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FOOD SECURITY THROUGH BIODIVERSITY CONSERVATION

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Abstract. The importance of biodiversity to food security is well recognized. About three-quarters of the varietals genetic diversity of agricultural crops have been lost over the last century and that hundreds of the 7000 animal breeds are threatened by extinction. Just twelve crops and fourteen animal species now provide most of the world's food. Fewer genetic diversity means fewer opportunities for the growth and innovation needed to boost agriculture at a time of soaring food prices. Furthermore, as biodiversity used in food and agriculture declines, the food supply becomes more vulnerable and unsustainable. Reduction of biodiversity entails a reduction of options for ensuring more diverse nutrition, enhancing food production, raising incomes, coping with environmental constraints and managing ecosystems. Recognizing, safeguarding and using the potential and diversity of nature is critical for food security and sustainable agriculture. This paper deals with importance of biodiversity conservation on food security. It outlines the genetic erosion in agriculture and importance of agricultural genetic resources. This paper makes a detailed discussion on role of agriculture biodiversity in food security and declining situation in domesticated plant diversity. The major food crops under the risk of extinction are spelt out in paper. Further attempts are made to examine the role of marine biodiversity in food security. This paper concludes with some policy measures to promote the biodiversity conservation towards food security.

Key words: Food security Agricultural biodiversity, Genetic erosion, Plant diversity, Marine biodiversity, Germplasam.

1. Introduction

Agro- biodiversity is a component of biodiversity which is the combination of life forms and their interactions with one another, and with the physical environment which has made the earth habitable for humans. Ecosystems provide the basic necessities of life, offer protection from natural disasters and disease, and are the foundation for human culture. Biodiversity in agricultural ecosystems provides for our food and the means to produce it. The variety of plants and animals that constitute the food we eat are obvious parts of agricultural biodiversity. It is important to take note that biodiversity in agricultural landscapes has powerful cultural significance, partly because of the interplay with historic landscapes associated with agriculture, and partly because many people come into contact with wild biodiversity in and around the farmland. Farmers especially in developing countries are responsible for managing agricultural biodiversity in agricultural ecosystems as a critical resource for providing them with food security, nutrition and sustenance of their livelihoods.

2. Genetic Erosion in Agriculture

Genetic erosion, the reduction of diversity within and between species, is a global threat to agriculture. The concern is not the loss of a single species like wheat or rice, but the loss of diversity within species of the same population.

The greatest factor contributing to the loss of crop and livestock genetic diversity is the spread of high-input industrial agriculture and the displacement of more diverse, traditional agricultural systems. Beginning in the 1960s and 1970s. The Green Revolution introduced high-yielding varieties of rice and wheat to the developing world, replacing farmer's traditional crop varieties and their wild relatives on a massive scale.

The same process continues today. New, uniform plant varieties are replacing farmer's traditional varieties and the traditional ones are becoming extinct.

- In the United States, more than 7000 apple varieties were grown in the last century. Today over 85 percent of those varieties-more than 6000-are extinct. Just two apple varieties account for more than 50% of the entire US crop.
- In the Philippines, where small farmers once cultivated thousands of traditional rice varieties, just two Green Revolution varieties occupied 98% of the entire rice growing area in the mid-1980s.

The same is true with animal genetic resources. The introduction of modern breeds that are better suited for high production demands of industrial agriculture has displaced indigenous livestock breeds worldwide.

- FAO's 1995 World Watch List for Domestic Animal Diversity predicts that of the 4,000-5,000 breeds thought to exist, some 1,200-1,500 breeds worldwide are currently under threat of extinction. If only five percent of these breeds are being lost per year, then average rate of breed loss could be about three breeds every two weeks.
- In India, just 3 decades after the introduction of so-called "modern" livestock breeds, an estimated 50% of indigenous goat breeds, 20% of indigenous cattle breeds, and 30% of indigenous sheep breeds are in danger of disappearing.

3. Importance of Agricultural Genetic Resources

Whether they are used in traditional farming systems, conventional breeding, or new biotechnologies, plant and animal genetic resources are the foundation for sustainable agriculture and global food security-now and in the future. Genetic diversity in agriculture enables plants and animals to adapt to new pests and diseases, changing environments and climates. The ability of a certain variety to withstand drought, grow in poor soil, resist an insect or disease, give higher protein yields, or produce a better-tasting food are traits passed on naturally by the variety's genes. This genetic material constitutes the raw material that plant breeders use to breed new crop varieties. Without genetic diversity, options for long-term sustainability and agricultural self-reliance are lost.

4. Preserving Options for the Future

As genetic diversity erodes, our capacity to maintain and enhance agricultural productivity decreases along with the ability to respond to ever-changing needs and conditions. Scientists predict that the build-up of greenhouse gases in the atmosphere will cause global temperatures to rise 1 to 3 degrees Centigrade during the next century; melting glaciers and thermal expansion of the ocean will bring an associated rise in sea level of 1-2 meters. Each 1 degree rise in temperature will displace the tolerance of terrestrial species some 125 km. towards the poles, or 150 meters in altitude. In other words, global warming will wreak havoc on the world's living organisms. Approximately 30% of the Earth's vegetation will experience a shift as a result of climate change. But since climate will be changing faster than the migration rate of most species, experts predict a "drastic reduction" in global species diversity.

5. Agro-biodiversity and food security

Agro-biodiversity for food and agriculture is constituted by various biological diversity components that include crops, fish, livestock, pests, inter-acting species of pollinators, predators and competitors among others. Cultivated agro-biodiversity together with wild relatives provides humanity with genetic resources for food and agriculture. Infact, the global food supply rests essentially on the biological diversity developed and natured by indigenous communities, local farmers and farming communities residing in genetic resources centers of origin and diversity.

Plants, fungi and animals have also provided the world with its medicine, and the pharmaceutical industry is based on these biological resources and related local knowledge.

Many ailments are being treated and cured due to the availability of these bio-materials and the economic value is extremely high both in the food and pharmaceutical sectors. The economic, social and cultural value of these materials is still being discovered, but unfortunately, the ecosystems which host these bio-materials is continuously and systematically being destroyed rapidly. For example, fewer than 3% of the

220,000 flowering plant species of the world have been examined for alkaloids and that too in a limited and haphazard manner. The rosy periwinkle of Madagascar, it will be recalled, produced the two alkaloids, *vinblastine* and *vincristine* which cured the two most deadly of cancers (Nijar 1996). The same can be said of plants as a potential food resource. Some 30,000 species of plants have edible parts. Throughout history a total of 7,000 plants have been grown or collected as food, of which 20 species provided 90% of the world's food (Nijar 1996). Just three of these-wheat, maize and rice supply more than half of the worlds food requirements. Tens of thousands of unused plant species still exist and require strategies and concerted efforts in terms of conservation for present and future use. For most communities in developing countries, reliance on biological resources accounts for up to 90% of their livelihoods requirements .The careful nurturing and development of biodiversity is for them, in truth, a matter of life and death. Since the dawn of agriculture 12,000 years ago, humans have nurtured plants and animals to provide food. Careful selection of the traits, tastes and textures that make good food resulted in a myriad diversity of genetic resources, varieties, breeds and sub-species of the relatively few plants and animals humans use for food and agriculture. These diverse varieties, breeds and systems underpin food security and provide insurance against future threats, adversity and ecological changes. Agricultural biodiversity is the first link in the food chain, developed and safeguarded by indigenous peoples, and women and men farmers, forest dwellers, livestock keepers and fisher folk throughout the world.

Further wild species of crop plants and their relatives are the source of many genes imparting resistance against many disease pests and abiotic stresses. They are also source of genes that determine quality and other attributes. But the greatest threat to these wild species comes from the destruction, degradation and fragmentation of their habitat. This activity has already reduced virgin forests by 90%, wetlands by 50% and so on. Thus reduction of biodiversity in variety, species as well as ecosystem pose a serious threat to our food security.

Success in any breeding programme depends largely on the extent of genetic variability present at different levels. Often it is observed that breeders only use a few varieties extensively in different breeding programmes for development of new varieties. Instances of such use can be seen in rice (IR-8), wheat (Sonalika) and in black gram (T9) etc. Extensive use of a few genotype in breeding programme reduces the genetic diversity among the varieties cultivated and makes them vulnerable to various diseases and pests. Irish late blight, a disease of potato is an eye opener in this context. Thus, there is need to change our approach in breeding so that adequate genetic diversity can be maintained. In recent years, agriculure has also witnessed several changes including shift from the mixed cropping and intercropping to monocropping due to various consideration. Intensive agriculture has increased area under monoculture and at the cost of mixed cropping and intercropping and this has resulted in loss of species diversity. This trend needs to be reversed. High yielding varieties for these intercropping and mixed cropping systems need to be bred for enhancing total productivity of the system. Other activities of agriculture which are also responsible for reduction in biodiversity include indiscriminate and massive use of pesticides, fungicides, weedicides and chemical fertilizers in the agricultural crop field. These activities are responsible for extinction of many insect pests, predators, parasites, snakes, birds, butter flies, many pollinators and other animals in aquatic ecosystem. Some of these species play an important role in agricultural production by associating them with pollination, improving soil condition, fixing atmospheric nitrogen, improving soil physical properties and decomposition of organic matter etc. Thus there is necessity to use eco-friendly techniques in agriculture and to minimize the use of pesticides and other chemicals and resorting to organic cultivation, crop rotation so as to check reduction in biodiversity.

6. Domesticated plant diversity

Of the 511 plant families currently recognized (Brummitt 1992), only 173 have domesticated representatives. Of these the Gramineae has the largest number of domesticated species with 379 (15.2% of all plant domesticates), mostly originated from the near east of Africa. The family Leguminosae follows with 337 species (13.5%) of varied origin, including the Indochina-Indonesia region, the Mediterranean coast and adjacent region, and Central America. Rosaceae ranks third with 138 species, mainly from China and Europe-Siberia, and Solanaceae fourth with 115 (4.6%), mostly from Central America and Bolivia-Peru-

Chile. A notable contributions of domesticates has also been made by the Compositae (with 86 species), Curcurbitaceae (53 species), Labiatae (52 species), Rutaceae (44 species), Cruciferae (43 species), Umbelliferae (41 species), Chenopodiaceae (34 species), Zingiberaceae (31 species), and Palmae (30 species). However, many (about 48) plant families include only one domesticated species (Zeven and Wet 1982). Despite this relatively large number of plant domesticates, 90% of national per capita supplies of food plants come from only 103 species (Prescott-Allen and Prescott–Allen 1990). The most significant of these are domesticated Gramineae (cereals), annual grasses cultivated for their grains. These, together with Leguminosae (legumes), have been the principal crops of most civilizations, and represent the main source of calories.

If we look at biodiversity in terms of species numbers, of the estimated total of 320000 vascular plants, about 3000 are regularly exploited for food. Most of these, some 2500, are domesticated, but 15-20 are the crops of major economic importance.

Table 1 Biodiversity at Risk for Major Food Crops

Family	Species	Conservation status
Gramineae	Avena Sativa (oats)	Unknown
	Hordeum vulgare (barley)	Concern about genetic erosion
	Oryza glaberrima	Many wild relatives lost, especially *O. glaberrima*
	O.Sativa (rice)	Unknown in the wild
	Panicum miliaceam (common millet)	Wild relatives lost due to habitat destruction
	Saccharum officinarum (sugarcane)	Unknown
	Secale cereal (rye)	Unknown
	Sorghum becolor (sorgum)	Wild restricted to small area
	Triticum aestivum	(need to ex situ conservation)
	T.turgidum (wheat)	Rediscovery of wild relatives; under protection
	Zea mays (maize)	Unknown; conservation priority
Leguminosae	Arachis hupogaea (groundnut)	Unknown
	Cajanus cajan (pegionpea)	Threatened or rare
	Cicer arietinum (chickpea)	Traditional landraces destroyed by modern cultivars
	Glycine max (soybean)	Unknown
	Lens culinaris (lentil)	Wild relatives widespread, but some forms need conservation
	Phaseolus vulgaris (haricot bean)	Conservation measures limited
	Pisum sativum (pea)	Unknown
	Vicia faba (broad bean)	Unknown
Rosaceae	Fragaria x ananassa (strawberry)	High conservation priority (IPGRI)
	Malus pumila (apple)	Protected
	Prunus amygdalus (almod)	Protected
	Prunus armaniaca (aprcot)	Unknown
	Prunus domestica (plum)	Unknown
	Prunus persica (peach)	Unknown
	Pyrus communis (pear)	Conservation priority (IPGRI)
Solanaceae	Capsicum annum (chilli and sweet pepper)	More collection for seed bank needed
	Lycopersicon exculentum (tomato)	Gene pool eroded due to habitat destruction
	Solanum melongena (eggplant)	Unknown
	Solanum communis (potato)	150 Wild wild species; 3000-5000 varieties recognaized; Conservation

		priority (CIP)

Source: A.K.M. Nazrul – Islam, Biodiversity for sustainable food security in Bangladesh. Bangladesh Agricultural research council Dhaka 2004.

Coverage percentages are estimates derived from scientific consensus. For wild gene pools coverage relates primarily to those species in the primary gene pool, i.e. species that were either progenitors of crops, have coevolved with cultivated species, continuously exchanging genes, or are otherwise closely related.

7. Biodiversity and Agricultural Practices

Swift and Anderson (1993) have classified agricultural systems on the basis of their biological diversity and complexity. The current dominance on incentive cereal production has led to a significant reduction in the number of species and of production system. For farmers practicing low input agriculture, the maintenance of species and genetic diversity in fields is an effective strategy to create a stable system of conservation. Cultivated crops often intercross with their wild or weedy relatives growing in the field or nearby fields, resulting in new characteristics.

Traditional agriculture has been characterized not only by high interspecies diversity, but also the use of a wide variety of crop species within the same system. In India one species of mango, *Mangifera indica*, has been diversified over 1000 varieties; and one species of rice has over 50000 varieties. In Java small farmers cultivate 607 crop species in their gardens, with an overall species diversity of comparable to deciduous tropical forest (Dover and Talbot 1987). This immense diversification within and between crops species was not accidental, but often carefully developed by farming communities. In the Amazon, there is often little distinction between cultivated and wild species, nor can a clear boundary be drawn between fields and fallow or between fallow and forest. Yet effects of indigenous cultivation are far reaching and have substantial impacts on levels of biodiversity. It is found that while routinely scavenging through the forest, the Kayapo Indians of Brazilian Amazonia gathered dozens of plants, carried them back to the forests campsites or trails, and replanted them in natural forest clearings. Such plants included several types of tubers, beans and other food plants. Such ‘forest fields’ are always located near streams , but even in the savannah where patches of forest are scattered, areas where collected plants have been replanted from useful food depots for the Kayapo. This age-old pattern has had profound effects on the distribution of plants in the forest and has been an essential contributor to the current high levels of biodiversity in Amazonia. Other studies have shown moderate levels of human use tend to increase local biodiversity, by opening up new niches, providing new food or shelter sites, and diversifying the micro habits. It is observed from a study that a tropical forest that has had some crop production has a larger number of insect species than a primary forest. A study of two oases in the Sonoran Desert on either side of Mexico-United States border found that the customary land use practices of Papago farmers on the Mexican side of the border contributed to the biodiversity of the oases, while the protection from the human use of an oasis 50 km to the northwest, within the Organpipe Cactus National Monument, resulted in a decline in the species diversity over a 25 year period (Nabhan *et al*. 1982). Saldariagga *et al*. (1988) found that old secondary forest has greater species diversity than mature primary forest, with each 0.03 ha plot in 14 year old secondary forest having 56 species, while plots of the same size in 30 year old secondary forest had 77 species, 80 year old secondary forest had 79 species, and mature primary forest had just 66 species

8. Productivity and Stability

More diverse ecosystems, with more species or more genetic diversity within species, often have higher overall productivity than simpler systems; this is not a new idea Huston MA (1995). Tilman and his colleagues have documented this most extensively for (non-agricultural) prairie ecosystems, where, for example, plots with 16 species produced 2.7 times more biomass than monocultures created species-rich and species-poor hay meadows; after eight years the richer meadows yielded 43% more hay than species-poor fields, an effect that was not due simply to the fertilizing effects of the greater number of legumes in the more diverse fields. More recent research has indicated that experimentally-manipulated diversity in grasslands promotes temporal stability at many levels of ecosystem organization simultaneously mixtures of barley varieties in Poland generally out-yielded the mean of the varieties as pure stands. Increased productivity is also associated with greater stability of yield; it could be noted that indicates that high-diversity plots were 70% more stable than monocultures. Tilman's measure of stability—the ratio of mean plot total biomass to standard deviation over time—is just one version of stability, and ecologists have long debated the relationship between complexity and various measures of stability in ecosystems and food webs (Jongebreur AA 2000).

9. Marine biodiversity and Food Security

A growing body of research reveals that changing biodiversity can influence several properties of marine food webs and ecosystems, including nutrient use and cycling, productivity, transfer of energy and materials between tropic levels, and the stability of these processes. The experimental evidence, mostly based on small-scale studies, thus suggests several important links between biodiversity and marine ecological processes. These generalizations have potential implications for fisheries, and consequently for human well-being.

Blue fin tuna have been severely over fished and some scientists believe they are in danger of extinction. To answer this question, it's worth first specifying what is meant by biodiversity loss. It's easy to understand that extinction of a fish species would be detrimental to the fisheries that target it directly. But complex interactions among species can also produce important rippling influences of loss of a species on the structure and dynamics of ecosystems. For example, the blue crab (*Callinectes sapidus*) is one of the largest fisheries in the Chesapeake Bay, USA, with a value of almost 19 $M in Virginia alone in 2004. Blue crabs have declined in abundance in recent decades, partly as a direct result of fishing, but also as an indirect consequence of loss of seagrasses that provide nursery habitat for young crabs. Similarly, when wasting disease decimated eelgrass (*Zostera marina*) throughout the North Atlantic in the 1930s, the Maryland and Virginia fisheries for bay scallops, which depend on eelgrass, crashed and never rebounded. These examples show how loss of a major habitat-forming species, eelgrass, can have important indirect consequences for other species.

For example, in the tropical Atlantic, long line fisheries for billfish show a pattern of sequential peaks in catch of different species, with decline of prized blue marlin in the 1960s accompanied by a rise in catch of sailfish, which then declined in turn as swordfish catches increased through the late 1970s and 1980s. The result was that total billfish catch remained relatively stable through time despite boom and bust patterns in the catch of individual species. A similar pattern has been seen on Georges Bank, where the decline of cod through the 1960s was accompanied by a steep rise in flatfishes. It has also been suggested that the booming Maine lobster catches of recent years may reflect their release from predation by the now collapsed stocks of predatory cod.

Seafood for sale at a fish market in the Malaysian city of Kota Kinabalu. These findings suggest that biodiversity can provide a form of security with an analog in financial markets: a diverse portfolio of fish stocks, like a portfolio of business stocks, can buffer an investment against fluctuations in the market that cause major declines in individual stocks, thus preserving society's options in the face of change. This stabilizing effect of a biodiverse portfolio is likely to be especially important as environmental change accelerates with global warming and other human impacts. For the industries that harvest seafood, and the human societies that are obliged to manage these public resources, the implication of these results is one that has not yet been widely integrated into fishery management, namely that productive fisheries that are sustainable over the long term depend on a normally functioning ocean ecosystem. This in turn depends on a variety of less conspicuous, easily ignored species of microscopic plankton, small invertebrates, coastal wetland plants, and so on. Growing evidence from a variety of sources indicates that loss or reduction of such species often has consequences that ripple out through the food web, degrading the ocean's capacity to provide not only fish harvests, but other services to humanity such as coastal erosion control and water purification. If such interactions are indeed general—and the concordance of theory, experiments, and observed trends in global fishery catches suggest that they are—they imply that continuing erosion of ocean biodiversity has real potential to compromise food security, particularly for the developing nations and small island states whose populations and economies depend heavily on wild fish harvests.

10.Fisheries Conservation

Threats to the ocean are multifaceted, and the solutions need to be as well. Effective ocean conservation and management involve three R's: *Reserve* unspoiled habitats where possible, *Restore* degraded ones, and *Reconcile* the several, often competing, demands of human society with the need for long-term sustainability of the natural infrastructure that feeds those demands. One promising approach that begins to address all three of these goals is ocean zoning, that is, designation of certain areas for particular uses and others that are partly or fully protected. Such zoning has been used routinely on land for many years.

11.Conclusions

Diversity at ecosystem, species and genetic levels, brings many direct benefits for specific aspects of agricultural production. However, our knowledge of the nature and extent of these benefits remains imperfect and further studies are needed to explore not only the intrinsic benefits but also effects manifested at different scales. The biodiversity is not a easy task. It requires a scientific approach to understand how different forms of agricultural biodiversity contribute to the goals of improved food and nutrition security and sustainability, and a recognition that while some principles and practices will be globally applicable, others may be constrained by locality and culture. Much remains to be done. It is also important to recognize that the extent and distribution of diversity in production systems may vary substantially depending on the properties of the production systems, their resilience and the ways in which production is managed.

It could be noted that, just as crop genetic erosion undermines food security, biodiversity loss in general undermines the provision of the ecosystem services agriculture itself depends on. Many examples can be given, in which the balance in the spectrum between short-term benefits at private and local level versus long-term benefits at public and global level tipped over to environmental degradation and out-migration in rural areas. In order to promote biodiversity conservation towards food security, the following policy suggestions can be considered.

Enlightened landscape planning and management that allows for multiple functions in landscapes and enables the balancing of development and environmental goals.

Development of sound agricultural policies that recognize and value the role of biodiversity in agricultural development and food security.

Markets and institutions for ecosystem services, and payments or governance for ecosystem service systems that work for farmers and poor rural people, implying clear tenure and resource access regimes, fair and equitable contractual arrangements, systems for efficiently transferring funds or advantages from buyers to sellers, and good verification and sanction systems so that stakeholders are satisfied.

The challenge of meeting the MDGs on biodiversity and food security and reversing the degradation of ecosystems while meeting increasing demands for their services involves significant changes in policies, institutions and practices.

- Effort should be made to protect the indigenous variety of food crops.
- Introduction of genetically modified crops could be prevented as they destroy the traditional crop diversity.
- Gene bank for all wild crop varieties could be created to conserve their species.
- Effort should be made to protect the domesticated plant diversity
- Genetic erosion on major food crops should be prevented with a view to ensure their continuous existence of such species.
- The government should discourage the mono crop cultivation practices as they destroy crop diversity.
- There is a need to encourage research on crop germplasam collection and preservation.
- The People should be educated about the importance of biodiversity towards food security.
- Low input sustainable agricultural practices should be encouraged with a view to protect the soil biodiversity.
- In order to protect the marine biodiversity, fishing can be prevented during breeding season.

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