Agriculture and Biodiversity

The Earth does not belong to us
we belong to the Earth.
For we do not weave the web of life;
we are merely strands within it.
Whatever we do to the web,
we do it to ourselves

[Chief Seattle, 1835]

I. INTRODUCTION

The commitment of the international community to ensure food and nutrition security to every child, woman and man on our planet has been reiterated at the following international conferences held since 1989:

1989 Bellagio Declaration : Overcoming Hunger in the 1990s
1989 Convention on the Rights of the Child
1990 World Summit for Children, New York
1991 UNICEF/WHO - Conference on Ending Hidden Hunger (Micronutrient Malnutrition)
1992 International Conference on Nutrition (ICN, 1992), Rome
1992 UN Conference on Environment & Development (UNCED, 1992), Rio de Janeiro
1993 World Conference on Human Rights (WCHR, 1993), Vienna
1994 International Conference on Population & Development, Cairo
1995 UN Conference on Social Development, Copenhagen
1995 Fourth World Conference on Women, Beijing.
1996 World Food Summit, Rome
1999 World Science Congress, Budapest
2000 Millennium Summit

Despite the high level political reaffirmation of the need to achieve speedily the goal of “Food for All”, over 800 million human beings suffer now from hunger and malnutrition. Hidden and endemic hunger is now more due to the lack of adequate purchasing power at the household level than due to the lack of availability of food in the market. Poverty as well as factors such as environmental hygiene, sanitation and lack of safe drinking water are becoming major contributors to food insecurity at the level of both community and individual.

Also, the earth's capacity to produce adequate food for the growing population is decreasing. The increase in human population, now mostly confined to the developing countries, enhanced purchasing power and increasing urbanisation will lead to a large demand for food as well as more diversified food products in the coming millennium. It is important that both intensification and diversification of agriculture, particularly in the developing countries is based on sound ecological foundations essential for sustainable advances in crop and animal productivity. The emerging situation has led to the ringing of alarm bells by experts concerning the earth's capacity to produce adequate food to meet growing needs [Lester Brown and Hane (1994); Lester Brown (1995)].

Among the many scientific components contributing to agricultural progress, the breeding of new varieties of plants, animals and micro-organisms has been especially important. The "Green Revolution" was triggered in Asia by high-yielding varieties of wheat and rice and hybrids of maize, sorghum and pearl millet. Success in breeding has, in turn, come from the intelligent use of genetic variability.

However, this very process has led to increasing genetic homogeneity in cultivated varieties and hybrids. Genetic homogeneity enhances genetic vulnerability to biotic and abiotic stresses, necessitating the increased use of pesticides. Indiscriminate use of chemical pesticides and mineral fertilizers will harm the soil, water, flora and fauna. In addition, it leads to new health hazards among the human population including the suppression of natural processes of immunity.

Genetic variability provides the feedstock for plant and animal breeding and genetic engineering enterprises. While, on the one hand, human capacity to produce novel genetic combinations through recombinant DNA technology is increasing, the rate of loss of genes, species and habitats, rich in biodiversity, is also increasing (Global Biodiversity Assessment 1995).

The Convention on Biological Diversity (CBD) adopted at the UN Conference on Environment and Development (UNCED) at Rio de Janeiro in June 1992, is a clear index of the concern and commitment on the part of the international community for the conservation and sustainable and equitable utilisation of biodiversity. Biodiversity occurring in plants and, animals is now referred to as 'agrobiodiversity'.

The future of global food security depends on the success of our efforts in the conservation and enhancement of agrobiodiversity. The technical conference convened by the FAO in Leipzig, Germany, in June 1996, to consider issues relating to the conservation of genetic resources has urged all nations to implement a global plan of action for the conservation and sustainable utilisation of plant genetic resources for food and agriculture (FAO, 1996).

Genetic engineering offers new opportunities for the development of effective Integrated Pest Management (IPM) and Integrated Nutrient Supply (INS) systems. However, the loss of every gene and species will limit our options for the future for genetic recombination.

II. AGROBIODIVERSITY: CULTURES, COMPONENTS AND CONSERVATION

From time immemorial, pastoralists and farmers have created a large number of intra-specific and inter-specific variants. Natural selection in the wild added more variants compared to those domesticated. These put together constituted the basis for food production through many centuries. This diversity is still being cultivated, tested, maintained, improved, stored as well as exchanged.

Agricultural scientists depend on intra-specific variation. It is the interaction of each variety and breed with its ecological and socio-cultural setting that defines its ability to contribute to the overall goal of sustainable food production.

Traditional agriculture also ensured the survival of certain non-agricultural species due to management techniques as well as specialised adaptational requirements. Perennial maize, Zea diploperennis, is maintained even today because of slash and burn cultivation. Use of fire by pastoralists enabled the persistence of several grass species. Agriculture in marginal areas always supported diversity with sustained production.

The 1960s witnessed the emergence of intensive agriculture aimed to maximise production. Use of a single or a few improved varieties over large areas, use of chemical inputs and the lack of environmental as well as ecological concerns on the part of agriculturists led to a stage where production was maximised but at the cost of natural resources. Though this was a necessity at that time to feed the billions, time has come to reconcile some of the factors that can be reversed.

As the Global Biodiversity Assessment puts it, “ overwhelming evidence leads to the conclusion that modern commercial agriculture has had a direct negative impact on biodiversity at all levels: ecosystem, species and genetic, and on both natural and domesticated diversity". What is now needed is a careful blend of modern agricultural techniques with traditional variants to assure a sustained food production for the decades to come.

II.1. Conserving Traditional Knowledge and Wisdom

It is now widely acknowledged that tribal and rural women and men have not only conserved biodiversity of great economic, cultural and social value, but have also enhanced them through selection and value addition through knowledge and information. Most of the domesticated plants and animals of today were identified centuries ago. Articles 8 (j), 10 (c) and (d) and 15 (7) of the CBD all recognise the role of indigenous and local communities in the conservation and improvement of genetic resources. Article 8(j) is particularly relevant for agricultural biological diversity because of the dominant role of farmers in the generation of intra-specific variability in crops and breeds and in the accumulation of specialised knowledge associated with these activities. Since the 1980s FAO and the Commission on Genetic Resources for Food and Agriculture have served as a forum to promote the concept of "farmers' rights". Several countries, including India have incorporated this provision in their national laws. Article 8, in general, dealing with *in-situ* conservation provided a framework for several countries like Sri Lanka, Brazil and Germany to have conservation activities of relevance to agrobiodiversity in protected areas.

An extremely urgent task is the preservation and revitalisation of this priceless heritage. In this connection, it will be appropriate to recall the verse of T. S. Eliot:

> "*Where is the wisdom that we have lost in knowledge,*
> *Where is the knowledge we have lost in information*".

It is thus appropriate to conserve not only agrobiodiversity, but also the traditions which led to the enrichment of our knowledge on valuable genetic material.

Agrobiodiversity

Agrobiodiversity refers primarily to genetic variability in cultivated plants and domesticated animals together with their progenitors and closely related wild species growing and evolving under natural conditions. Plants and animals gathered and hunted from the wild are also included in this term (Thrupp, 1997).

Besides contributing directly to national economies, agrobiodiversity also provides employment and livelihood to a large section of the economically active population. On a global scale, it is noteworthy that nearly 2.5 billion people rely heavily on wild and traditionally cultivated plant species to meet their daily needs. Tribal women and men also serve as repositories of knowledge systems on the utilization of these plants.

Sustainable Grain Production for Food Security

There is increasing concern about the earth's capacity to produce adequate food for the growing population. The increase in human population with enhanced purchasing power leading to greater capacity to buy food and increasing urbanisation will lead to a higher growth rate in demand for food as well as for more diversified food products in the coming millenium. Thus, on one hand, there will be a need for intensification and diversification of agriculture, particularly in the developing countries. Changing food habits, especially the increasing preference for meat will add to the burden of more grain production, since 100 kgs of plant protein is equivalent to 12 kgs of animal protein. This will necessitate more grain production across the world.

The Living Planet Report 1998, produced by the WWF, predicts that the global grain production can be maintained and distributed evenly at the present rate of production of approximately 2 billion tonnes per year to supply about 330 kgs per person per year. However, these figures are based on current world population and on the current patterns of consumption.

Source: Living Planet Report, WWF - International, 1998.

While informal crop improvement by farm families is largely based on selection of superior types, scientific plant breeding draws heavily upon planned hybridisation among land races, locally adapted cultivars and wild relatives of crop plants. Such planned pyramiding of genes results in superior varieties combining high productivity with better quality traits, genetic resistance to diseases and pests, and greater tolerance to stress environments, including drought, salinity, water logging and extreme temperature regimes.

II.2. Identifying the Components of Agrobiodiversity

Ecosystems and habitats containing high diversity: Certain ecosystems are considered to be high in agrobiodiversity because of the nature of the environment in which the species and communities have to exist, adopt and survive. Marginal environments like the coastal areas (with high salinity) and areas with deficient rainfall tend to have more diversity. Special emphasis on conservation of agrobiodiversity in such areas would enhance the utilitarian value of the species (and the gene[s] they contain).

Ecosystems and habitats containing wilderness: The concept of wilderness is non-existent in agricultural ecosystems. However, marginal areas tend to maintain wilderness and because of this such habitats support additional adaptational provisions facilitating the continued existence of traditional cultivars. This kind of wilderness also support enhanced evolution since the selection pressures are more.

Ecosystems and habitats that are representative : Agrobiodiversity in protected areas and certain regions like the Andean-eco region and the north-eastern Himalayan biosphere represent unique germplasm. Prioritisation of conservation must begin with such areas.

Ecosystems and habitats associated with key evolutionary or other biological processes : Though the association with key evolutionary processes is a problematic concept, little is known on the mechanisms of long-term evolution to enable singling out particular habitats and/or species. However, one specific example where a wild rice that evolved with the mangrove habitat, *Porteresia coarctata* Tateoka, which has the potential to transform rice cultivation in coastal areas stand out - emphasising the need to look at conservation of such habitats and ecosystems which support key biological adaptations (Balakrishna, 1999).

II.3. Ecosystem Approach to Conservation of Agrobiodiversity

The ecosystem approach is based on the application of appropriate scientific methodologies focussed on levels of biological organisation which encompass the essential processes and interactions amongst organisms and their environment. The ecosystem approach recognises that humans are an integral component of the ecosystem (Anonymous, 1998).

Agro-ecosystems comprise a special category where people purposely selected crop plants and livestock animals to replace the native flora and fauna. These systems vary a great deal depending on the intensity of human intervention. Shifting cultivation, nomadic pastoralism, savannah mixed farming, rotational fallows and traditional home gardens involve low intensity of human intervention. Improved pasture, mixed farming, multiple cropping and traditional horticulture involve a greater degree of human management. High-intensity management is characteristic of intensive cereal cropping and cereal-based farming systems, intensive livestock production, orchards and plantations. Increasing human intervention often

Principles of Ecosystem Approach to Conservation

- Management objectives are a matter of societal choice
- Management should be decentralised to the lowest appropriate level
- Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems
- Recognising the potential gains from management there is a need to understand the ecosystem in an economic context
- A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning
- Ecosystems must be managed within the limits of their functioning
- The ecosystem approach should be undertaken at the appropriate scale
- Recognising the varying temporal scales and lag effects which characterise ecosystem processes, objectives for ecosystem management should be set for the long term
- Management must recognise that change is inevitable
- The ecosystem approach should seek the appropriate balance between conservation and use of biological diversity
- The ecosystem approach must consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices
- The ecosystems approach should involve all relevant sectors of society and scientific disciplines

Source: Report of the Workshop on the Ecosystem Approach, Malawi. 1998.

leads to a reduction in the diversity of plant and vertebrate animal species. Continued harvesting and the unsustainable practices of plant, soil and pest management tend to lower the diversity of associated plants, invertebrates and microbes. Decreases in diversity of plant species may contribute to increased pest and disease problems.

Modern intensive agriculture utilises a strikingly narrow range of crop species and fewer crop varieties that have been bred for higher yield, including better response to inorganic fertilizers and incorporating built-in genetic resistance to selected diseases and pests. An ecosystem approach can be used in dealing with these issues. Both generic as well as ecosystem specific recommenda-tions flow from such analyses.

As in the case of biodiversity as a whole, these issues have to be dealt with at the following three levels (Anonymous 1996).

- The community (Habitat)
- The species
- The organism (genotype) / the Gene

The Community

Natural communities represent the highest level of complexity with their diversity of species, individuals and genes in dynamic interaction, enhanced by natural and human selection in diverse environments. The eight centers of origin of crop plants proposed by N.I.Vavilov provide excellent examples of dynamic interaction and evolution among communities. Such areas include “hot spot” locations for pests and diseases such as the Toluca valley in Mexico, which constituted an ideal location for screening potato germplasm for resistance to biotypes of *Phytophthora infestans.*

The Species

The species occupies a pivotal place in conservation programmes. According to the Global Biodiversity Assessment (GBA) report, about 1.9 million species have been described so far. The GBA also estimates that about 13-14 million species may exist, if we are able to identify and describe all invertebrates and micro-organisms. Two categories of species call for special attention. Domesticated species come under the first category. These are the ones which either directly or indirectly sustain humankind. Their wild relatives constitute valuable breeding material. There is extensive intra-specific variability in many of the domesticated species due to variability in soil, hydrological status, micro-climate and human selection.

The second category consists of species that are endangered in their habitats (Red Data Book Species). Their preservation has become an issue of great urgency, since many of them may possess genes of inestimable value in agriculture, industry and medicine.

The Organism (Genotype) and/ or the Gene

The critical importance of individual genotypes and genes in plant and animal improvement is well known. Several improved rice varieties get their resistance to two of Asia’s four main rice diseases from a single sample of wild rice, *Oryza nivara*. These varieties are now grown on more than 30 million hectares in Asia and have helped to double Indonesia’s rice production.

Similarly, wild cotton, *Gossypium tomentosum,* has provided a strain that does not produce the leaf nectar that attracts the insects, thus reducing the need for pesticides.

Wild genes, like wild species, are threatened both by habitat loss and loss of the on-farm conservation traditions of rural and tribal families.

With advances in modern biotechnology, the identification, isolation and transfer of gene(s) from one species to another are possible. Conservation of specific genotypes, after a detailed character-based finger printing will help to accelerate the pace of plant breeding. This approach will be valuable, particularly for the incorporation of genes for tolerance to abiotic stresses.

II.4. Methods to Conserve Agrobiodiversity

While dealing with genetic conservation methods, it is important to distinguish the roles of *in-situ* and *ex-situ* conservation. *In-situ* conservation helps not only to preserve genetic variability, but also its enrichment through mutation, recombination and selection. Thus, it involves both conservation and continued evolution. In contrast, *ex-situ* conservation is more appropriately defined as preservation. Hence, it would be useful to refer to *in-situ* methods as conservation and *ex-situ* methods as preservation. An integrated conservation strategy will involve both *in-situ* and *ex-situ* methods as well as *in-vivo* and *in-vitro* techniques.

An important feature of many plant communities is their resilience and ability to resume successional processes even after release from long-term disturbances such as grazing that may have been intense for decades. Under conditions of scarcity of financial and technical resources, a rational, scientifically based decision on priorities in conservation would have to rest on an assessment of the importance of the community, its current health and its likely resistance to further change. (Frankel, Brown and Burdon, 1995).

II.4.1. Ex-situ Conservation

Ex-situ conservation is an important and tested practice to support conservation. It primarily refers to preservation of genetic resources. While in *ex-situ* conservation evolution is largely stopped due to removal of material from its original habitat, *in-situ* conservation allows evolution to occur since the material are allowed to breed and recombine. Largely *ex-situ* preservation is carried out through gene banks.

Types of Genebanks

- An institutional genebank is set up to conserve only the germplasm which is used in the research programmes in its host institute.

- A national genebank is set up as a national plant genetic resource centre, maintaining many different germplasm samples of current and potential interest to people working in plant research nationally. Commonly, it contains germplasm which has been collected nationally. Also, it may be closely associated with a research programme or undertake its own research. A national genebank can be a collaborative venture between national institutes, or under the management of one institute which collaborates with other national institutes.

- A regional genebank is set up as a collaborative venture between a number of countries in the same geographical region to conserve the germplasm from that region and to support plant research.

- An International Agricultural Research Center collection is found in all the centers of the Consultative Group on International Agricultural Research (CGIAR) with a mandate for particular crops. Much of the germplasm is collected world-wide with international collaboration, and is conserved for the benefit of plant genetic resources activities world-wide.

Types of Collections

- A base collection comprises a set of genetically different accessions of a given genepool conserved for the long term, ideally under long-term storage conditions. The international base collection of a genepool can be regarded as the sum total of all genetically different accessions conserved *ex-situ* in genebanks around the world. Base collections are not normally used as a routine distribution source.

- An active collection is a collection of germplasm for regeneration, multiplication, distribution, characterisation and evaluation. Ideally, germplasm in the active collection should be maintained in sufficient quantity to be available on request. Active collection germplasm is commonly duplicated in a base collection and is often stored under medium to long-term storage.

- A field collection or field genebank is a collection of living plants (eg fruit trees, glasshouse crops and perennial field crops). Germplasm which is difficult to maintain as seed can be kept in field collections.

- An *in-vitro* collection is a collection of germplasm kept as plant tissue. In some cases, the tissue is stored at very low temperatures such as under liquid nitrogen (cryopreservation).

A core collection attempts to store a large proportion of the genetic variation of a species within a manageable number of samples. Core collections are a mechanism to improve the accessibility and increase the use of collections. They are not a substitute for base and active collections (IPGRI, 1993).

Genebanks and Accessions in Ex Situ Collections, by Region (IPGRI 1993)

Region	Accessions		Genebanks	
	Number	%	No.	%
Africa	353,523	6	124	10
Latin America & the Caribbean	642,405	12	227	17
North America	762,061	14	101	8
Asia	1,533,979	28	293	22
Europe	1,934,574	35	496	38
Near East	327,963	6	67	5
Total	**5,554,505**	**100**	**1,308**	**100**

With the increased threat to genetic erosion, voiced by Harlan and Martini in the 1930s, international initiatives began in the 1940s, to collect and preserve crop plants under controlled environmental conditions. Such repositories, called gene banks, today form the important holdings of over 6 million accessions, being held in more than 1300 gene banks all over the world.

According to latest estimates 40% of the accessions are cereals, 15% are food legumes and 10% each of vegetables, roots and tubers, fruits and forages.

Article 9 of CBD dealing with *ex-situ* conservation, emphasises the need for countries to support and enhance capacities of *ex-situ* conservation. But major steps need to be taken to strengthen such conservation efforts. These include:

- More than 50% of available collections lack appropriate passport data and hence are of little use. There must be appropriate efforts to fill the gaps of information

- Facilities for cheaper storage need to be developed

- The use of available collections must be encouraged
- Several *ex-situ* collections need to be segregated to assess their viability
- Policy measures on exchange and use of *ex-situ* collections need to be strengthened (in light of the patenting regimes over-shadowing their use).

Even though criticised for its biological status, *ex-situ* preservation is the most suitable way to preserve agrobiodiversity.

Repatriation of the IRRI collection of over 7000 varieties back to India when the "Assam rice collection" was lost, the Seeds of Hope Programme in Rwanda and the LAMP project in Latin America are examples where *ex-situ* collections can help rejuvenate crop diversity when such diversity is lost.

Issues relating to access and benefit sharing for ex-situ collection, especially those in CGIAR centers are points of discussion both with CBD and IUPGRFA processes. With the IUPGRFA taking final shape for implementation let us hope that these issues would be resolved.

II.4.2. In-situ Conservation and Traditional Agriculture

Traditional agriculture has always been the dynamic interface between cultivated and wild species. It is based on cycles of careful selection and further introgression, over a period of time, suited appropriately for local environmental conditions. Such conservation efforts that is based on farm is called *in-situ* conservation. To mention the most important contribution of on farm conservation, it has been the diversity that it supports. This also has a strong undercurrent of traditional agricultural practices, knowledge systems and innovations.

Traditional farming have thus far contributed immensely to improve organised and commercial agriculture. Be it breaking the yield barrier or the resistance incorporation against pests and diseases, traditional cultivars have been of great use. But, in general, traditional cultivars do not yield well compared to modern varieties or high yielding varieties (HYVs). This has led to a lot of pressure on the farming communities in many parts of the world to discard traditional varieties and switch over to modern varieties. The primary factor for this transition has been that of increased yield per hectare and quick crop.

Such pressures on the farmers can be also attributed to policy considerations of different governments. These policies include those of giving subsidies for growing HYVs, use of chemical fertilizers to maximise the yield and so on. CBD actively envisages a shift in such policies and encourages governments to adopt changes to let farmers continue traditional farming. While it is easy to propose the change it may be difficult to put it into practice owing to the increasing demand for more food. Here, it may be useful to consider the fact that transition from modern agriculture to sustainable agriculture need not be sudden and whole but may be slow and progressive. To give an example, in countries like the Philippines there has been proven success with influencing farmers against the wide use of pesticides and instead towards the use of natural enemies of insect pests. Such practices coupled with transparent answers will probably be the best way to achieve the transition.

Article 2 of the CBD takes the term “sustainable use” to mean “the use of components of biological diversity in a way and at a rate that does not lead to long term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations”. In setting out its principles that guide the implementation of this objective, Article 10 of the Convention provides five central elements that need elaboration here. These are: the integration of considerations of biological resources into national decision making; adoption of measures that avoid or minimise adverse impacts on biological diversity; the protection and encouragement of customary uses of biological resources; support to local communities to implement remedial action in degraded areas where biological diversity has been reduced and encouraging cooperation between public and private sector in promoting the sustainable use of biological resources.

Thus there is a clear indication of the interests of the Parties to the CBD in implementing the interests of the CBD. But what is required is more consolidation of approaches and collation of information on successes and failures. The Conference of Parties (CoP) to the CBD have categorically stated their immediate wish to consider actions relating to the conservation of agrobiodiversity. The following considerations may be helpful in helping both CBD and CoP in their efforts

II.5. Prioritising in Conservation

Global priority setting efforts are driven by several considerations. First, biodiversity is unevenly distributed, with some nations having more diversity than others, just as some ecosystems have more species than others. Biodiversity is useful not only for the local community but to the world at large when it comes to its use in agriculture, pharmaceuticals, human health and environment. Conservation of such resources require both national and international initiatives especially in terms of finances, expertise and information exchange besides prospecting.

But, with biodiversity occurring at all levels and present everywhere, there is a need to prioritise the areas/species to be conserved mainly because of a lack of finances and trained manpower. Hence there is a need to prioritise our initiatives with respect to biodiversity conservation. Taking agrobiodiversity into consideration, the need to conserve becomes more specific as we add value to the diversity for a specific purpose i.e. their use in improving global agriculture. For this to succeed there will be a necessity to prioritise conservation efforts on a regional level for global use. The principles for prioritising conservation include:

a) Linking priorities with clear objectives and goals
b) Laying down local, regional, national and international priorities
c) Evaluating the priorities
d) Understanding the needs and inputs of local communities and stake holders.

A crop like Teff grown widely in Ethiopia may not be important in all countries, but it is a key cereal in Ethiopia. Similarly, crops such as Chenopodium, Amaranths and Fagopyrum were in the past extremely important in the diet of the people in the mountain ecosystems such as the Himalayas. But these have tended to be replaced by wheat and rice in recent decades. A major reason for such a shift is the low yield potential of the crops grown earlier. Just as the introduction of the Norin dwarfing genes in wheat and Dee-gee Woo gen dwarfing gene in rice helped to raise the yield ceiling in wheat and rice, there is a need for launching a search for new genes for improving the yield potential of neglected and under-utilised plants.

On the basis of this analysis, there is a need to accord priority attention to the following :

a) Saving endangered habitats, species and land races rich in agrobiodiversity.
b) Revival and revitalisation of the *in-situ* and *on-farm* conservation traditions of indigenous communities.
c) Supporting emergency conservation action in countries and regions affected by civil strife, ethnic conflicts or social disintegration.
d) Capacity building for launching integrated agrobiodiversity conserva-tion strategies involving appropriate combinations of *in-situ* and *ex-situ* measures.
e) Training biosystematics and conserva-tion professionals.
f) Helping nations to implement appropriate components of the Leipzig Plan of Action and to develop and implement a National Agrobiodiversity Programme for Sustainable Food and Livelihood Security.

Conserving plant genetic resources: what should we preserve?

It is hard to predict what will be the future requirements of people with respect to plant genetic resources. The purpose of establishing the ex-situ collections, that costs millions of dollars every year, is to ensure that we have a pool to choose from for tomorrow's needs of plant breeding. However, there is a need for us to take a practical approach rather than an idealistic approach to address the issue of what is to be conserved. The following may serve as guiding principle.

Resources can be grouped as:

1. Varieties and breeds of current agricultural value which differ genetically from each other;
2. Landraces, breeds and ecotypes that are well adapted to specific regions and, although often they are less productive than the previous group, many provide genes conferring quality, adaptation and hardiness;
3. Wild parents of domesticated species, whose function as a gene pool for agriculture is now well established;
4. Genetic material obtained for research purposes (haploid, aneuploids, translocated and transgenic material, recombinant inbred lines) in order to provide research with the appropriate means of responding fast and efficiently to future agricultural needs.

However, it will be unrealistic to conserve all of the above. Frankel (1984) suggested the need to have a core collection that is representative of the diversity.

(Modified after Lefort and Chauvet, 1996)

II.6. Priorities for Action

(a) Promote research on traditional farming systems. There is a need to understand the dynamics and applications of traditional farming systems with a view to understanding their prudence in natural resource management, breeding for specific qualitative and quantitative characters and selection methods, besides learning about their integrated approaches to apportion their time, resources and energy.

(b) Understand reasons for the disappearance of such traditional farming systems: the reasons can be socio-economic or ecological. For example, the policies of government to encourage cropping of high yielding varieties, market forces, increasing influence of novel crop varieties and others may cause disappearance of traditional cultivation. Other reasons can be loss or fragmentation of habitats, increasing or decreasing availability of resources like water may necessitate local communities to abandon traditional cropping systems. Understanding reasons for these may help develop mitigating strategies.

(c) Enhance scientific understanding of the impact of conservation methods on large-scale commercial farms, including economic and ecological benefits. Concepts like Low-Input Sustainable Agriculture (LISA) are still lacking convincing evidence to support more research into influencing large-scale farmers to think about ecological benefits. Economics of traditional crop systems are also poorly understood. This situation needs more understanding, on a scientific basis, the impact of conservation methods on large-scale farming versus traditional farming.

(d) Promote, the concept of increasing the diversity of food basket. Nutritional requirements of local communities largely depend upon diversity of the food they consume. Promotion of *in-situ* conservation of diverse crops may help increase the diversity of their food baskets.

Management of *in-situ* conservation and encouraging such methods of conservation can be based on the following points:

(a) Integrating biodiversity impact assessment as a part of environmental impact assessment (EIA) procedures

(b) Encouraging traditional agriculture by providing suitable incentives

(c) Enhancing public and private sector cooperation

(d) Returning some nationalised resource systems, such as forests and wildlife to community based tenure rights

(e) Supporting establishment of a Farmers' Rights regime

(f) Developing equitable and fair benefit sharing methods to encourage use of traditional resources and increase participation of local communities in such efforts.

II.6.1. One Example of Prioritisation at Ecosystem Level: Arid and Semi-arid Ecosystem

Conversion of semi-arid or arid lands to agriculture (usually by providing irrigation) may increase local net primary productivity (the amount of plant material produced by photosynthesis per unit area, per unit time), but the effects on biodiversity are severe. When native plant communities are displaced, it is difficult to restore them even after cultivation is abandoned.

Biological activity plays an important role in moderating the harsh environment of arid regions and drastic alterations in biodiversity may lead to the formation of alternative stable states of the system with stronger control by abiotic forces. Human alterations of biodiversity in desert regions have been mediated chiefly by the management of semi-arid and arid regions for livestock use and by the introduction of non-native plants.

Biodiversity which is moderately high in semi-arid regions declines with the increase in aridity beyond a critical level, more diversity of certain taxa adapted to these situations notwithstanding. Farming is usually highly diversified in this ecological region, both in terms of the number of crops and varieties within crops. Success in crop production depends largely on the right choice of crops and their varieties, keeping in view the soil moisture availability. Farmers, engaged in crop production and orchard keeping, also raise livestock such as cattle, buffalo, goat, sheep, pigs and camel, to supplement their income.

Under situations marked by high temperature and low humidity, soils are highly deficient in organic matter and nitrogen. Green manuring with leguminous crops and adopting suitable crop rotations and mixed farming are the key to maintaining remunerative yield levels.

Application of irrigation for crop production may lead to the development of salinity problems because of poor management and inadequate drainage or use of poor quality water. Locally adapted farmers' traditional varieties are often highly tolerant to saline and drought conditions.

Growing of multipurpose shrubs and trees is common and many of these are life saving species during years of drought. Range lands and community managed pastures are a common feature. Grasses and forage species, grown traditionally, are highly drought tolerant.

Arid and semi-arid regions are a reservoir of genes and co-adapted gene complexes that will be immensely useful for the development of new crops and superior varieties of existing crops, better suited to agriculture in marginal and stress environments.

A large number of cultivated plants, including cereals, pulses, fibre crops, oilseeds, vegetables, fruit plants, forage species and multipurpose shrubs/trees, have areas of their diversity in semi-arid areas of the world. Some prominent among them are sorghum, pearl millet, durum wheat, barley, pigeon pea, groundnut, chickpea, moth bean, cluster bean, green gram, black gram, horse gram, peas, flax, castor bean, tree cotton, upland cotton, sesame, cucumber, bottle gourd, melon, several forage grasses, alfalfa, pomegranate, date palm, mulberrry, jujube and numerous species of Salvadora, Acacia, Eucalyptus, Casuarina and Atriplex.

II.6.2. Prioritisation at Use Level: Exploring and Promoting the Use of Under-utilized Crops

At the global level, most of the world's major staple crops are served by substantial crop improvement programmes. International crop improvement efforts have delivered spectacular production increases, especially for crops such as wheat, maize and rice, at least in areas of relatively high potential. These crops received particular attention during the "Green Revolution" and continue to be the focus of major improvement efforts in both developed and developing countries. The private sector also tends to focus on the crops that cover either large acreages (maize, soybean, wheat, rice) or those that generate high per acre income (tomatoes, sugar beet etc.) (FAO, 1996b).

There is, though, a need for public sector funding of improvement programmes for other staple crops (eg. millets, cassava, sweet potato, plantains) where the commercial incentive is much less due to the lack of 'effective demand' by either producers and/or consumers. Far less resources are therefore invested in these food crops, which are sometimes described as "orphan crops". These crops however include many food and export crops which are important to many developing countries. Limited research and very few breeding programmes exist for many under-utilized species, despite the fact that they contribute to healthy and balanced diets, and offer farmers opportunities for agricultural diversification and additional income. Many countries have stressed the need for increased breeding and research on under-utilized species, and for domesticating many wild and semi-domesticated food plants (FAO, 1996b).

There is also a potential for the development and marketing of new crops to contribute to the diversification of agricultural systems. This might also include the development of energy crops, for instance to deal with the growing fuel-wood shortages in many developing countries. The Global Plan of Action, through its activity 12, promotes the development and commercial application of under-utilized crops and species. The activity aims to: (a) identify under-used species; (b) develop sustainable management practices; (c) develop post-harvest and marketing methods; and (d) promote policies for the development and use of under-utilized species. Additionally, through activity 14, (Developing new markets for local varieties and diversity-rich products) the Plan aims to stimulate demand for diverse products derived from landraces and farmers' varieties, including through the development of niche markets, labeling and niche variety registration schemes to permit and promote the production and commercialisation of local varieties (FAO, 1996a).

III. CROSS-SECTORAL APPROACHES FOR AGROBIODIVERSITY CONSERVATION

III.1. Agriculture and Forestry

Agriculture and forestry are often discussed as incompatible partners. The influences of pastoralists and farmers involved in shifting cultivation have contributed, atleast to some extent, to the destruction of forests. However, by the influence of natural balances of forest regeneration and revitalisation of soil fertility, forests and agriculture co-existed. Agro-forestry is not new in several parts of the world. Agro-forestry is seen as a good management of useful species, which allow conservation of a good part of animal and plant diversity. Several studies have shown that biodiversity levels between natural forests, several agro-forests and monospecific plantations show the high potential of the original type of resource management system in conserving forest biodiversity in agricultural lands.

Agriculture is seen as a useful buffer zone management technique outside protected areas.

Conservation outside Protected Areas: Traditional agro-ecosystems

Conservation of biodiversity often subscribes to the creation of protected areas. Such protected areas are of different categories and may contain a varying range of undisturbed ecosystems. However, the nature and dynamics of protected areas (PAs) need different management practices.

The emerging problem with respect to PAs has been the issue of increasing pressure to delimit the areas. The opportunities to conserve biodiversity therefore looks for new approaches that are both complementary and supplementary to PAs. Conservation outside PAs is seen as an alternative. Two specific examples are given below pertaining to roles of traditional agro-ecosystems to help achieve the aims of PAs and thus avoiding creating more PAs.

Contd., next page

[1] Agro- pastoralism and biodiversity conservation in East Africa: The case of Maasailand , Tanzania (Mwalyosi 1995)

The Maasai community lives in the arid and semi-arid areas of East Africa. These areas are unsuitable for rain-fed agriculture. Communities, over a long period of time, switched from pastoralism to agro-pastoralism due to changing land use patterns and resource availability. The traditional and sustainable Maasai system of rangeland resource management was supplanted by new power structures in the 1970s. This resulted in a new pattern of settlement and land use that is difficult to reconcile for the communities and their traditional life styles, as well as, natural resource management practices.

A study conducted on changing land use patterns recommended that traditional pastoral communities like those of the Maasai should be allocated specific areas for rotational grazing to allow livestock raising. Correction of inadequacies of existing land tenure policy to allow for community property ownership in Tanzania was recommended. The study concluded that for these traditional systems to work, there is a need for on-farm research into pastoral range/livestock production systems, as well as, rangelands research and extension services. The study also suggested participatory approaches to be of great use and would ensure effective management of rangelands and conserving agrobiodiversity.

[2] The Indonesian agro-forest model: Indigenous agro-forests (Michon and Foresta 1995)

Rural life in Indonesia is still largely dependant on forests, although resource use by local populations tend to be exploitative. As native populations' traditional access to natural forests becomes limited, forest resources are often managed through an agro-forestry reconstructon of the ecosystem: the agro-forest. The tumpangsari and pekarangan agro-forestry systems encouraged and were based on mixed cropping and were not homegardens. These systems are close to natural forests in their structure, dynamics and composition. The Sumatra Kalimantan agro-forests achieve better management of forest resources together with conservation of biodiversity. This is possible by bringing in agriculture in forest areas and helping both agriculture and forests to exist together. However, agro-forestry can be viable only if supported by suitable social, institutional and management policies.

III.2 Agriculture and Fisheries

Except for very few aquatic species, like the common carp, farming aquatic species is thousands of years behind crop and livestock farming. For long, it was felt that aquaculture need to be recognised as agriculture in that it uses land, water and nutrient resources as in the case of food crops. Aquaculture is considered in many parts of the world as a good source to low-cost food supplement, where farmers need to choose alternatives. Therefore, aquaculture can be considered as a part of integrated livestock and crop farming systems.

Aquaculture is one of the most important and rapidly growing food production sectors and is an important source of animal protein and income. Approximately 83% of production comes from the developing countries and the low-income food deficit countries account for 74% of the total aquaculture production (Bartley, 1997).

The integration of aquaculture into conventional agricultural systems is common in Asia. Un-consumed organic matter is recycled to increase production from fish ponds and subsequently the organic residues from ponds can be used as fertilizer for farmers' crops. In several developing countries, crop rotation also involves culturing vegetables and fruits in fallow fish ponds. Rice fields that are flooded support a variety of fish species, increasing the productivity. Integrated and intensive farming systems are seen as a means to increase production, reduce risk of food shortages and minimise pollution.

Thus agriculture and aquaculture are increasingly seen as activities that are mutually reinforcing each other, when considering food security issues.

III.3. Agriculture and Health

Modern requirements of organic foods and pharmaceutical products necessitates a sound knowledge of agriculture as a science-based technology. Organic foods are today finding a larger place in consumer's choice. Modern agricultural interventions like hydroponics are finding a greater demand not only due to the fact that they are safe and better but also because such agricultural practices also needs less space and can be highly intensive without having any effect on biodiversity, soil and water.

The growing need for organised cultivation of medicinal and aromatic plants for bioprospecting and the pharmaceutical industry requires an enormous understanding of the agronomic characteristics of such species. In addition, the harvesting, storage, and use of many of the medicinal plants needs inputs from several facets of agriculture like IPM, nutrient dynamics of soil etc. since the qualitative and quantitative characteristics of the medicinal and aromatic principles largely depend on the agri-management.

III.4. Agrobiodiversity Assessment and Valuation using GIS Tools and Agro-Ecological Zoning

Agro-ecological zoning (AEZ) provides a framework integrating assessment, planning, management and monitoring of land resources. The AEZ concept involves a simplified representation of land with individual components of topography, landform, soil, climate, vegetation, land use etc.

Antoine and Koohafkhan (1997), explain the zoning process which involves a subdivision of the land on the basis of physical, biological and prevailing socio-economic condition. These sub-divisions are called Resource Management Divisions (RMDs).

Such developments in databases and analytical tools in various land resource and use applications would have a strong implication on agriculture, especially in biosphere reserves where land use patterns have a strong relationship to biodiversity occurring within them. Changing land use patterns in areas - both under agriculture and those under non-agricultural practice - can be better assessed with respect to agro-biodiversity using the Resource Management Divisions (RMDs).

III.5. Agriculture and Land Use Policies

Land tenures: Agriculture has always been an activity that weaves itself with several social and cultural practices and norms. Such norms and social rules impact the decisions of farmers in practising agriculture.

One such important norms has been that of tenure rights in cultivated areas. Insecure land tenure rights affects the very basis of agriculture in most of the developing countries, where land holdings are becoming smaller and smaller. Such insecurities result in reduced farmer incentives to plan for long term productivity and management. Though improving tenure may not directly affect biodiversity, it would have indirect influences on protecting the benefits that a farmer can accrue from the diversity.

Insecurity of land tenure also influences intensifying agricultural productivity. This results in growth that is extensive rather than intensive (Anonymous 1996). Activities such as agroforestry tend to receive less attention when the land tenure rights are insecure or short-term.

It must also be noted that some times security in tenurial rights might also be a disincentive to biodiversity conservation as seen in the case of Brazilian Amazon, where conversion of natural ecosystems into agricultural lands proved disastrous.

Communal Rights: Community rights and / or common property resources (CPRs) from a major source of control over harvesting, use and management of natural resources in many parts of the world. Several countries, including Sri Lanka, are facing serious problems due to unsustainable resource utilisation by the communities and are finding it difficult to correct the damage. Public awareness and education can substantially correct the situation. However, the mismatch in government policies on property rights and common property rights are taking a toll on the biodiversity. The best example of this is the policy of the Government of Orissa, in India, to construct Jettys in Bay of Bengal to facilitate better navigation and eroding the CPRs of the communities living along the coastal areas in Orissa.

Laws: Rules and laws often tend to affect conservation. Brazilian tax and tenure laws that encouraged the clearing of Amazon forests is a good example of this. Also, extensive laws on felling and cutting of trees have often proved to be a disincentive for agro-forestry programmes in India (Anonymous, 1999).

III.6. Food Security and Trade

There are two broad options for achieving food security at the national level: the pursuit of food self-sufficiency or the pursuit of food self-reliance. Food self-sufficiency means the satisfaction of food needs as far as possible from domestic supplies with minimized dependence on trade. The concept of food self-reliance takes into account the possibilities of international trade. It implies maintaining a level of domestic production plus a capacity to import in order to meet the food needs of the population by exporting other products. Trade contributes to food security in a number of ways: through making up the difference between production and consumption needs; reducing supply variability; fostering economic growth; making more efficient use of world resources; and permitting global production to take place in those regions most suited to it. Over time, global food security depends on maintaining and conserving the natural resource base for food production in both developed and developing countries (Anonymous, 1996).

For any country, whether developing or developed, there is an unequivocal need for both access and the production of more and better food. We need not only to fill our existing 'Food basket' but also enlarge the diversity in the basket. This necessitates exchange of germplasm and improvement of a wide variety of crops. Increasing tendency to categorise crops as commercial and non-commercial crops threatens the very basis on which we recognise the importance of locally significant crops and those at global level. Greater emphasis should be placed on underutilised crops and lost crops (NRC 1989; 1996). This will not only ensure conservation but also encourage a broader base for food production, especially at local and regional levels, minimising pressures on commercial food crops besides contributing to increasing micronutrition availability.

It is worth mentioning about the influence of the Uruguay Round Negotiations on agriculture and related trade. The Uruguay Round has been described as an important event in the evolution of agricultural policy. It paved the way to harmonise both national and international policies on agriculture for the first time. These advances are contained in a series of agreements and ministerial decisions and declarations, annexed to the Marrakesh Agreement. These are the Multilateral Agreements on Trade in Goods; General Agreement on Trade in Services; Agreement on Trade Related Intellectual Property Rights; Plurilateral Trade Agreements and Ministerial Declarations and Decisions. The Multilateral Agreement on Trade in Goods contains 13 individual agreements of which three are relevant to agriculture - agreement on agriculture, agreement on application of sanitary and phytosanitary measures and agreement on technical barriers to trade. Details of these are presented separately.

III.7. Agriculture and Biotechnology

Genetic engineering or biotechnology to assist crop breeding have been used for four broad goals: changing the product characteristics, improving the plant's resistance to pests and pathogens; increasing the yield and increasing the nutritional quality. Biotechnology is a broad term to describe various methodologies ranging from simple microbial process like fermentation to a complex genetic transformation work like transgenic production. For convenience let us concentrate on the genetic transformation technology which is receiving both support and criticism today.

The FLAVRSAVR(TM) tomato is one of the first genetically engineered crop to be made available in the market. The fruit ripening characteristics of this variety were modified to increase shelf-life. Biotechnology has also been used to change the proportion of fatty acids in Soybeans, modify the composition of canola oil, change the starch content of potatoes, and increase the production of pro-vitamin A in rice.

Natural variability in plants to resist pest and disease attacks has been exploited for long by plant breeders. Biotechnology provides new tools to the breeder to expand his capacity. Unlike traditional breeding, biotechnology offers techniques to swap genes between species, between species and genera and also between plants and microbes.

Thus gene transfers are independent of the gene's origin. Transferring the *Bacillus thuringiensis* (Bt) gene into crop plants like corn, rice, tomato is so far the most significant and popular use of biotechnology to confer resistance against lepidopteran pests in crop plants. Other strategies to prevent insect damage include using genes of plant origin to produce proteins that retard insect growth (lectins, amylase inhibitors, protease inhibitors, etc). Use of Coat Protein Mediated Resistance (CP-MR) (Beachy et al. 1996) is popular to prevent viral attacks in plants.

Apart from these successes to protect plants against pest and pathogen attack, several strategies seem to increase the potential crop yield, including the exploitation of hybrid vigour, delaying plant senescence, induction to flower earlier and increasing starch production. Use of cytoplasmic male sterility (CMS) was widely used, long before the age of biotechnology, to produce hybrid seed to increase yield potential. But strategies to exploit male sterility required biological manipulations that can be carried out using molecular biology tools. Successes of using such techniques are already on the scene. Biotechnology also provided methods to increase the nutrient content of crop plants. Research into packaging a rice chimeric gene with a coding sequence for the highly nutritious hydrophilic protein like casein, under the control of prolamine regulatory and signal sequence, is found to increase the digestibility of prolamines in human intestine, resulting in the availability of vitamins. The possibility of enhancing Beta-carotene availability (a precursor of vitamin A) in rice is also exciting. Incorporation of Ferritin gene into rice, transgenic bananas and rice with ability to produce vaccines in-vivo are some of the exciting developments in agricultural biotechnology (Balakrishna 1999).

It is important that biotechnology based research also contributed enormously through other techniques like tissue culture, somatic hybridisation, wide hybridisation to increasing food production. However all the above possibilities exist because the gene(s) that can confer characters are available somewhere in the plant species. Without such variants it is impossible to practice any biotechnology. Genetic diversity thus form the basis for modern biotechnology and will continue to help food production in the years to come (Balakrishna and Swaminathan, 1994).

III.8. Other Impacts of Agriculture

The impacts of agriculture on ecosystem functions can be grouped into five areas: soil structure, nutrients and micro-organisms; water cycle, landscape complexity and linkages; and atmospheric properties (Anonymous, 1996).

Agriculture affects soil structure and biota primarily through reduction of organic matter incorporated from above-ground activities and processes. Simplification of agriculture by removal of multi-storied vegetation results in exposure of soil and erosion. This affects soil invertebrates, microorganisms and soil insects which form an important component in decomposition and nutrient cycling. Use of chemicals, as a part of agricultural practices, also affect these organisms.

Soil composting, elimination of landscape features, lack of water infiltration, reduction of ground water recharge, changes in qualities of run-off water, affect the movement and quality of water needed for agriculture and its associated ecosystem functions.

Intensification of agriculture also results in removal of several land areas like woodlands, hedges, fallow fields and smothens the wetlands, streams and ravines which all affect the biodiversity associated with such areas. Very often this also results in the loss of natural enemies of pests.

Research into effects of intensified agriculture have clearly shown how agriculture could influence the generation of green-house gases, impact carbon and nitrogen fixation (IRRI, 1997). All these have impacts on climate change in the long-run. Methane released from flooded rice cultivation as well as ruminant production cause severe green house effect. Research into alternate cropping in such areas, like rice-wheat cropping, have shown how such deleterious effects of intensive agriculture can be reduced.

IV. AGROBIODIVERSITY UNDER INTERNATIONAL INSTRUMENTS

IV.1. Convention on Biological Diversity (CBD)

The objectives of this convention, to be pursued in accordance with its relevant provisions, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.

For the purpose of the convention, the term ‘biological diversity’ has been defined as ‘the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and ecosystems’.

The Convention on Biological Diversity has several articles relating to Technology Transfer (Article 16), determining how to establish a clearing house mechanism to promote and facilitate technical and scientific cooperation (Article 18.3), sustainable use of biodiversity (Article 10), sharing benefits derived from the use of biodiversity (Article 19.2) and involvement of and equitable sharing of benefits with indigenous and local communities (Article 8(j)).

To achieve all this, it is necessary to a) identify components of biological diversity important for conservation and sustainable use, b) identify processes and categories of activities, which have or are likely to have significant, adverse impact on the conservation efforts and use, c) encourage use of biological resources that are compatible with sustainable use, and d) involve the local population to develop and implement remedial action in the degraded areas where biodiversity is either reduced or threatened.

This process has built-in mechanisms for introducing economically and socially relevant measures that can act as incentives for the conservation efforts of the local communities (Article 8(j)); exchange of information (Article 17); technical and scientific cooperation (Article 18); research and training (Article 12); public education (Article 13); access to and transfer of technology (Article 16); sustainbale use (Article 10) and identification of suitable financial resources (Article 20); are all important for arresting the loss of agrobiodiversity.

Thus, the process of agrobiodiversity conservation and sustainable and equitable use will involve a blend of political will and action, professional skill and know-how and peoples' concern and participation. Such a blend will have to be generated at the local, national, regional and global levels.

While the strength and capability of individual nations in the field of planning and implementing "Agrobiodiversity for Sustainable Food and Livelihood Security" programmes may vary, the collective strength of the international community for achieving this task is considerable. To facilitate this, Article 6(a) calls for development of national strategies for conservation and 6(b) for sectoral basis of implementation. Article 8 lays the basis for the *in-situ* conservation of biological diversity, which is set out as the most fundamental approach under the Convention. Article 9 relates to *ex-situ* conservation and is aimed at complementing *in-situ* conservation. Article 11 looks at implementation of incentive measures to farmers and thus encourage such practices.

Articles of the CBD relevant to the thematic areas identified by Conference of parties (COP) Decision III/11 are:

Thematic areas	Relevant CBD Articles	
Land resources	Article 10.	Sustainable use of components of biodiversity
Water resources	Article 6.	General measures for conservation and sustainable use
	Article 10.	Sustainable use of components of biological diversity
Plant, animal and microbial	Article 8.	In-situ conservation
genetic resources	Article 9.	Ex situ conservation
	Article 15.	Access to genetic resources
Wildlife	Article 15.	Access to genetic resources
Farm inputs	Article 6.	General measures for conservation and sustainable use
	Article 10.	Sustainable use of components of biological diversity
Wild sources of food	Article 8.	In-situ conservation
Traditional knowledge	Article 8.	In-situ conservation
Marketing conditions for agricultural products	Article 11.	Incentive measures
Land-use pressures	Article 7.	Identification and monitoring
Agroforestry	Article 8.	In-situ conservation
	Article 10.	Sustainable use of components of biological diversity
	Article 18.	Technical and scientific cooperation
	Article 15.	Access to genetic resources

IV.1.1. Agricultural biodiversity conservation in the CBD processes

(Modified after IUCN Background Brief, SBSTTA 3, 1997)

SBSTTA1 (Paris, September 1995)

Recommendation I/4. Ways and means to
promote and facilitate access to, and transfer and development of technology (...)

- for the COP2 to consider inviting “relevant submissions by State Parties, observers and relevant international and non-governmental organization, including, in particular, the private sector, and to take these into account in the preparation of (a) background document (...)”.

Recommendation I/7, Contribution to the preparation for the forthcoming International Technical Conference on the conservation and Utilization of Plant Genetic Resources for Food and Agriculture in 1996

- the COP may include *inter alia* the following in the possible statement it is preparing for the Conference:

  i) "the importance attached by the COP to the conservation of plant genetic resources for food and agriculture and their use in a sustainable manner;
  ii) "recognition that plant genetic resources for food and agriculture are critical components of biological diversity;
  iii) "the need to assess the current situation of plant genetic resources for food and agriculture and identify gaps and needs for priority action;
  iv) "the relevance of the issues to be considered by the fourth International Technical Conference on the Conservation and Utilization of Plant Genetic resources for Food and Agriculture to the provisions of the Convention on Biological Diversity".

- to examine the outcome of the above Conference at the third meeting of the COP and consider it "in relation to the agenda item.... on agricultural biological diversity".

Recommendation I/9. Draft provisional agenda for the second meeting of the SBSTTA.

- included in the matters on which advice is required by the third meeting of the COP is the "scientific, technical and technological aspects of the conservation agricultural biological diversity and sustainable use of its components (also taking into account the other provisions in Article 25, paragraph 2)".

COP2 (Jakarta, November 1995)

Decision II/I. Report of the First Meeting of the SBSTTA

- noted SBSTTA's recommendation to provide COP with "advice on scientific, technical and technological aspects of the conservation of agricultural biological diversity and sustainable use of its components (also taking account the other provisions of Article 25, para 2).

Decision II/15. FAO Global System for the Conservation and Utilization of Plant Genetic Resources for Food and Agriculture

- recognized the “special nature of agricultural biodiversity, its distinctive features and problems needing distinctive solutions”.

Decision II/16, Statement to the International Technical Conference of the Conservation and Utilization of Plant Genetic Resources for Food and Agriculture

- drew the attention of the Conference to the following considerations:
  i. “the importance attached by the Conference of the Parties to the conservation of plant genetic resources for food and agriculture (...);
  ii. “the recognition that plant genetic resources for food and agriculture are critical components of biological diversity (...)”;

SBSTTA2 (Montreal, September 1996)

Recommendation II/7. Agricultural biological diversity

- Agricultural biodiversity has an influence on the following:

  i. socio-cultural activities
  ii. economic activities
  iii. genetic adaptation to biotic and abiotic stresses
  iv. insect pollinators
  v. soil biological diversity
  vi. market responsiveness
  vii. new opportunities of economic importance
  viii. natural life cycles and life support
  ix. wildlife management
  x. protection against perturbations

- Agricultural practices have an impact on biodiversity on the following levels:
  i. ecosystem
  ii. species
  iii. genetic

- Some of the agricultural practices that have an impact on biodiversity are:
  i. inappropriate monoculture
  ii. over-mechanization
  iii. misuse of agrochemicals

Among the specific recommendations to the COP are:

- “consider the contributions of conservation and sustainable use of agricultural biological diversity to sustainable agriculture (....);

- “consider agricultural biological diversity in its work programme on indicators and methods of assessment (...)

- study the positive and negative impacts on ecosystems and biomes of agricultural transformation resulting from intensification or extensification;

- “conduct a gap analysis of the activities and instruments related to agricultural biological diversity in order to promote the conservation and sustainable use of biological diversity in the agricultural sector (...);”

Decision II/18, Medium-term programme of work of the Conference of the Parties for 1996-1997

- consider the “conservation and sustainable use of agrobiodiversity at the meeting of Conference of the Parties.

COP3 (Buenos Aires, November 1996)

Decision III/11. Conservation and sustainable use of agricultural biological diversity

- establish a multi-year programme of activities on agricultural biological diversity (...);

- “(...) identify and assess relevant ongoing activities and existing instruments (....);

- “(...) to identify issues and priorities that need to be addressed at the national level (....);

- encouraged Parties to develop national strategies, programmes and plans (...).

- affirmed its “willingness to consider a decision” by the FAO that the International Undertaking on Plant Genetic Resources be revised “in harmony with the CBD” and “should take the form of a protocol to the CBD;”

- in the Basis for Action (Annex 1), noted the interrelationship of agriculture with biodiversity; enumerated some of the impacts of biodiversity on agriculture and of agriculture on biodiversity;

- Annex I identifies the following thematic areas:
  i) soil erosion control;
  ii) sustainable tillage;
  iii) sustainable farming or cropping;
  iv) marginal land use;
  v) stock of agricultural land including pressures of urbanization;
  vi) integrated land and resource management;
  vii) restoration of degraded landscapes.

2. Water resources

i) precipitation;
ii) irrigation management;
iii) sustainable use;
iv) water quality;
v) farm waste.

3. Plant, animal and microbial genetic resources

i) in-situ;
ii) ex-ssitu;
iii) role of botanical gardens and zoos vis a vis agricultural biological diversity;
iv) sustainable use.

4. Wildlife

i) habitats;
ii) populations (e.g., pollinators, nematodes, soil micro-organisms);
iii) biocontrol organisms;
iv) border habitats for natural organisms beneficial to agriculture.

5. Air and climate

i) greenhouse gas emissions;
ii) temperature and precipitation variability.

6. Farm inputs

i) sustainable/water use efficiency;
ii) energy use efficiency ;
iii) input costs;

iv) pesticide use involving integrated pest management;
v) nutrient soil micro-organisms.

7. Wild sources of food

i) wild relatives of domesticated species;
ii) other wild species.

8. Traditional knowledge

9. Marketing conditions for agricultural products

The relationship between biological diversity-friendly agricultural practices and market forces.

10. Land-use pressures

Examining land-use pressures which make it more difficult to maintain biodiversity-friendly practices, such as lack of services for rural people, and the artificial maintenance of some land far below productive capacity;

11. Agroforestry

COP 4 (Bratislava, May 1998)

Decision IV/6 on agricultural biological diversity:

- Governments, funding agencies, the private sector and non-governmental organisations should join efforts to identify and promote sustainable agricultural practices, integrated landscpe management of mosaics of agricultural and natural areas,
- Identify and promote appropriate farming systems that will reduce possible negative impacts of agricultural practices on biological diversity
- Conduct case studies based on socio-economic and ecological analyses of different land-use management options
- Expand focus on soil micro-organisms and soil biota
- Provide inputs for the development and application of
- Criteria and indicators of biological diversity
- Rapid assessment techniques
- Identification of underlying causes behind the loss of biological diversity

- Identification of incentives to overcome constraints and enhance the conservation and sustainable use of agricultural biological diversity and the fair and equitable sharing of benefits

- Requests SBSTTA 4 to develop and provide, to the COP 5, advice and recommendations for the development of the first phase, and subsequent phases, of the multi-year work programme on agricultural biological diversity

- Study the impact of trade liberalisation on conservation and sustainable use of agricultural biodiversity in consultation with bodies such as WTO

- Requests SBSTTA 4 to advice on the effects of new technology for the control of plant gene expression, on conservation and sustainable use of biological diversity.

COP 5, Nairobi 2000

Decision V/5 on agricultural biological diversity:

I. Programme of work

- Endorsed decision III/11

- Recognise the need for incentives and support for capacity building and information exchange to benefit farmers, indigenous and local communities

- Expand cooperation by inviting other relevant organisations in supporting the implementation of the programme of work, and avoid duplicating of activities

- Invite multilateral and bilateral funding agencies to support implementation of activities of the programme of work

- Raise public awareness for sustainable farming and food production systems

- Recognise the potential contribution of the International Undertaking for Plant Genetic Resources

- Affirm willingness to consider a decision by FAO that the international undertaking becomes a legally binding instrument with strong links to both FAO and CBD.

- Welcome adoption of Rotterdam Convention

- Encourage support of application of SCBD as observer on Committee on Agriculture of the WTO

II. International initiative for the conservation and sustainable use pollinators

- Decide to establish an international initiative for the conservation and sustainable use of pollinators as a cross-cutting initiative
- Request SBSTTA6 and GEF to pay attention to pollinators issue and support activities

III. Genetic Use Restriction Technologies (GURTs)

- Invite relevant organisation to study the impact of technologies on the protection of intellectual property in the agriculture sector
- Recommends parties not to approve GURTs for field testing until appropriate scientific data on impacts is available
- Study impact of GURTs on safe and sustainable use of genetic resources
- Assess positive and negative impacts of GURTs
- Use CHM for information dissemination on various aspects of GURTs

Annex: Programme of Work

The proposed programme of work has been developed in light of the basis for action annexed to decision III/11

The proposed elements are:

1. Assessments
2. Adaptive management
3. Capacity building
4. Mainstreaming

IV.2. The International Undertaking on Plant Genetic Resources for Food and Agriculture (IUPGRFA)

The World Food Summit (1996) made a public commitment to end hunger. Through the Plan of Action adopted by the Summit, governments, international organizations and all sectors of civil society are encouraged to join forces in an effort to ensure access at all times to the food required for a healthy active life for all the world's people (FAO, 1997).

The Summit recognized the importance of plant genetic resources for food security and called on countries to implement the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture. This Global Plan of Action was adopted in June 1996 by 150 countries, at the International Technical Conference on Plant Genetic Resources, held in Liepzig, Germany (FAO, 1996a). The International Technical Conference also adopted the "Leipzig Declaration" through which governments committed themselves to implement the Global Plan of Action. The Leipzig Declaration asserts that "our primary objective must be to enhance world food security through conserving and sustainability using plant genetic resources".

Cross-cutting Themes of the Global Plan of Action (Cooper et.al. 1997)

The Plan aims to strengthen the links between conservation and utilization, through better information generation and management (Activities 1, 9, 17, 18), by improving the links between conservers and breeders through national plant genetic resources programmes and crop networks, and by greater investment in pre-breeding activities (Activity 10). Similarly, the Plan aims to promote not only the greater use of genetic diversity and resources, but also the strategic employment of genetic resources and practices which may lead to the maintenance of greater diversity in use (Activity 11). It also promotes an integrated approach to conservation, using both *in-situ* and *ex-situ* approaches and strengthening the links and complementarities between them.

The Plan focuses on action at the national level. particular attention is given to strengthening national plant genetic resources programmes which are regarded as pre-requisites to effective action. Whilst two activities of the Plan focus on these areas (Activities 15 and 19), action at the national level is stressed in many other activities. The importance of international collaboration is also recognised. The Plan gives particular importance to regional and sub-regional plant genetic resources networks (Activity 16).

The Plan promotes the full participation of farmers and local communities in planning and decision making processes relating to the conservation and use of PGRFA. The activity on national programmes (Activity 15) emphasises the need to involve all stakeholders, including farmers and local communities, with particular attention to women farmers. One activity area is devoted to on-farm conservation and improvement of PGRFA (Activity 2). Perhaps more significantly, the importance of farmer participation is integral to several other activities. Thus the importance of local PGRFA related knowledge (Activity 1) and of involving local communities in collecting (Activity 7), in situ conservation (Activity 4), evaluation (Activity 9),

participatory plant breeding (Activity 11), management and development of under-utilized species (Activity 12) and seed distribution (Activity 13) is recognized. The training needs of farmers and local communities is also addressed (Activity 19). Also, the Global Plan of Action contains a special programme to support and restore traditional locally adapted farming systems in cases of war and natural disasters (Activity 3).

Agenda 21 and Agricultural Biodiversity Conservation

Chapter 14 of Agenda 21 specifically addresses the issue of promoting sustainable agriculture and rural development. It calls for adjustments needed in agricultural, environmental and macroeconomic policy both at national and international levels; in developed as well as developing countries.

The following programme areas are included in this Chapter:

1. Agricultural policy review, planning and integrated programming in light of the multifunctional aspect of agriculture, particularly with regard to food security and sustainable development,
2. Ensuring people's participation and promoting human resources development for sustainable agriculture,
3. Improving farm production and farming systems through diversification of farm and non-farm employment and infrastructure development,
4. Land resource planning information and education for agriculture,
5. Land conservation and rehabilitation,
6. Water for sustainable food production and sustainable rural development,
7. Conservation and sustainable utilisation of plant genetic resources for food and sustainable agriculture,
8. Conservation and sustainable utilisation of animal genetic resources for sustainable agriculture.

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9. Integrated pest management and control in agriculture,
10. Sustainable plant nutrition to increase food production,
11. Rural energy transition to enhance productivity,
12 Evaluation of the effects of ultraviolet radiation on plant and animals caused by the depletion of stratospheric ozone layer.

(Source:Agenda 21: Earth's Action Plan, Nicholas A Robinson (ed.) IUCN ELC Paper No. 27)

Finally, the Plan promotes complementarity between the public and private sectors, based on a recognition of the strengths of each. The Plan, by its very nature, focuses on those activities which need to be supported by public funds, especially at an international level. These activities include long term PGRFA conservation itself (Activities 2, 4 and 5 - 8), as well as other upstream, pre-competitive activities such as germplasm evaluation and pre-breeding, especially long term programmes to broaden the genetic base of breeders populations. Besides these "public goods", public sector support is also required to meet the needs of resource poor farmers for improved varieties and seeds which are suited to their needs, since they are often unable to express an effective market demand (Activities 2, 11 - 14).

List of Priority Activities under the Global Plan of Action

In-situ Conservation and Development

1. Surveying and inventory plant genetic resources for food and agriculture (PGRFA)
2. Supporting on-farm management and improvement of PGRFA
3. Assisting farmers in disaster situations to restore agricultural systems
4. Promoting in-situ conservation of wild crop relatives and wild plants for food production

Ex situ Conservation

5. Sustaining existing ex-situ collections
6. Regenerating threatened ex-situ accessions
7. Supporting planned and targeted collection of PGRFA
8. Expanding ex-situ conservation activities

Utilisation of PGR

9. Expanding the characterisation, evaluation and number of core collections to facilitate use

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10. Increasing genetic enhancement and base-broadening efforts
11. Promoting sustainable agriculture through diversification of crop production and broader diversity in crops
12. Promoting development and commercialisation of under-utilised crops and species
13. Supporting seed production and distribution
14. Developing new markets for local varieties and 'diversity rich' products.

Institutions and capacity building

15. Building strong national programme
16. Promoting networks for PGRFA
17. Constructing comprehensive information systems for PGRFA
18. Developing monitoring and early warning systems for loss of PGRFA
19. Expanding and improving education and training
20. Promoting public awareness of the value of genetic resources for PGRFA

Source: Harnessing plant genetic resources for sustainable agriculture by Cooper et. al. 1997

IV.3 IUPGRFA and the CBD

Article 15 of the Convention on Biological Diversity (CBD) deals with issues relating to access to genetic resources. Articles 15.2, 15.3, 15.4, and 15.5 deal with issues discussed under the IUPGRFA (International Undertaking on Plant Genetic Resources for Food and Agriculture) especially on access to PGRFA. Also, Article 15.3 deals with the issue of the access to germplasm pre-CBD. Similarly the International Undertaking (IU), Article 11, provides a number of options with respect to access.

One option provided for access in accordance with national legislation, and sharing out the benefits derived on a multilateral basis, according to a mechanism to be established by the Commission. This would apply to a list of genera, covering both in-situ and ex-situ material, as well as material collected before and after the entry of the CBD. The list could be based on importance for world food security and greater world-wide interdependence. There was wide agreement that this proposal might provide a useful starting point, although the disadvantages of limited inclusive lists were also stressed.

Another option was to bring an indicative list of genetic resources which directly or indirectly contribute to food security within the scope of the agreement, while allowing countries to include or exclude material according to agreed criteria.

Various ways of developing lists were considered: (i) starting from a comprehensive list, and excluding those taxa on which agreement could not be reached, or (ii) beginning from a short agreed list and agreeing on further genera to be included. There was wide agreement that should a list be developed, provision should be made for countries voluntarily to designate additional materials under the agreement. Some countries in fact noted that they would be willing to designate all their plant genetic resources that are in the public domain. There was also agreement that any multilateral agreement should not preclude regional agreements with a more comprehensive scope.

Article 15 (7) explicitly deals with the issues of benefit sharing which is also dealt with in IUPGRFA as 'farmers' rights'.

IV.4 Intellectual Property Rights (IPRs) in Agriculture

(a) Traditional Forms of IPRs

Under the CBD, references to IPRs are to genetic resources and to conservation enhancing technologies.

Two formal types of IPR protections are possible for protection of land races and other genetic resources. These are:

(i) Patents -Patents on genetic resources may be sought in the form of an entire organism or parts thereof, such as a group of genes, provided there is some human invention involved in it. Patenting of genes, excepting human genes, is not a legal problem and several countries allow such patents. Under the Trade Related Inteectual Property Rights (TRIPs) agreement micro-organisms may not be excluded form patent protection. Petty patents or utility patents are a weaker form of regular patent with less duration and limited royalty but is less expensive and easier to get. The crucible group, established by the CGIAR in 1995 advocated that genetic resources are best protected under utility patents.

(ii) Plant Breeder Rights:- Plant Breeders' Rights (PBRs) as embodied in UPOV are a form of patent like protection especially for plants. PBRs apply to whole plant and are easy and inexpensive to acquire. PBR provides specific research exemption which provides access to protected materials. Varieties discovered in the wild are protectable with PBR, always they need to satisfy the homogeneity and stability requirement. (Juma and Ojwars 1989). PBR would apply to many of the needs for protecting genetic material in agriculture.

(b) Non-Traditional Form of IPRs

Many times traditional forms of IPRs may not be applicable to all forms of conservation, use and benefit sharing. Non-formal methods like the following may provide possible alternatives to protect the genetic resource as well as knowledge associated with it.

(i) Farmer's Rights - Farmer's Rights is the terms developed by FAO under the IUPGRFA. Farmer's Rights (sensu FAO) are described as rights arising from the past,

present and future contributions of farmers in conserving, improving and making available plant genetic resources". However, the concept of Farmers Rights stays on even today as a moral obligation rather than to foster economic incentive to farmers.

(ii) Folklore - WIPO and UNESCO (1985) agreement on 'Model Provision for Nation Laws' on folklore is seen as parallel to protecting genetic material. The components of this agreement is expected to have several similarities to conservation of land races by farmers as compared to traditional folklore practices. But due to lack of helpful details on how to apply this agreement in implementing the protection of agricultural practices and knowledge, this still remains largely as a concept.

(iii) Code of Conduct - Beginning with FAO's code of conduct for plant germplasm collecting and transfer in 1993 several attempts are being made to develop codes of conduct on research, for ethics and collaboration. The CoP-4 decision (iv/8) to request countries develop non-legal mechanisms to address issues of access and benefit sharing gave a new life to the codes of conduct. Codes of conduct can be institution specific (like the code of conduct for the Royal Botanic Gardens, Kew, UK) or activity specific (like code of conduct for participatory plant breeding) or group specific (Code of Conduct for ethnobotanists). Operationalising such codes, however, seem to be slow and many lessons need to be learnt to effectively implement such codes of conduct in the field.

(iv) Apellations of Origin - With the classical controversy of using the name 'Basmati' for a variety of rice developed by Rice Tech, USA, the protection that countries are seeking on geographic apellation is increasing. Though formed in 1958 under the Lisbon Agreement and administered by WIPO, the Apellations of Origin is increasingly seen as a form of protection to material as 'geographical name of a country, region or locality, which serves to designate a product originating therein, the quality and characteristics of which are due exclusively or essentially to the geographical environment, including natural and human factors.

Multilateral Agreement on Trade in Goods - Relevance to Agriculture

The Multilateral Agreement on Trade in Goods contains 13 individual agreements of which three are relevant to agriculture. These are:

Agreement on Agriculture (AoA)

Agreement on Application of Sanitary and Phytosanitary Measures (SPS) and

Agreement on Technical Barriers to Trade (TBT)

Agreement on Agriculture (AoA)

The main provisions of the agreement are aimed at:

Improving market access

Reducing domestic support and

Reducing export subsidies

A number of agricultural commodities were, however, not covered by this agreement (eg. rubber, fish and fish products and forest products)

Agreement on the Application of Sanitary and Phytosanitary Measures (SPS)

The SPS agreement concerns the application of measures associated with the protection of human, animal and plant health in such a way that they are not a disguised restriction on international trade. These provisions largely are concerning quarantine measures and food safety measures. The SPS agreement requires governments to adopt measures only to the extent necessary.

Agreement on Technical Barriers to Trade (TBT)

The TBT seeks to ensure that technical regulations and standards, including packaging, marking and labelling requirements and procedures for assessing conformity with technical regulations and standards do not create unnecessary obstacles to international trade.

Source: FAO, 1999 Agriculture and Trade: The Uruguay Round Agreements and Trade

IV.5. Combating Desertification and Drought under the Convention on Combating Desertification

Desertification and drought are closely interlinked with issues such as loss of biodiversity, food security, population growth, poverty, climate change, water resources, deforestation and resource consumption. Desertification is also a social, economic as well as environmental problem and drought and land degradation can occur in dry climate zones.

In relation to agriculture, the most valuable tool to conservation will be to preserve the knowledge of local farmers and indigenous people concerning dryland management and survival strategies. Their full involvement in the sustainable development of these drylands needs to be ensured. The amounts of genetic diversity of plants and animals microbes in drylands are unique and important. Their adaptation, which evolved over hundreds of years, can be vital tools for sustainable use and development. Traditional techniques of water management, irrigation, soil nutrient replenishment, crop rotation, cropping pattern, agronomy are all important tools in conservation of agrobiodiversity in drylands.

Future work, in collaboration with CBD UNFCCC, CCD and other related processes, are essential and vital. Under the CoP-4, SBSTTA4 directives countries need to come together to address the issue of biodiversity conservation in drylands on high priority basis and ensure that some of the poorest people in the world are fed nutritiously and sustainably.

V. WAYS FORWARD

V.1 Biodiversity Friendly Technologies

V.1.1. Integrated Soil, Water and Plant Nutrient Management

Even today in rural households mixed farming, involving agroforestry, mixed aquaculture/agriculture systems and agro - silvi - pastoral systems are popular as an integral part of agriculture.

Such integrated system generally increase productivity with utmost sustainability of available natural resources. Careful and often successful, planning of the village watershed/ catchment system, maintenance of soil cover, maximising water infiltration, management and control of runoff water, soil fertility management, reduction of pesticides and chemicals, and nutrient recycling all form a collage to give a better soil - plant - water relationship, contributing to economic efficiency of the agroecosystems and also enhance the rural livelihood securities (Swaminathan, 1997).

Integrated Intensive Farming Systems

FAO and UNDP's Farmer Centered Agriculture Resource Management (FARM) project was established to capture the power of partnership in accelarating agricultural progress based on principles of ecology, economics, social and gender equity and employment generation.

This necessitated development of intensive agricultural practices with both diversification and value-addition. With ever-decreasing per capita availability of land, water and energy for agriculture there is a need for us to produce more food with the available units of resources. Several methods and alternatives were suggested. One of these is the Integrated Intensive Farming Systems (IIFS) approach which describes itself as knowledge rather than capital intensive. IIFS is being tested in a few places including in India. IIFS stresses seven basic principles to achieve long term goals of sustainable agriculture and related social and economic development. These principles are: soil health care; water harvesting and management; crop and pest management; energy management; post harvest management; choice of crops and other components of farming systems; and information and skill organisation and empowerment.

Based on : Farmers' Wisdom: Pathways to Evergreen Revolution. Eds. G Venkataramani and Sudha Umapathi, MSSRF

V.1.2 . Integrated Pest Management (IPM)

During the green revolution period, pesticides were the most important part of packages for crop intensification. A number of policy instruments were applied to make purchased inputs, including subsidised pesticides available to the farmer. Pesticides also became a part of loan packages from government and are still a part of government's extension package, in several countries. However, now everyone realises the damage such pesticide use caused to several ecosystems. Such realisations gave birth to the concept of Integrated Pest Management (IPM). A number of IPM programmes have been implemented in developed countries. However, the most successful one was in Asia which was a result of IPM as well as proper extension programmes. IPM focuses on the importance of natural enemies in keeping pest populations under control.

Policy changes in support of IPM implementations, such as, removal of subsidies for pesticides (India, Indonesia, Philippines), taxation on use of pesticides (India), prioritisation of funding for IPM activities (Philippines) are some of the important policy changes that influenced better adoption of IPM in agricultural practices.

V.1.3. Integrated Gene Management (IGM)

FAO at the suggestion of international Rice commissions initiated an Indica and Japonica hybridisation programme in rice, to improve the yield potential of Indica rice. This led to great advantages and improvements in rice breeding which is feeding the world to a large extent.

Such targeted programmes are needed even today. The advantage we have now is the availability of superior techniques which can combine and recombine quantitative characters, beginning from wide hybridisation to transgenics. Such research must aim at enhancing the capacity of the plant to produce higher biomass since the scope for yield improvement through the lowest index pathway has been practically exhausted.

Pingali, Hossain and Gerpaciao (1997), in their book "Asian Rice Bowls: The Returning Crisis" draw attention to several challenges facing rice research, which by all means, apply to other crops as well. Basically, they all point to one question: how much more improvement can we bring about in productivity without ecological harm?

To answer this question, M.S Swaminathan, a pioneer in green revolution research suggests an Integrated Gene Management (IGM) approach which is based on the principles of the CBD; viz, conservation, sustainable use and equitable sharing of benefits. In conservation, research and development programmes must aim at *in-situ*, on-farm and *ex-situ* conservation. Several thousands of varieties are available for different crops, both in current usage and those which are under - utilised, which can form the basis for increased productivity and quality. With developments in molecular genetics it is important to integrate Mendelian genetics to promote ecologically desirable agriculture, aimed at sustainably using the diversity. Once the use of such material gains importance it is essential for us to address the issue of equitably sharing the benefit of such use. This can be achieved by strengthening the FAO's IUPGRFA and getting it included as a protocol under the CBD and to promote a multilateral system of exchange of genetic resources in crops of importance to food and nutrition security.

V.2. International Cooperation and Initiatives to Conserve Agrobiodiversity

Analysis of successes and failures is important for charting future strategies and priorities. A major lesson from *ex-situ* Gene Banks is the high rate of loss of genetic material in *in-situ* conditions (Frankel et al, 1995) and the subsequent possibilities of rejuvenating some of the germplasm that was lost. The CGIAR system has the world's largest well preserved and well documented *ex-situ* collections of agrobiodiversity. This has been rendered possible because of adequate and sustained donor support and because of the establishment of the International Board for Plant Genetic Resources (IBPGR) which has now been reorganised as the International Plant Genetic Resources Institute (IPGRI).

A series of examples are given in the following pages to draw attention to a few significant initiatives in the area of agrobiodiversity conservation and sustainable use. The examples are illustrative of the power of national action and international support and are not intended to be an exhaustive compilation. They, however, provide a basis for designing pioneer projects (Anonymous, 1996)

V.2.1. Seeds of hope - A joint rehabilitation initiative of the Consultative Group on International Agricultural Research (CGIAR):

Large-scale destruction of crops and livestock in countries torn by armed conflicts and civil wars, as witnessed in Rwanda during 1994, poses a serious threat to locally-adapted native agrobiodiversity. Sudden spread of ethnic strife sweeping over vast areas may not only mean human starvation and death, but also the irreparable loss of hundreds of crop varieties containing valuable genes for resistance to local pests and diseases and adaptation to abiotic stresses.

“Seeds of Hope” is a joint initiative by seven CGIAR centres involved in agriculture research in Africa to locate Rwandan germplasm and repatriate supplies of landraces and traditionally grown cultivars to revitalise the country’s agriculture. The CIAT led the action plan, initiated in May 1994 and organised a search for Rwandan germplasm in collections held by CGIAR centres and other international organizations.

A search of materials held by CGIAR centres revealed the following 761 accessions of germplasm, originally collected from Rwanda:

ICRISAT	*Sorghum bicolor*	:	293 accessions
	Sorghum drummondii	:	one
IITA	*Glycine max*	:	one
	Vigna spp.	:	9
ILRI	22 forage species	:	90
ICARDA	*Triticum spp.*	:	2
CIP	*Ipomoea batatas*	:	4
CIAT	*Phaseolus vulgaris*	:	331
	9 forage species	:	30

Continued searching added more material including maize. The IARCs produced seeds and vegetative planting materials, both at their experimental farms and in cooperation with national agricultural programmes and farmers in several surrounding countries including Burundi, Ethiopia, Kenya, Malawi, Tanzania, Uganda and Zaire. This massive effort contributed significantly towards reviving Rwanda's traditional agriculture and promoting food security in a war-torn country. This initiative was taken, however, on an ad hoc basis and the effort was voluntary. A better course will be to have agreed upon institutional responsibilities to meet such emergencies.

V.2.2 Regeneration of Latin American maize through LAMP:

Maize is the most important grain crop in Latin America and a major export crop of the United States. The large size of the seed makes dehydration difficult for long-term storage in gene banks. Consequently, the accessions require regeneration more frequently than most smaller grains. Twelve maize-breeding countries in the Americas agreed to collaborate in a germplasm project called the Latin American Maize Project (LAMP). Pioneer Hybrid company provided $1.5 million and technical inputs in support of this project. LAMP has been a highly successful initiative in regional collaboration to improve the conservation and use of maize genetic resources. While the main objective of the program was to evaluate, for future use, the agronomic characteristics of maize accessions in germplasm banks in Latin America and the USA, the secondary objectives were to :

- determine the exact number of accessions in each bank;
- identify the amount and quality of seed in each accession and;
- list accessions that are in need of regeneration.

In response to the information on regeneration needs, a subsidiary project entitled Regenerating Endangered *Latin American Maize Germplasm* was developed by USAID, USDA and CIMMYT to salvage maize holdings in Argentina, Bolivia, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Mexico, Peru and Venezuela. These 13 countries are participating in the regeneration of nearly 10,000 endangered land race accessions. Newly regenerated material is conserved in the national collections with samples duplicated at CIMMYT and/or National Research Systems.

V.2.3. Desert Margins Initiative (DMI) - A System-wide Ecoregional Programme to combat Desertification in Sub-Saharan Africa:

The spectrum of desertification, also referred to as ‘dryland degradation’, is immense as seen in arid, semi-arid and dry sub-humid drylands that cover nearly 40 per cent of the earth’s land surface and affects the livelihood of over 900 million people. The goal of the Desert Margins Initiative (DMI) is to address problems of food security, poverty and the sustainable management of natural resources in such areas.

Initiated by a consortium of six research centres within the CGIAR, the UNEP and other international, regional and national institutes, this programme is headed by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). In the countries of sub-Saharan Africa participating in the DMI (Botswana, Burkina Faso, Kenya, Mali, Namibia, Niger, Senegal and South Africa), population growth rates are among the highest in the world and cereal production per unit area of land is very low. There is a urgent need to enhance the food security of poor rural populations and alleviate poverty by halting or reversing desertification processes.

This Initiative has identified three priority research areas:

- Developing sustainable pastoral grazing systems for dryland regions.
- Managing water and nutrient resources more effectively within rain-fed farming, mixed tree/crop/livestock systems and natural and plantation woodlands.
- Designing policies and institutional options for improved natural resource management.

Biodiversity conservation is a major theme in the DMI. Inventories are being compiled of species adapted to dryland habitat and those that are the mainstay of this diverse agro-ecosystem. Tree and crop improvement programmes linked to diversified agricultural systems will strive towards enhancing and conserving native biodiversity. It will be worth expanding the scope of programmes of this nature by adding pilot studies on *in-situ* conservation of agrobiodiversity.

In the implementation of the desertification convention, the conservation of agrobiodiversity of arid and semi-arid areas and areas prone to desertification should be accorded priority. There can be a regional programme specifically designed to harness agrobiodiversity for halting desertification and for reclaiming desertified land.

V.3. National Level Actions

Farmers produce landraces for both subsistence as well as for commercial purposes. Promoting commercial production of traditional crops can achieve the development goal of increased income and the conservation goal of maintaining traditional crop germplasm. Commercial production linked to appropriate markets will help governments avoid development of either positive or negative sanctions to farmers. This will also encourage farmers in marginal areas to conserve their traditional cultivars and at the same time enjoying the economic benefits arising out of the use of such cultivars. As Brush (1991) points out, subsidies to pay farmers to grow traditional crop varieties is not a viable option. Besides being costly they cannot be sustainable. Market options are among the least expensive conservation tools because they can rely on existing institutions and on farmer's choice. Brush (1991) offers three policies to encourage *in-situ* conservation through the market: market incentives, removal of disincentives and grass-root support. He argues that market incentive for conservation can be strengthened in two ways - first improving the marketing system for traditional varieties by improving transportation, by supporting wholesale operations focussed on traditional varieties, education and communication and identifying special niches. Secondly, by lowering unit production price of native varieties. On removing disincentives like delinking agricultural loans with use of modern cultivars and use of fertilizers etc. Another disincentive will be the national commodity programme that subsidises some crops and not others. An example of this is the Peruvian policy to subsidise rice and not potatoes. By strengthening grassroot support like organising fairs and expositions on the use and better nutrition of traditional varieties etc. there can be better demand and a market for traditional varieties. Such activities carried out in Southern India proved to be attractive and useful. Development of participatory plant breeding approaches can be another activity to strengthen the conservation of local varieties and at the same time improving on them.

Agrobiodiversity and Farmers' Rights

In 1989, more than 160 countries adopted the concept of Farmers' Rights in the voluntary International Undertaking on Plant Genetic Resources (IUPGR). Despite several resolutions and reiteration of a need to have Farmers' Rights by both CBD and Agenda 21 there was a general lack of progress. In 1996 a technical consultation was held to develop operation guidelines for Farmers' Rights. The following gives the salient features of the outcome, followed by the consultations at FAO on this issue.

Technical Consultation in M S Swaminathan Research Foundation, India, 1996:

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Framers' Rights - Objectives

1. For farming communities to be entitled to receive a fair and equitable share of the benefits arising from the use of agrobiodiversity
2. For farming communities to achieve recognition for their past, present and future contributions to conservation and agriculture
3. To promote the conservation and sustainable use of plant and animal agrobiodiversity by farming communities

Means to achieve these objectives

1 Free choice of and access to germplasm
2. Freedom to sell harvested produce
3. Freedom to improve cultivars
4. The ability to influence future breeding efforts
5. Access to technologies and training
6. The ability of farming communities to control access to agrobiodiversity under their custodianship
7. The economic incentive to continue to conserve agrobiodiversity
8. Recognition for past (and present) achievements

Source: Agrobiodiversity and Farmers' Rights. 1996 (Ed.) M S Swaminathan, Konark Publ. Pvt. Ltd.

V.3.1 National level community gene fund

Charity begins at home. Therefore, it is both a fundamental responsibility and a privilege for agrobiodiversity-rich developing nations to take immediate steps to allot *new and additional* resources for recognising and rewarding the contributions of their own tribal and rural families to the conservation of their genetic wealth. It should be emphasised that ex-situ preservation of genetic resources is no substitute for in-situ conservation. *In-situ* conservation represents both preservation and continuous evolution through mutation, recombination and selection. Hence, investing in a few *ex-situ* gene banks and arboreta is not a substitute for preserving and revitalising the *in-situ* genetic conservation traditions of tribal and rural women and men. Both pathways, if funded adequately, will become mutually reinforcing (Swaminathan 1995) .

V.4. Participatory Approaches

V.4.1. Farmers Contribution to Agrobiodiversity

In an interesting study carried out by IPGRI, Eyzaguirre and Iwanaga (1997) advocate greater use of agrobiodiversity through decentralised breeding in support of traditional farming systems. This offers the opportunity to narrow the gap in human welfare between the favoured and marginal areas without sacrificing the genetic diversity in crops or for increased farm incomes.

Farmer-based breeding or participatory plant breeding is an important strategy to maintain as well as use the available agrobiodiversity. Several CGIAR institutions and National Agricultural Research Centers (NARS) support this strategy as it:

- Makes a wider range of samples available to farmers
- Makes partnerships between developers and users of varieties
- Enhances on-site conservation

Based on gender analysis it will be possible for us to identify several indicators that can identify the role of women in conservation:

- Knowledge of natural resources and environmental issues
- Amounts of time spent on household management and community based natural resource management
- Relationships they foster between and within households and communities
- Responsibilities in the household and community, and
- Skills and expertise they have in conservation of natural resources

Two major barriers that women face in society which impact on their capacity as community natural resource managers, are - the social, cultural and legal norms that relegate women to occupying a limited position in society and the women's invisibility in decision making.

Agenda 21, adopted at Rio de Janeiro in 1992, as a framework for a Sustainable Future for Humankind stresses the need for strategies which will strengthen women's involvement in national ecosystem management and control of environmental degradation (Chapter 24). This necessitates the gender sensitisation and gender-oriented participatory action research and policy analysis.

V.4.2 Women and Knowledge on Agrobiodiversity

The present agrobiodiversity management systems are being developed on a scanty information base. There is a need to incorporate gender analysis into projects concerning agrobiodiversity because the rights/role of women in conservation is insufficiently recognised. Considerable information is now available on the role of women in agriculture. The role women play in identification of variants of crop plants in the field, careful selections they do for seed that need to be saved for next crop *versus* the seed they use for consumption, storage methodologies, ways of processing different varieties, methods of pest and disease control, sustainable harvesting of plants including medicinal plants are a few key areas where there is a need for more formal research and understanding of processes based on science.

V. 4.3. Conservation : Establishing the Linkages between Gender and Biodiversity

- Bringing together theory and practice by attitudinal and methodological changes in the fields of gender and biodiversity.

- Reviewing existing information by scientists and social scientists of their own existing data on biodiversity conservation and resource transformation through collaborative arrangements with those involved in gender studies.

- Building models and analytical tools for opening up the household, and establishing its linkages with the community and society. Effective models of the gender dimensions of biodiversity management therefore need to be created.

V.4.4. Enhancing the Role of Women in Agrobiodiversity Management

- The recording of oral history is an important means of giving illiterate women a voice, and will provide an inventory of their perceptions, knowledge and skills of both men and women. Analysis of such oral history would provide important insights for further research.

- Building gender analysis into project plans from the very beginning, so that the gender dimension gets proper attention and is not merely added on. This requires sensitisation and training of different levels of functionaries, both in governmental and non-governmental organisations and agencies.

- Training modules and other educational resource materials should be developed for all the above. Such training material should comprise of both generic and culture/locality specific issues.

Participatory Plant Breeding

The term Participatory Plant Breeding (PPB) is used with different meanings. It ranges from, in its widest context, decentralised breeding controlled by plant breeders to involving farmers at various stages of a breeding programme. PPB is applicable to both complex agro-ecosystems, like the marginal lands to favourable agro-ecosystems. In the former, the aim of PPB is to improve the farmers' time tested varieties (traditional varieties) while in the later it is to make the crop plant robust.

PPB is now favoured as a good solution to plant breeding in marginal ecosystems that are largely bypassed by formal breeding programmes. Small farmers in marginal areas lack economic and institutional capacitties to transform their environments into more productive ones. Average yields of varieties they grow are low but consistent. Improvement of yield characters of such varieties help them not only to conserve the varieties but also to get better economic returns. The agromorphological and adaptive characters of traditional varieties can be captured to breed modern varieties through PPB.

Improving the livelihoods of marginal farmers, through economic value addition to their genetic resources can be the best ethical and viable strategy. The ultimate goal will, however, be to make landraces competitive with elite varieties and make them more productive to farmer conservers who grow them.

PPB : Evaluation Criteria (Louise Sperling, 1996)

Functional Perspectives (Orientation : Products)

Production/Impact Enhancement	Genetic Diversity
No. of farmer acceptable varieties	Genetic profile of released varieties
• No. of disease resistant varieties	Incidence of landrace parents
• Absolute production gains	
• Rates of adoption	

Control/Empowerment Perspectives (Orientation : Process)

Degree to which:
Farmers' skills are enhanced to more effectively cross/select themselves

- Farmers gain full access to wide pool of germplasm
- Farmers control local testing
- Farmers are involved in decisions of varietal release

V.4.5. Role of Private Sector in Agrobiodiversity Conservation

The rapid development in science, trade and commerce, law and policy encouraged tremendous advancements in private research, including in agriculture. The private industry plays an important role in agriculture all over the world. With the advent of modern biotechnology, such research and development by private sector increasingly aims to privatise genetic resources and germplasm. The evolution in global seed exchange under international trade in the commercial seed sector has been rapid, growing from 0.86 billion (USD) in 1970 to 3.3 billion in 1996 (ASSINSEL, 1998).

It is increasingly debated whether private industry is a boon for development or a bane on environment. This applies to agro-based industries also. Several CBD articles refer to use, transfer of technology, access to resources benefit sharing and financial mechanisms. They all refer to the increasing need for private sector participation to further the goals of CBD.

A survey conducted by Kerry Ten Kate and Sarah Laird (2000), revealed that the private sector does not think that CBD has any impact on them, and so there is no need to comply. The approach to principles like benefit sharing under the purview of pharmaceutical industry is different from that of the seed industry. The demands for access to genetic resources is different for different uses. In agricultural crops research still aims at improvements in qualitative characters while little attention is paid to quantitative traits. This scenario makes accessing wild relatives of crop plants and traditional varieties a good source of material (or gene (s)) for improvement.

The commercial sector was never interested in investments into traditional crops or land races, nor in under-utilised crops. This is mainly because of increased time and monetary investments needed. Also, the government policies in several parts of the world do not encourage the use of such germplasm. Lack of appropriate national policies, increasing perverse incentives, overwhelming investments to own genetic resources by commercial companies, lack of awareness and instruments both by private and public sector, lack of capacity are all taking a heavy toll on possible involvement of commercial seed sector in agrobiodiversity conservation.

V.5. Innovative Methods to Promote Conservation of Agrobiodiversity

V.5.1. Policies of Industrialised Countries in Promoting Genetic Conservation (Anonymous, 1996)

It may be appropriate in this context to cite the lead given by industrialised countries in providing farm families with financial incentives to safeguard biodiversity. The following extracts would suffice to indicate that economic reward for the contributions of farm families to environment protection and genetic conservation is an accepted procedure in Europe and North America. Therefore, there should not be any difficulty for the public of rich nations to accept that such a reward should also be extended to the farm families of biodiversity-rich developing countries.

European Union: The following decisions have been taken by the European Union for fostering agricultural production methods compatible with the requirements of the protection of the environment and the maintenance of the countryside:

“Whereas the requirements of environmental protection are an integral part of the common agricultural policy”,

“Whereas an *appropriate aid scheme* would encourage farmers to serve society as a whole by introducing or continuing to use farming practices compatible with the increasing demands of protection of the environment and natural resources and upkeep of the landscape and the countryside.”

“Whereas the resources available for implementing the measures provided for in this Regulation must be additional to those available for the implementation of measures under the rules governing the Structural Funds, and in particular, for measures applicable in regions covered by Objectives 1 and 5(b) as defined in Article 1 of Regulation (EEC) No 2052/88 (OJ No L 185, 15.7. 1988,p.9).”

“This community aid scheme is intended to promote ways of using agricultural land which are compatible with protection and improvement of the environment, the countryside, the landscape, natural resources, the soil and genetic diversity.”

“The maximum eligible amount of the premium shall be European Currency Unit (ECU) 250 per hectare for the cultivation and propagation of useful plants adapted to local conditions and threatened by genetic erosion.”

United States of America: In the United States of America, Farm Bill HR 2854 of 1996, substantial financial allocation has been made for rewarding the contributions of farm families in the field of environment protection and genetic conservation. President Clinton's statement on the Farm Bill, dated April 4 1996, said, "$300 million in additional resources are being provided for rural development and agricultural research through the Fund for Rural America. The Farm Bill provides more than $1 billion over seven years for on-farm conservation measures, including assistance for livestock producers, which will help prevent soil erosion and clear our streams and air".

Of particular significance is the provision of $ 50 million in total funding from financial year 1996 to 2002 for providing assistance to land owners to develop and implement approved management practices to improve wildlife habitat.

Thus, methods of rewarding the contributions of farmers for the conservation of habitats rich in biodiversity are commonly adopted in industrialised countries. Third World countries happen to be the major repositories of genetic wealth, since most of the mega-diversity areas occur in developing countries. There is therefore an urgent need for providing a mechanism of funding which can lead to the enhancement of the *in-situ* and *ex-situ* conservation practices of rural and farm families. It is important to compensate them economically for the loss they sustain as a result of continuing to plant land races and folk varieties in preference to improved high yielding varieties of crop plants. Above all, equity demands that their contributions over the millennia of value addition to genetic resources through additional knowledge and information ought to be rewarded economically.

V.5.2. Global Fund for Biodiversity for Sustainable Food Security (Anonymous, 1996)

At the UN Conference on Environment and Development held at Rio de Janeiro in June 1992, the Government of the Netherlands proposed that all industrialised countries provide an additional ODA of 0.1 per cent of their GDP as an "Earth Increment". The essence of the Dutch proposal is to ensure that this additional 0.1 per cent ODA assistance is entirely reserved for conserving and improving the earth's life support systems of land, water, forests, biodiversity, oceans and the atmosphere. If on the occasion of the fifth anniversary of the Rio Conference in 1997, all industrialised countries agree to increase their ODA by 0.01 per cent of their GDP for promoting the conservation of agrobiodiversity through implementing the Global Action Plan developed by FAO for the Leipzig conference and for rewarding the contributions of indigenous and rural communities to genetic conservation and enhancement, there will be new and additional resources for this purpose. According to UNDP, the GDP of industrialised countries was US $ 18,710 billion in 1992. 0.01 per cent contribution would provide annually nearly $

2.0 billion at the current GDP level of G-7 nations. Such an amount will help to implement both the Global Action Plan and Farmers' Rights as well as the equity provisions of CBD.

Enlightened self-interest on the part of the rich billion of the human population to whom nearly 84 per cent of the global annual income is flowing today, demands that no further time is lost in recognising and rewarding the contributions of the families of indigenous, tribal and rural communities to sustainable food security through their continued efforts in the area of plant and animal genetic resources conservation and enhancement. It should not be a big burden for rich countries to *add* 0.01 per cent of their GDP to their ODA budget specifically for being credited to a *Global Fund for Biodiversity Conservation for Sustainable Food Security.* This Fund, estimated at about $ 2 billion each year, can be administered through a *well defined and earmarked* window in the Global Environment Facility. Well defined indicators and transparent mechanisms for the use of this Fund will have to be developed.

V.5.3. GEF's new Operational Programme on Agrobiodiversity

In May 2000, the GEF approved the elements of a new Operational Programme (OP 13) on agrobiodiversity. Considering the global interest in maintaining agricultural biodiversity, the GEF extended support to help integrate global environmental imperatives into existing sustainable development efforts in appropriate regions and countries. The activities identified in the Programme are reflections of priorities set through the CBD-COP decision V/6 (Visit GEF website at www.gefweb.org 'whats new' section for details).

V.6. Adoption of the IUPGRFA as a Protocol under the CBD

FAO's international undertaking on Plant Genetic Resources for food and agriculture (IUPGRFA) is so far the most important and comprehensive strategy to discuss and address all three principles of the Convention on Biological Diversity (CBD).

Its scope and objectives address issues relating to conservation, use and benefit sharing in the area of agrobiodiversity. With such a comprehensive agreement by several governments, who also are the signatories of the CBD, it is strategic to use the undertaking to further the programme of work under CBD relating to agrobiodiversity. Under the SBSTTA-3 as well as CoP-3 directives, countries need to address the possibility of making the IUPGRFA as a protocol to the CBD (Decisions III/11 of CoP-3). FAO's efforts in this direction, especially in revising the IUPGRFA is progressive and in general the principles of equitable benefit sharing under the name of 'Farmers Rights' has been negotiated.

The activities relating to agrobiodiversity conservation, the multi-year programme of work, the sanitary and phytosanitory standard (SPS) protocol of FAO, the code of conduct in germplasm collection, the multilateral system of exchange of germplasm are all vital elements that can address concerns voiced in CBD negotiations.

Unlike the biosafety protocol, where negotiations started a fresh and new, the IUPGRFA is agreed and accepted by several countries in spite of its continuing revisions. No time must be lost to adopt and implement the undertaking as a protocol to the CBD.

V.7. Management Issues

V.7.1. Monitoring, Evaluating and Improving Progress

Monitoring and evaluation of biodiversity conservation programmes have become important concerns among conservationists, biologists, economists, planners and funding agencies. Unlike other programmes, conservation programmes have strong linkages, not only with biology, but also with social and cultural traditions. All the following three areas have feedback linkages :

- Resource conservation
- Community participation
- Legal and institutional framework including that of policy matters.

V.7.2. Monitoring and Evaluation as a Management Tool

Selection of appropriate variables to address short and long-term threats to biodiversity increases the likelihood that monitoring and evaluation will serve as a management tool. With appropriate variables such as creating incentives to promote better monitoring, laying down specifications for a realistic evaluation needs to be included in the programme design.

Agrobiodiversity projects need more careful monitoring and evaluation as they can serve as credible indicators of the impact of investment in time and money. Monitoring, evaluation and management strategies in agrobiodiversity will have quicker and better results in adding value to the entire programme. To be cost-effective, a self-monitoring system should be built into the design of the project. Also, to be sustainable in the long term, a strategy for the self-mobilisation of the people in agrobiodiversity rich areas must be built into the project design (Global Environmental Facility 1992).

V.7.3. Selection of Appropriate Time Scale

Unlike other development activities, conservation poses difficulties in assessment by scientists and planners. This is because there are no homogeneous physical measurements that can be used for benefits, no well developed model and sectoral planning methodologies and nor is there a probable time scale. Some activities such as conservation or restoration of a habitat may take five to ten years and restoration of an endangered species may take three to five years, but monitoring these activities to relate them to success will take a longer time. Certain activities, incremental to a conservation project, such as soil conservation or water management, may require a still longer time-scale to measure results. Activities such as inventorying, assessment, cataloguing and characterisation may take longer periods than expected to arrive at minimum base-line data. All these activities must be considered carefully on a sectoral basis before deciding on an appropriate time scale. Caution is required to draw conclusions either from completed or ongoing programmes as the basic mix of socio-political, cultural, environmental and financial components may be different from the ones proposed.

V.7.4. Selection of an Appropriate Spatial Scale

Looking for successes or failures from several small-scale projects is much easier than to look for them in a large-scale project. This is essentially due to the complexity of projects that are intricately associated with several ongoing activities. Three levels of questions need to be answered here:

- Is the project site-specific?
- Is the project linked to other functional systems?
- Is the project developed with consideration of incremental activities, benefits, and costs?

If the answer to question one is yes, the project must address how the implementation will promote conservation and maintain the diversity across the landscape, ecosystem or habitat. This can be addressed in clearer terms with particular reference to conceptual and analytical issues.

If the answer to question two is yes, the project must address a properly designed hierarchical and monitoring schedule. Here, the project may promote creation, conservation or protection of a specific area where there is need to look into aspects relating to social, economic and political changes the project might bring about. One or more of these may result from such a programme. Careful analysis with reference to the relevance, timing and organisation of the project is very essential in this context.

If the answer to question three is yes, the funding agency must not only look into the two considerations above, but must also consider the viability of the project with reference to new funding, either available or promised, probable benefactors in the long run and how far the project's baseline and incremental activities are different with a crucial analysis on the expected time scale to obtain results from the programme.

V.7.5. Incremental Activities and Costs

Incremental activities for agrobiodiversity conservation is a concept that needs to be based on concepts of incremental costs and incremental benefits arising out of careful cost-benefit analysis. Certain aspects of the concepts of incremental activity are vital for conservation effort. These include those of baseline against which increments are to be defined; the increments that need a priority; the system boundaries and sensitivities of the estimates of costs and benefits.

Many times the incremental project is the difference between the actual project and the baseline project. It may be impossible to identify the incremental project with any specific component of the actual project.

Such a baseline is counterfactual and non-explicit. But for operating a financial mechanism at a global level this may be a challenge. Taking example from the Montreal Protocol where the baseline is not precise for the operation of the Multilateral Fund, it is mutually exclusive for countries.

Incremental projects are always tied up with incremental costs. These are, however, imposed on the country by a binding protocol.

There is no agreed way to value biodiversity and line it to "dollar value". But there are scientific agreements on threats of loss of biodiversity and how to make trade-offs. These trade-offs however need to be given in implicit values.

In terms of GEF who base support on incremental costs the financial support relates to securing benefits to the global environment that are additional and complimentary to sources of support that promote national sustainable development. Here it is important to realise that the 'programme' approach is better to 'project' approach. Agrobiodiversity projects can fit in more explicitly to this requirement since the global benefits many times outweigh local benefits. Conservation of wild crops and their relatives, neglected species can be of use not only to the country where they occur but for the community at large. Study by FAO on inter-dependence of countries of crop genetic resources shows clearly that there is no country which does not depend on another for its agrobiodiversity resources.

There are two aspects to the relationship between economic growth and environmental protection. While they are mutually contradictory, they are also mutually complementary. Economic growth does bring along environmental problems, but it can also strengthen man's hand in tackling these very problems whose successful solution will, in turn, create more favourable conditions for economic growth (Liu Guogang et al 1987).

VI. CONCLUSIONS AND RECOMMENDATIONS

An ecosystem classification system for the evaluation, monitoring, and external management of the global agrobiodiversity must be:

a) based completely on quantitative data
b) as objective as possible
c) reflective as closely as possible of the ecosystems functions
d) convenient for expanding or contracting spatial scale
e) useful for anticipating changes
f) applicable
g) ecologically sound, environmentally sustainable and socially acceptable.

Even for generating non-monetary contributions such as people's participation, some monetary resources are necessary for awareness generation and for developing participatory action plans. The world is now facing what is commonly called the 'fatigue' of green revolution of the 60s and 70s. Yields of major staples have remained stagnant or are often declining. Because of the soil fatigue in areas of intensive agriculture, more nutrients are needed to produce the same quantity of food as compared to 25 years ago. Per capita land and water resources are shrinking, while biotic and abiotic stresses are increasing.

Agrobiodiversity offers a powerful defence against the fatigue of green revolution and impending food shortages. Intensification of efforts to conserve can help us to decrease the burden on the environment Such efforts must include the following (Anonymous, 1996):

1. Enlarge the food basket by including crops which the research and development systems bypassed like neglected fruits, minor grains like Amaranth, Quinoa, Buckwheat and others.

2. Raising the yield ceiling by improving both total biomass and the harvest index.

3. Enlarging the genetic base of crop plants and farm animals by tapping the gene pool which was not available in the past owing to problems of gene transfer.

4. Achieving pyramiding of genes for biotic and abiotic stresses since heterogeneity will reduce the risk of vulnerability.

5. Creating an economic stake in conservation through a more equitable sharing of benefits.

6. Promoting greater regional and international cooperation in the conservation of centers of diversity of economically useful plants and protection of natural enemy complexes of pests and pathogens.

7. Establishing national and regional agrobiodiversity conservation corps who will influence conservation of agrobiodiversity for public good.

8. Creating suitable avenues for private sector participation in conservation of under-utilised crop species.

9. Implementation of suitable mechanisms to prioritise and relate inter-ecosystem dependence.

10. Developing case studies on individual ecosystem based needs.

Ultimately, self-reliance and skill- and labour-intensive technology must be the basis of food and nutrition security. As agriculture provides most of the jobs in many developing countries, the import of food by these nations would be equivalent to importing unemployment.

The following agenda can provide the basic framework for achieving sustainable food and nutrition security nationally and internationally (Anonymous, 1996).

1. An Evergreen Revolution must increase output in an economically viable, socially equitable and environmentally sustainable manner, focusing on the food and nutrition supply system as a whole. Beyond investing in new scientific technologies, this will require public policies which provide a supportive economic and social environment.

2. Science and technology for the public good is the key to improving agricultural productivity among the resource poor. With the spread of the free-market and intellectual property rights culture, it is essential that science designed for the public good receives adequate political and financial support. Scientists working in the areas of food and health security should regard themselves as trustees of the communities' intellectual property.

3. Sound environmental policies must provide the foundation of agricultural sustainability. Therefore, high priority must go to combating desertification, restoring degraded land and preventing water pollution and depletion. Equally important is the development of avoidance and adaptation strategies to cope with potential changes in climate, sea-level and ultraviolet radiation.

4. Entitlements, assets reform and technological empowerment of the poor will be essential in ensuring economic access to balanced diets, and would help address the triple goal of natural resources conservation, poverty alleviation and food security.

5. Agriculture must serve as an instrument of income and livelihood opportunity as well as of food production. Therefore, it is important that the economic benefits of agro-processing and agribusiness are taken to poor families through rural value added enterprises and partnerships with the private sector.

6. Macro-economic policies in the areas of pricing, trade and investments should be based on both environmental sustainability, as well as gender and social equity. A systems approach must be taken, with a holistic view of production, distribution and consumption.

7. The Information Age has provided tools such as the Internet and GIS mapping to promote a learning revolution in agriculture.

8. Existing global conventions must be implemented, including those on climate, biodiversity, desertification and the oceans, as well as Agenda 21 of UNCED and the global plans of action on population, gender, habitats, social development and plant genetic resources.

9. Public policies for sustainable food and nutrition security must institutionalise procedures to focus on both production and access.

An evergreen revolution must increase output in an economically viable, socially equitable and environmentally sustainable manner. Finally, policies for sustainable food and nutrition security should ensure:

- that every individual has the physical, economic, social and environmental access to a balanced diet that includes the necessary macro- and micro-nutrients, safe drinking water, sanitation, environmental hygiene, primary health care and education, so as to lead a healthy and productive life.

- that food originates from efficient and environmentally benign production technologies that conserve and enhance the natural resource base of crops and animal husbandry, forestry, and inland and marine fishers.

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