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# Biological Diversity and Global Food Security

by

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## 1. Introduction

Towards the close of the 20th century we are re-discovering once again the eternal truth - all life on earth is part of one great interdependent system and that economic progress has to remain within the carrying capacity of the earth's ecosystems, if it is to confer lasting benefits. The perpetuation of poverty and the spread of environmental degradation reminds us that development has to be both people-centred and conservation-based. With the global population growing fast towards six billion, we realise that sustainable advances in biological productivity are essential for safeguarding both global food security as well as the security of the livelihoods of millions of rural families in developing countries. Such advances have to take place in the context of diminishing land and fresh water resources for agriculture and expanding biotic and abiotic stresses.

The experience of the last 30 years reveals that given access to a wide range of plant and animal genetic resources, it is possible to keep grain, milk and meat production above population growth levels and in addition, prevent the further denudation of forests for expansion of agriculture. We can neither sustain a global food security system nor face the challenge of climate change and enhanced ultraviolet-B radiation, if we fail to conserve biological diversity and utilize them using both through conventional and frontier technologies. The conservation of biodiversity is thus fundamental to the success of the development process.

## 2. Genetic Erosion

Many experts believe that at present species are being lost throughout the world at a rate which is at least 1000 times the background rate. What we are witnessing is more severe than any that has occurred during the past 65 million years, since the end of the Cretaceous period, when the dinosaurs disappered. Such extinction is occurring at a time when genetic engineering has opened up possibilities for moving genes across sexual barriers and thus generate novel genetic combinations to meet new needs and situations.

We do not even know what we are losing. Wilson (1988) estimated that about 1.4 million species of organisms have been named so far. These include about 750,000 insects, 41,000 vertebrates, and 250,000 plants. The remaining species comprise bacteria, protozoa, algae, fungi and invertebrates. Participants at a Symposium held at the Royal Society, London, in 1990 under the auspices of C.A.B. International concluded that if extensive biosystematic work is undertaken in invertebrates and micro-organisms, the total number of species on our planet may exceed 50 million. Erwin (1988) places the total number of species at 30 million, while Stork (1988) places it at 80 million or more. May (1988) lamented at the fact that there is no area on earth, large or small, where we have a complete census of living organisms. Raven (1990) has therefore pleaded for systematic efforts in the compilation of biological inventories, leading to an encyclopedic treatment of all of the organisms on Earth. A global biological inventory network coupled with a conservation monitoring network is essential to understand the rates of species extinction and genetic erosion.

A systems approach is needed in such studies, since understanding biodiversity involves a study of both the variety and variability among living organisms and the ecological complexes in which they occur. As pointed out by the U.S. Congressional Office of Technology Assessment in 1987, diversity can be defined as the number of different items and their relative frequency. For biological diversity, these items are organised at many different levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity.

Species-rich ecosystems exist primarily in tropical regions; species-poor ones in areas such as the arctic, where conditions for growth are more limiting.

**3. Recent efforts in arresting genetic erosion**

The following are some recent efforts in this direction:

- past and present contributions of farmers in conserving, improving and making available plant and animal genetic resources as part of their farming operations over centuries, in particular those in the centres of origin/diversity;
- activities initiated by the Russian geneticist N.I. Vavilov in the late 1920's for collecting, evaluating, conserving and utilizing genetic resources from the major centres of diversity of crop plants; this effort stimulated similar interest among animal breeders.
- steps initiated by FAO from the late fifties to focus attention on the conservation of PGR, leading ultimately to the establishment of a Global System and a FAO Commission for Plant Genetic Resources in 1983; FAO has also initiated similar efforts in the conservation of animal genetic resources.

- the significance of genetic resources was stressed by the first United Nations Conference on the Human Environment in Stockholm in 1972;
- steps initiated by UNESCO in the seventies for the establishment of Biosphere Reserves, for the conservation of World Heritage Sites and for the preservation of microbial genetic resources;
- the establishment of the International Board for Plant Genetic Resources (IBPGR) by the Consultative Group on International Agricultural Research (CGIAR) in 1974 [in 1991 renamed the International Plant Genetic Resources Institute (IPGRI)];
- the World Commission on Environment and Development (WCED) in its report submitted in 1987 stressed the urgency of conserving global biological diversity for ensuring both food and ecological security;
- the emphasis placed on prevention of genetic erosion in UNEP's Environmental Perspectives to the Year 2000 and Beyond, published in 1987;
- the decision by the CGIAR in 1991 to establish a new International Forestry Research Entity for global forestry research within the CGIAR and the admittance of the International Centre (formerly Council) for Research on Agro-Forestry (ICRAF). These institutes will be concerned with genetic resources of those ecosystems that are relevant for their mandates;
- the recent initiative by the World Bank, the UNDP and UNEP to form a three-year pilot programme, the Global Environment Facility (GEF) supported by a Core Trust Fund together with various co-financing arrangements. One of its four major objectives concerns the protection of biodiversity;

- the report titled "Caring for the Earth" issued by IUCN, WWF and UNEP in October 1991, which calls for a major global effort in protecting biological diversity and promoting its sustainable utilization.
- A global biodiversity strategy prepared in 1992 by the World Resources Institute, The World Conservation Union and the United Nations Environment Programme.

Several other activities of a legislative nature have taken place at the international level. These include a recently concluded revision of the International Union for the Protection of New Varieties (UPOV) Convention and the patenting of plant-related biotechnological inventions. In addition, the Trade-Related Intellectual Property Issues (TRIPS) in the negotiations of the current Uruguay round of the General Agreement on Tariffs and Trade (GATT) also deal with the patenting of products in addition to processes and of living organisms.

At the national level also, several significant developments have taken place. In India, for example, the Indian Council of Agricultural Research has established National Bureaus of Plant, Animal and Fish genetic resources. The World Wide Fund for Nature-India is establishing with the support of the Ministry of Environment and Forests of the Government of India a national conservation monitoring centre.

The three basic principles which should govern action are:

1. Contain and prevent genetic erosion,
2. Use genetic resources effectively and sustainably, and
3. Share the benefits equitably.

If these principles are followed, we can usher in a new paradigm of biodiversity conservation based on the integration of principles of ecological sustainability, economic efficiency and social equity.

**4. Biodiversity and Animal Husbandry**

Unfortunately, efforts in the conservation of animal genetic resources have not been as systematic as in the case of plants. In situ conservation through National Parks and Protected Areas has centred around wild life. It is only in recent years that interest in the conservation of wild relatives and biotypes of domesticated animals has grown. The best form of conservation will be the involvement of local communities in the in situ preservation of germplasm. In vitro preservation of germ cells and embryos is also gaining ground.

There is need for greater efforts in the training of biosystematists and Genetic Resources Managers. Special courses need to be designed to provide background, rationale, scientific objectives and overviews of conservation strategies. The genetic basis and theory for conservation also needs to be taught. There is also need for laboratory exercises for providing experience with sampling and collection strategies, with techniques for assessing genetic variability of isozyme analysis and DNA sequence analysis, with sterile culture and reproduction techniques, and with computer database development and use. An integrated national conservation strategy involving in situ and ex situ and in vitro and in vivo methods needs to be developed for every animal species.

## 5. Global Biodiversity Strategy

The World Resources Institute, IUCN and UNEP (1992) have recently compiled guidelines for action to save, study, and use earth's biotic wealth sustainably and equitably. The strategy includes the following components:

a. Establish a national policy framework for biodiversity conservation,

b. Create an international policy environment that supports national biodiversity conservation,

c. Create conditions and incentives for local biodiversity conservation,

d. Manage biodiversity throughout the human environment,

e. Strengthen protected areas,

f. Conserve species, populations and genetic diversity, and

g. Expand human capacity to conserve biodiversity.

The Inter-Governmental Convention on Biological Diversity currently being negotiated under the auspices of UNEP aims to serve as a key coordinating, catalyzing, and monitoring mechanism for international biodiversity conservation. From the point of view of the developing countries three issues are pivotal.

First, it is not only important to conserve but there is an equally urgent need for utilising genetic diversity for strengthening the livelihoods of the poor.

Secondly, the patenting of living forms will create numerous problems in the free exchange of genetic material and in sharing the economic benefits. The relative roles of

formal and informal innovations in animal and plant breeding will have to be articulated in terms of reward and recognition.

Thirdly, protecting the protected areas is itself becoming a serious problem in many developing countries. Local communities feel that biosphere reserves and national parks often erode their livelihood security rather than strengthen it. There is urgent need for arresting this alienation and for restoring the ancient tradition of involving local people in the management and use of common property resources. Unless the poor and the panda receive concurrent attention, conservation of habitats rich in biological diversity will be a lost cause.

**6. Genetic resources for National Food Security**

Sustainable advances in biological productivity are ecological and economic imperatives in most parts of the world. The conservation, evaluation and sustainable utilisation of plant and animal genetic resources are essential for achieving such advances. Sustainable agriculture has many dimensions such as ecological, economic, technological, social and political. The ultimate goal of sustainable agriculture should be the improvement of the food and nutrition security of a country and the livelihood security of its rural families with due consideration to the carrying capacity of the supporting ecosystems.

The conservation of plant, animal and fish genetic resources should be viewed in an integrated manner in tropical countries, since mixed farming is both a way of life and means to livelihood security in countries like India. A Farming System based conservation programme should be implemented at the ecosystem, species and sub-specific level.

In situ conservation of land races and wild relatives of crop plants by farm women and men has been an important factor in the maintenance of genetic heterogeneity in cultivated plants. Such informal innovation systems have played a pivotal role in the conservation of genotypes with desirable qualities, particularly tolerance or resistance to biotic and abiotic stresses, and have consequently been the backbone of traditional sustainable agriculture systems. It is important that such informal innovation systems are recognised, rewarded and encouraged. Community involvement in the conservation of biological diversity is essential for ensuring that the fruits of thousands of years of natural and human selection are preserved for current and future use.

The participants at a workshop held in Madras in November 1991 recommended that in every country a Genetic Resources Consortium for Sustainable Agriculture be established comprising the following:

a. Non-governmental Conservation Organisations
b. Government organisations such as National Bureaus of Plant, Animal, Fish and Forest genetic resources and
c. Appropriate International Agricultural Research Centres (IARCs) and Gene Banks like the Vavilov Institute of Plant Industry at St Petersburg, the Bari gene bank in Italy, University of Viterbo in Italy, the Nordic gene bank and the Tsukuba gene bank. In India, it was suggested that the N.I. Vavilov Centre of the M.S. Swaminathan Research Foundation at Madras may take the lead in organising such a Consortium.

The Genetic Resources Consortium for Sustainable Agriculture could have the following mission and mandate.

Identify key scientific and socio-economic components of a sustainable crop-livestock integrated production system and assemble specialised gene pools for selecting/breeding crop and animal species and strains adapted to the production system both through conventional and genetic engineering techniques. For this purpose, the consortium should promote the establishement of Genetic Gardens for Sustainable Agriculture to cater to the following needs.

a. Genetic heterogeneity and genetic adaptation to the biotic and abiotic stresses which a particular farming system is subjected to.

b. Provide to the maximum possible extent the nutrient requirements of a high-yield farming system through biological nitrogen fixation, biofertilizers and crop rotations and residues and assemble for this purpose germplasm of green manure crops, *Azolla*, blue green algae and pulse crops suitable for inclusion in the farming system.

c. Accord priority to irrigated and complex, risk-prone and diverse rainfed farming systems as well as to coastal and hill ecosystems.

d. Assemble genotypes suitable for an agro-forestry system of land management, with special emphasis on sylvi-horticultural and sylvi-pastoral systems and

e. Assemble candidate genes for use in recombinant DNA experiments leading to new genetic combinations of interest in imparting the dimension of ecological sustainability to the recommended cropping/farming system.

The Genetic Resources Consortium for Sustainable Agriculture should promote not only in situ and ex situ conservation by local communities and official agencies but should also ensure attention to evaluation, classification, utilisation and monitoring. Bio-indicators

and bio-monitoring techniques should be standardised and popularised among local schools and village communities.

In addition, there is need for undertaking the following tasks.

a. Organisation of awareness generation programmes and educational and media resources centres.
b. Mobilisation of school children in the application of bio-indicators in pollution monitoring work.
c. Research on methods of according recognition to informal innovation by rural women and men.
d. Training of grass-roots level conservation workers in the conservation of plant and animal genetic resources.
e. Development of a political constituency for Genetic Resources through organisation of Dialogues involving scientists and political leaders.
f. Mobilising public opinion for the conservation of economic and ecological key species as well as special genotypes like mangroves, sea grasses and coral reefs.
g. Setting priorities in collection, evaluation and conservation work.

Obviously, priority in conservation should go to the species listed in Red Data books and to life support species and under-utilised plants. Local breeds of farm animals and fishes should also receive priority attention. The different members of the consortium can divide the work among themselves, in accordance with their own mandate, priorities and facilities.

## 7. World Biodiversity Conservation Day

In order to spread public awareness of the fact that loss of every species and ecosystem limits our options for the future in terms of adaptation to new needs and climatic situations, it is suggested that November 24th of each year be commemorated worldwide as "World Biodiversity Conservation Day". November 24 represents the birthday of N.I.Vavilov. This will help to promote public understanding of the urgency of conserving the genetic wealth of our planet.

## 8. Biotechnology and biodiversity

Sustainable development demands the integration of the principles of ecological soundness and of equity with those of economic efficiency in the development of both technology and public policy. The broad group of technologies associated with modern biotechnology offer new opportunities for promoting a better quality of life for all, while living within the carrying capacity of supporting ecosystems, provided proper research priorities and strategies and public policies are followed.

The scientific principles and tools underpinning biotechnology are largely the outcome of research done in universities and public-funded institutions. On the other hand, the conversion of scientific discoveries into economically viable technologies is being done largely in the private sector in industrialized nations. The hard core of modern biotechnology is genetic engineering or recombinant DNA methodology, which enables the creation of novel genetic combinations. Research on novel combinations needs access to a wide range of

genetic material, thereby resulting in a feed-back relationship between biotechnology and biodiversity.

These features of biotechnology have resulted in international debates and dialogues between industrialised and developing countries on matters relating to intellectual property rights and patenting procedures for living organisms on the one hand, and reward and recognition to the informal innovation systems of rural women and men, responsible for the preservation of wide range of intra-specific genetic variability, on the other. The recent adoption of a revised UPOV convention for the protection of new varieties and the patenting of plant related biotechnological inventions, the statement of the Green Industry Biotechnology Platform and the acceptance of the concept of Farmers' Rights in FAO meetings are significant events in the ongoing debate on biotechnology and IPR. The establishement of an International Centre for Genetic Engineering and Biotechnology (ICGEB) by UNIDO is an important milestone in the history of biotechnology development for developing countries.

Biotechnological innovations offer scope for making substantial impacts on crop and animal husbandry, fisheries, forestry, biomass-based energy, bioremediation, health, industry, pollution control and a wide range of human activities having a bearing on sustainable development (Swaminathan, 1991). No wonder many members of the UN family, as well as the World Bank and REgional Development Bank like the Asian, African and Inter-American Development Banks are playing a pivotal role in the development of biotechnological innovations and their widespred dissemination in developing countries. In addition, international scientific bodies like the International Council of Scientific Unions

(ICSU), regional associations like the Commission of the European Communities and private industry are actively involved in various aspects of biotechnology research and development.

The human population is likely to double in about 35 years. More than 10 billion people will have to be fed, clothed and provided with jobs under conditions of shrinking land and water resources for agriculture, expanding biotic and abiotic stresses, increasing genetic erosion and rising cost of fossil fuel energy reserves. Compounding these social and economic problems is the possibility of alterations in climate, rise in sea levels and greater incidence of ultraviolet-B radiation, caused by both unsustainable life styles and the undesirable consequences of some of the current industrial and agricultural technologies.

It is in the above context that the Preparatory Committee for the United Nations Conference on Environment and Development (UNCED) concluded at its Third Session held in Geneva from 12 August to 4 September 1991, that the environmentally sound and safe application of biotechnology is essential for health care and food security, pollution control, higher efficiency of industrial development processes and biodegradation of industrial wastes. The Committee therefore urged the acceleration of current efforts on the development and application of biotechnologies, particularly in developing countries.

How can such a goal be achieved ? Obviously this will call for institutional mechanisms which can ensure that public good and private profit are not mutually antagonistic. The UN principle of "one country one vote" helps to keep all points of view in decision making. The UN principles are the ones which will promote harmony and understanding under conditions of diversity in needs, perceptions, socio-economic conditions, technological capability and biological wealth. How can the power of modern

biotechnologies be used for promoting economic development without damage to the ecological health of our planet and for ensuring that the welfare of the poor is enriched and not eroded by technological progress ?

During the last two decades, the institutional structure represented by the Consultative Group on International Agricultural Research (CGIAR), consponsored by FAO, UNDP and IBRD, has proved to be an effective mechanism for reaching the resource poor farmers as well as for inspiring donor confidence. As a consequence, the annual budget of CGIAR comprising voluntary contributions by bilateral and multilateral donors and philanthropic foundations rose from about US$ 10 million in 1971 to about US$ 350 million in 1991.

Considering the far-reaching implications of biotechnology for human welfare and planet protection, it would be appropriate if a global coalition is formed through a Consultative Group for Biotechnology (CG-Biotech), which can bring together appropriate members of the UN system, bilateral and multilateral donors, foundations, private and public sector industries and governmental and non-governmental organisations. The CG-Biotech could help to mobilize the necessary financial, technical and institutional resources for ensuring that the benefits of "green" or environmentally benign biotechnologies reach the unreached.

The participants of the International Conference on "An agenda of science for environment and development into the 21st century" (ASCEND 21) sponsored by ICSU and held at Vienna from 25-29 November 1991, concluded that unprecedented crises are likely within the lifetime of half of the world's population, arising from such changes as:

- world population doubling to 10 billion in only 35 years;
- migration and urbanization, assuming dramatic proportions, with notable consequences on coastal zones;
- continuing rise of energy consumption exerting increasing pressures on the global ecosystem;
- climate change, sea-level rise and associated impacts on the biosphere;
- irreversible loss of a substantial part of the total number of living species;
- continued reduction and deterioration (including chemical population) of quality of the natural resource base including the exhaustion, degradation, salinization and loss of a major proportion of the world's soils;
- growing and widespread water scarcity.

Biotechnology can be a powerful ally in the development of avoidance and adaptation mechanisms which can prevent or mitigate the adverse impact of such crises.

Hence, no further time should be lost in the development of a suitable institutional framework, which can foster the growth of a global coalition committed to removing the technological component of the wall dividing prosperity and poverty. Innovative and dynamic institutional structures are essential for dealing with the human implications of a dynamic science.

At the same time, it should be emphasised, as was done by participants at the Keystone International Dialogue on Plant Genetic Resources, that the traditional donor-receipient concept is not relevant while dealing with biodiversity and biotechnology. The

GIFTS concepts is more appropriate. This involves all countries giving and/or receiving one or the other of the following

G - Germplasm

I - Information

F - Funds

T - Technology

S - Systems

If seen in this light, differences between developing and industrialised nations on patenting new strains of crops and farm animals can be resolved.

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