and safety guidelines are followed. Most of the advanced countries working with biotechnology have 'biosafety guidelines' and also 'Act' passed by parliament which has to be followed strictly for doing research in the field of biotechnology.

Bangladesh, though belated in the field of biotechnology, for bio-ethical issues it is quite conscious. Biotechnology, specially the work on genetic engineering, is at present at a very nescent stage. But, before embarking on a broad-based research programme, Bangladesh government has given thoughts for enacting 'biosafety guidelines' and through an expert committee and a national seminar the national 'biosafety guidelines' have been framed to be followed by the scientists working in the area of Biotechnology.

The salient features of the biosafety guidelines are:

- Procedures and guidelines on the introduction, movement and field release of regulated materials.
- Physio-chemical and biological containment procedures and facilities.
- Guidelines for classification of micro-organisms according to their risk assessment.
- Good laboratory practices.
- Good industrial large scale practice.
- List of organisms according to different risk groups.
- The Universal Biohazard sign.
- Framework for risk assessment.
- Biosafety Committees.

Having set up the appropriate biosafety guidelines for working in the area of biotechnology, Bangladesh is now thinking to enact an 'Act' passed by the national parliament on the issue of biotechnology. The act to be named as 'The Bangladesh Biosafety Act-2001' is in its final stage of preparation prior to the submission to the government for placing before parliament as a bill for endorsement. The salient features of this 'Act' will be:

- Short title of the act.
- Definitions of different terms/connotations.
- Formation of National Committee on Biosafety of Bangladesh (NCBB).
- Power and Responsibilities of NCBB.
- Risk Management of GMOs.
- Contained use of GMOs.
- Field Release of GMOs.
- Public Deliberations/Awareness.
- Restriction on Certain activities related to GMOs.
- Working Principles for NCBB.

It is expected that after the 'Act' has been passed by parliament, biotechnological research in Bangladesh will be carried out under more congenial atmosphere and bioethical problems will be taken care more diligently.

In response to 'Bioethics' Bangladesh recently is going to support the International Convention against human cloning for reproduction to be placed on the agenda of 56th UN General Assembly. Bangladesh strongly feels that human reproduction cloning is against the human dignity and in the long run it may also cause havoc to mankind. Universal declaration on the human genome and Human Rights adopted in 1997 by UNESCO specifies that "Practices which are contrary to human dignity, such as reproductive cloning of human beings shall not be permitted". In pursuance of this declaration, any attempt to clone human being should be prevented through appropriate action/convention of United Nations, as it is contrary to 'bioethics'.

IPR and Biotechnology: Bangladesh Perspectives

A draft legislation on ‘Biodiversity and Community Knowledge Protection Act’ of Bangladesh has been prepared which is a positive step towards implementation of obligations on the part of the parties of Convention on Biological Diversity. But more things still have to be done. There is need for elaboration of detailed outline of the capacity building and stock taking with regards to access to genetic resources, traditional and community knowledge, transfer of technology issues related to bioprospecting of biodiversity. The stock taking may include assessments of the current legislative and regulatory frameworks on access to genetic resources, evaluation of strengths and weaknesses of the country’s institutional and different stakeholders, which include particularly scientific, technological and administration set-ups.

Biodiversity and Community Knowledge Protection Act of Bangladesh.

On this issue also a draft has been prepared which is under active consideration of the Government of Bangladesh. The draft act deals primarily with community knowledge, collective innovation and community rights.

The Act shall be the principal instrument to guide, inform, determine, control, reinterpret and give effect, where necessary, to the rights and privileges granted, if any, to the innovations of any form that have used natural and biological resources including knowledge and culture of the country or of other countries with which Bangladesh has reciprocal recognition of similar acts or ordinances or laws.

The Act shall include all biological and genetic resources and related knowledge and their derivatives within the jurisdiction of the country, both *in-situ* and *ex-situ*.

Potentials and Challenges for Capacity Building in Biotechnology

A. Requirements for Capacity Building in Biotechnology:

1. *Infrastructure development:* For infrastructure development the following essential facilities are needed:
 - (a) Laboratory building
 - (b) Ancillary facilities: Growth Room, Green House, Animal House, Insectaris, Aquarium, Hatcheries, etc.
 - (c) Facilities for field experiments: specialized, well protected and isolated.
 - (d) Specialized laboratories: DNA Lab, Genetic Engineering laboratory, preferably P4 type.

2. *Manpower development:* For biotechnological work well qualified and experienced scientists are needed in the field of:
 - (a) Molecular biology,
 - (b) Genetic engineering,
 - (c) Protein chemistry,
 - (d) Chemical engineering, etc.

3. *Equipment:* Biotechnology needs costly and modern equipment like:
 - (a) DNA synthesizer,
 - (b) DNA sequencers,
 - (c) PCR machine,
 - (d) Ultracentrifuges,
 - (e) Laminar Hoods, etc.

4. *Chemicals:* For biotechnological research work a regular supply of costly chemicals like enzymes (Restriction Endonucleases), radioactive substances, chemicals for DNA/RNA isolation, chemicals for *in-vitro* DNA/RNA preparation and synthesis, chemicals for enzyme isolation and characterization are needed.

B. Potentials for a Developing Country like Bangladesh

Although Bangladesh is one of poorest among the developing countries in Asia, yet for biotechnology development it has great potentials. These potentials lie primarily in its rich fertile agricultural land and biodiversity. Agriculture being the traditional industry of Bangladesh, agricultural biotechnology – be it plant biotechnology, animal biotechnology, fisheries or aquaculture – in every aspect Bangladesh has a great potentiality for future development. No where in the world such a fertile alluvial soil is available where plants could be grown so easily. The general mass are also well accustomed to different agricultural practices. What is needed is a good variety of plant or a good stock of animal/poultry/fish, etc. which can be developed through the modern biotechnological research. For this the country needs a good infrastructure and a team of well trained manpower for doing research in the modern field of biotechnology like genetic engineering, cell culture, cell fusion, protein engineering, enzyme technology, etc. Bangladesh has also a good potential for the development of industrial biotechnology based on agriculture. For this, small scale agricultural biotechnology may be encouraged, which is most suited for the country.

C. Constraints for Capacity Building

The constraints for capacity building in biotechnology in Bangladesh may be summarised as follows:

- Capital incentiveness of biotechnology.
- Poor economic condition of the country.
- Lack of venture capital.
- Lack of political will.
- Lack of adequate trained manpower
- Lack of incentives for biotech researchers.

But having a strong political will, these constraints, however difficult they may appear to be, could be easily overcome. Bangladesh Government is at present having a strong political will and is giving due incentives for the

development of biotechnology in the country. A National Institute of Biotechnology is being built up which will take its due shape in the near future.

Suggestions for Future Improvement of Biotechnology in the Region of Asia

The following suggestions are being put forward for effective development of Biotechnology in the Asian region:

- ***Prioritizing biotechnology for national development by respective governments of Asian countries:*** This has to get the first priority because without strong political will the development of the subject will be delayed further as had been the case in the past.
- ***Task Force for biotechnology development:*** A strong Task Force, consisting of members from all Asian countries, well trained in biotechnology, has to be formed for chalking out future plan of action.
- ***Perspective plan for next 20 years:*** A perspective 20-year plan has to be drawn immediately so that no time is lost unnecessarily for lack of proper planning and an action plan also has to be formulated simultaneously.
- ***Common consortium for Asian countries:*** Most of the Asian countries are poor. Therefore, a 'common fund' for biotechnological development raised through voluntary or compulsory contributions, commensurating with the national capacity, may be raised in order to take action-oriented programmes common to all countries of the region. This will also avoid duplication of efforts by individual countries and save fund.
- ***Creation of centres of excellences under joint collaboration:*** Biotechnology is a subject of precision and excellence. Therefore, it needs centres of excellences. But, since for individual nations of

Asia it is difficult to build up such centres, a joint collaborative programme of the region may solve the problem.

Conclusion

Biotechnology has revolutionized the field of biology and genetic engineering is in the pivot of it. Bangladesh is on the threshold of entering into the arena. Joint programme of the countries of the Asian region may help in the accelerated development in the field of biotechnology which has great potentials for mitigating the suffering of the teeming millions of the region.